# Sustainable Livelihood Systems in Nepal

## Principles, Practices and Prospects

Editors: Ambika P. Adhikari, Govinda P. Dahal, Ishara Mahat,
Bishwa Regmi, Kalidas Subedi and Bharat Shrestha

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www.cffn.ca

This book is dedicated to the victims of
the earthquake that struck Nepal in 2015.

# Table of Contents

## List of Tables

## List of Figures

## List of Boxes

## List of Abbreviations

| | |
|---|---|
| AAH | Annual Allowable Harvest |
| ADS | Agricultural Development Strategy |
| AET | Alternative Energy Technologies |
| AICL | Agricultural Input Corporation Limited |
| APP | Agricultural Perspective Plan |
| ARI | Acute Respiratory Infection |
| AS | Ammonium Sulphate |
| ASEAN | Association of South East Asian Nations |
| BASF | Badische Anilin- und Soda-Fabrik |
| BBC | British Broadcasting Corporation |
| BCC | Behavioural Change Communication |
| BHC | Benzene hexachloride |
| BMP | Best Management Practices |
| BQ | Black Quarter |
| CBO | Community Based Organizations |
| CDP | Community Development Project |
| CEC | Caution Exchange Capacity |
| CF | Community Forestry |
| CFFN | Canada Foundation for Nepal |
| CFUG | Community Forestry User Group |
| CGIAR | Consultative Group of International Agriculture Research |
| COPD | Chronic Obstructive Pulmonary Disorder |
| CP | Crude Protein |
| CRT | Centre for Rural Technology |
| DALY | Daily Adjusted Life Years |
| DDT | dichloro-diphenyl-trichloroethane |
| DFID | UK Department for International Development |
| DFO | District Forestry Officer |
| DMI | Dry Matter Intake |
| DNA | Deoxyribonucleic Acid |
| DoA | Department of Agriculture |
| EBC | Everest Base Camp |
| EPA | Environment Protection Agency |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| FCHV | Female Community Health Volunteers |
| FMD | Food and Mouth Disease |
| FUG | Focussed User Group |
| FYM | Farmyard Manure |
| GDP | Gross Domestic Product |
| GEAC | Genetic Engineering Appraisal Committee |
| GMO | Genetically Modified Organisms |
| GoN | Government of Nepal |
| HA | High Altitude |
| HAN | Hotel Association of Nepal |

| | |
|---|---|
| HS | Hemorrhagic Septicemia |
| IAA | Indolebutyric Acid |
| IDRC | International Development Research Centre |
| IFAD | International Fund for Agricultural Development |
| IHME | Institute for Health Metrics and Evaluation |
| IMF | International Monetary Fund |
| IPM | Integrated Pest Management |
| IPNM | Integrated Plant Nutrient Management |
| IPNS | Integrated Plant Nutrition Survey |
| IRAC | Insecticide Resistance Action Committee |
| IRDP | Integrated Rural Development Programme |
| ISFM | Integrated Soil Fertility Management |
| LGU | Local Government Units |
| MAS | Market Assisted Selection |
| MDG | Millennium Development Goal |
| MoA | Ministry of Agriculture |
| MoAD | Ministry of Agricultural Development |
| MoFSC | Ministry of Forest and Soil Conservation |
| MoHP | Ministry of Health and Population |
| MoL | Ministry of Labor |
| MRL | Maximum Residue Limits |
| NAA | Naphthylacetic Acid |
| NARC | National Agricultural Research Council |
| NCD | Non Communicable Diseases |
| NDS | National Development Service |
| NGO | Non-Government Organizations |
| NHP | National Health Policy |
| NHSP | National Health Sector Policy |
| NMA | Nepal Mountaineering Association |
| NPC | National Planning Commission |
| NSP | National Seed Policy |
| NTB | National Tourism Board |
| NTFP | Non-timber Forest Product |
| ODK | Open Data Kit |
| PCB | Polychlorinated biphenyls |
| PCRW | Production Credit for Rural Women |
| PGR | Plant Growth Regulator |
| PMRA | Pest Management Regulatory Agency |
| POP | Persistent Organic Pesticides |
| PPD | Plant Protection Directorate |
| PPR | Petits Ruminants |
| PPRMD | Pesticide Registration and Management Division |
| REDD | Reducing Emissions from Deforestation and Forest Degradation |
| RE | Renewable Energy |
| RSL | Residual Soil Nitrogen |
| SALT | Sloping Agricultural Land Technology |
| SAP | Structural Adjustment Program |

| | |
|---|---|
| SDA | Swiss Development Agency |
| SDH | Social Determinants of Health |
| SFDP | Small Farmers Development Programme |
| SOM | Soil Organic Matter |
| SPS | Sanitary and Phytosanitary |
| SSE | Small Scale/Seed Enterprise |
| SSNM | Site Specific Nitrogen Management |
| SSSA | Soil Science Society of America |
| TAAN | Trekking Agencies' Association of Nepal |
| TDN | Total Digestible Nutrients |
| USAID | United States Agency for International Development |
| VDC | Village Development Committees |
| VHW | Village Health Workers |
| VOC | Volatile Organic Compounds |
| WCED | World Commission on Environment and Development |
| WFP | World Food Program |
| WHO | World Health Organization |
| WTO | World Trade Organization |

# Foreword

In order for Nepal to graduate from the ‘least developed country’ status by 2022, improving rural livelihoods and economies is critical. 80 percent of the Nepal’s population resides in villages (2015 estimate), and thus drastic improvement in Nepal’s economy is not possible without lifting the rural masses out of poverty, and dramatically improving rural economic systems. There are very few books that have comprehensively dealt with topics related to rural livelihoods in Nepal. This book, “Sustainable Livelihood Systems in Nepal”, fills a very important knowledge gap in this area.

The use of sustainable livelihoods framework in the national development strategy by development agencies started during 1980s. While different versions of the framework have emerged over time, they have generally failed to address the problems related to livelihoods linking across disciplines such as agriculture, forestry, bio-diversity, environment, tourism, gender, energy, health, equity and rural development. Without using an integrated approach, it is difficult to comprehend how different knowledge networks and themes interact with each other for effective livelihood outcomes.

This book offers an interdisciplinary approach to this endeavour, where contributions of 36 Nepali Diaspora authors from Canada, USA, Australia, United Kingdom, Switzerland and Nepal have been synthesised, using topic-specific evidence reviews and rigorous research processes. The editors, contributors and reviewers of this book have professional and academic expertise and international experience in their respective fields helping them to create a useful book.

The primary aim of this book is to fill knowledge gap in the ‘sustainable livelihoods’ field in Nepal, which has been unmet till now. Dr. Ambika Prasad Adhikari and Dr. Govinda Prasad Dahal, editors of this book, including associate editors, are experts in their fields and have published books, scientific articles and reports related to international development. Dr. Adhikari is a former Country Representative of IUCN Nepal, and Dr. Dahal has worked in academic settings in Canada, UK and Australia.

Using the sustainable livelihood framework developed in the 1990s by DFID—the United Kingdom’s Department of International Development—as a reference, this book deals with several emerging knowledge fields related to rural livelihoods and their interconnections. In addition to considering topics which have strong bearing on rural livelihoods, agriculture and livestock production in Nepal, this book also considers biodiversity and other environmental issues and various cross-cutting themes such as tourism, gender, energy, health and international trade.

The book should prove useful by providing new concepts beyond the contents of available textbooks and articles related to sustainable livelihood systems in Nepal. This is because, unlike other textbooks, this book deals with a comprehensive list of factors that are key for rural livelihoods and development. Topics included in the book are: land degradation and soil fertility decline, management practices to enhance sustainability of soil fertility, alternative sources of plant nutrients, plant genetic resources with various approaches to crop improvement including the possible use of transgenic traits in crop improvement, the prospect of developing a commercial fruit tree production system, the current scenario of the proper use and challenges of agro-chemicals, and the importance of improved ruminant production and for sustainable livelihoods.

Similarly, this book also looks into aspects of forest and tree resources, especially community forestry in the context of a changing rural landscape and its relation to sustainable livelihoods and the value of social capital in relation to forest management. Reducing emissions from deforestation and forest degradation and other benefits (REDD+) is one of the large-scale mechanisms proposed by the United Nations Framework Convention on Climate Change to combat climate change, biodiversity loss and rural poverty. In this context, this book analyses REDD+ as a development tool to improve rural livelihoods in Nepal.

Likewise, to link livelihood issues with rural development, this book synthesises evidence through the lens of gender, energy, tourism and rural development policies. Impacts of these factors can help enhance the quality of life and can be measured by the health status of citizens. The book also highlights the importance of the social determinants of health and health equity, mobile health and health risk communication strategies, and reforming health insurance policies to improve sustainable livelihood systems in Nepal.

With all this well researched knowledge and updated information base, this book, jointly published by the Canada Foundation for Nepal (CFFN) and International Union for Conservation of Nature (IUCN), should be useful for students, academics, policy-makers, practitioners, rural entrepreneurs and researchers in Nepal and elsewhere who are interested in the livelihood systems in Nepal.

On behalf of IUCN, I would like to thank CFFN, the editors and associate editors, and all the contributors for producing this book. In addition, I would like to thank the Open University section of CFFN for its financial support in the publication of this book. I would also like to thank IUCN staff for helping in the layout and publication process. A special thanks is due to Rajendra Khanal, Amit Poudyal and Kyle LaVelle of IUCN who helped in the publication process.

IUCN is pleased to have the opportunity to collaborate in the publication of this important book.

Dr. Yam B. Malla
Country Representative
IUCN, Nepal
Lalitpur, Nepal

# PREFACE

I am pleased to write this preface for the book "Sustainable Livelihood Systems in Nepal" published jointly by the Canada Foundation for Nepal (CFFN) and International Union for Conservation of Nature (IUCN).

Canada Foundation for Nepal (CFFN) is a registered non–profit organisation based in Ottawa, Canada and is dedicated to advancing education and wellbeing in Nepal. Through the works of the Nepali Diaspora, CFFN supports development in Nepal in capacity building, sponsoring research and awareness building on current developmental issues.

IUCN is a leader in finding solutions to environment and development challenges. IUCN's work includes conserving nature and deploying workable solutions to global challenges in climate, food and development.

This book is a Diaspora group effort, and is the first of its kind in my opinion. Dozens of Diaspora members under the aegis of CFFN have taken this initiative to write and publish a book that is relevant in the Nepali situation. This effort gives this book a unique benefit of comparative perspective based on their experience. The majority of the writers live in Canada, and they have helped to enrich the content of this book with their personal experiences in Nepal and internationally.

Various livelihood aspects including education, health, agriculture, community forestry, migration, and tourism affect the rural economy of Nepal. Though many development agencies have made efforts to address different development challenges from their perspectives, the integration of sectorial initiatives that enhance entrepreneurship are often missing in official efforts to improve rural livelihoods. This book tackles sustainable livelihood systems in Nepal from a multi-disciplinary perspective, which includes viewpoints from the subject matter areas of economics, agriculture, tourism, gender, health, forest, biodiversity, climate change and sustainability. The chapters in the book systematically highlight the interconnectivity of all these sectors, which collectively affect the rural livelihoods in Nepal. Further, the writers articulate how these elements work in the institutional settings of Nepal. Some initiatives in Nepal have become exemplary in the world stage (e.g. community forestry), whereas in many areas (e.g. entrepreneurship, medical insurance) the situation in rural Nepal is quite rudimentary.

I believe that this book would be valuable for students, professors, policy makers, practitioners, rural entrepreneurs and researchers in Nepal and outside who are interested in the livelihood systems in Nepal.

As Nepal is working hard to graduate from the 'least developed country' status by 2022, addressing rural livelihoods and the rural economy is of critical importance. Without lifting the rural masses out of poverty, and without improving the rural economic systems, enhancing Nepal's economic development would not be feasible. Very few books have dealt with the comprehensive topics related to rural development in Nepal, and this book fills an important gap in this area.

The National Planning Commission (NPC) provides advisory support for policy reforms and facilitates the coordination among the sectors and planning guidance to Nepal's overall development. NPC welcomes contributions made in this book to fill knowledge gaps in critical developmental areas. From the perspective of the NPC of Nepal, I welcome this Diaspora effort to provide important insights in rural development and livelihoods in Nepal while citing international best practices in the areas of rural development, sustainability and development.

**Prof. Govind Raj Pokharel, Ph. D.**
Vice Chairperson
National Planning Commission, Nepal

## Acknowledgements

This book “Sustainable Livelihood Systems in Nepal” was conceived by Canada Foundation for Nepal (CFFN) as a way of channelling Canadian Nepali and other Diaspora thoughts into a book that could be of use to Nepal in the area of rural development, livelihoods and sustainability.

It is the product of the teamwork among the editors, contributors, reviewers, publishers and organisations which supported this effort.

We sincerely thank our associate editors—Dr. Ishara Mahat, Dr. Bishwa Regmi, Dr. Kalidas Subedi—and all the theme editors—Dr. Bharat Shrestha, Dr. Krishna Hari Gautam, Dr. Bhim Adhikari and Dr. Kedar Nath Adhikari—for their service in the production of this book from the beginning. They dedicated many hours to ensure that we had chapters covering all important areas which were initially identified. They participated in numerous in-person and online meetings and followed up with the authors to quickly produce and subsequently review the manuscripts.

Most importantly, we are grateful to all the contributors in this book. They took time to contribute to this book in spite of their busy professional and family schedules. We also appreciate their patience through periods of delay in the publication schedule.

We also thank all anonymous reviewers for their comments and suggestions on the book chapters.

We are grateful to IUCN Nepal for agreeing to publish this product of the Nepali Diaspora efforts. In particular, we want to thank Dr. Yam Malla, Country Representative of IUCN Nepal, who supported our efforts the moment we asked him. We are also thankful to IUCN Nepal staff for the support in organising IUCN funding for the publication and for designing the layout and final editing of the book. Our thanks go to Mr. Rajendra Khanal, Mr. Amit Poudyal, Mr. Kyle LaVelle, and the IUCN officials who worked to make this book a reality. Also thanks go to Ms. Reejuta Sharma (who has now left IUCN).

We are grateful to Dr. Michael G. Tyshenko for his voluntary service in proof reading all chapters of this book.

We are thankful to the CFFN board and general members who are directly or indirectly involved in editorial work, provided moral support and encouragement in proceeding with the book project, especially Prashanta Dhakal for some editorial suggestions and formatting, and Michael Casey for some comment suggestions and editorial supports. They deserve a big thanks. We want to thank all the CFFN officials and affiliated individuals who envisioned this book, including Martina Casey, Mr. Ben Wood, Dr. Jaya Ram Simkhada, Dr. Drona Rasali, Dr. Shiva Ghimire, Dr. Pramod Dhakal, Mr. Robin Pudasaini, Mr. Rajendra Gurung, Mr. Michael Casey and many other well-wishers. Last, but not least, the support of Dr. Ram Acharya and Dr. Toya Baral of the book project in its initial phase is much appreciated.

The editors, associate editors, theme editors, contributors, and everyone who worked in the production of this book did so on a voluntary basis. The views presented in each article are those of the authors and do not necessarily represent the organisations where they work, and also not that of CFFN and IUCN.

Editors
Ambika P. Adhikari, Dr. Des.
Govinda P. Dahal, Ph. D.

1

# Introduction:

## Theoretical and analytical framework

Govinda P. Dahal, Ishara Mahat, Bishwa Regmi, Kalidas Subedi, Ambika P. Adhikari and Bharat Shrestha

## 1. Introduction

Many developing countries face multiple problems related to poverty, malnutrition, lack of adequate health care, poor drinking water quality, low literacy and energy insecurity in the 21st century. Continuing national and international efforts to contribute to socio-economic advancement in many developing countries has helped, but it is acknowledged that enjoying a basic standard of living remains almost impossible for many in low-income countries. Most devastating problems that affect the livelihoods of billions of people are problems that come into view from a single source: the consequences of poverty and inequality (Paluzzi & Farmer, 2005). Although no single country in the world is untouched by this problem of inequality, individuals in low-income countries suffer the most.

Nepal is one of the least developed countries, situated in South Asia between two most populous countries: India and China. Over 75 percent of its people live in rural areas (2015 estimates), and the vast majority of those are engaged in subsistence farming for their livelihoods. The rural population (in general), and poor farmers (in particular), are often faced with the predicament of maintaining their livelihoods in the absence of sufficient productive resources, capacities and access to other social and economic opportunities. They often face difficult choices in order to preserve their traditional lifestyle. Traditional farming is a means to their survival in the midst of tumultuous changes, and the use of modern techniques as a way to increase productivity is often less friendly to their conventional farming systems. Agriculture, forestry, livestock, and tourism have remained the major areas of focus of development agencies in Nepal for over five decades (GoN/NPC, 2014), but only with limited success. It is time to re-think this paradigm and explore new ways of thinking and new ideas related to sustainability that will improve future sustainability in Nepal.

Agricultural productivity and the rural economy have advanced to some extent over time; however, the livelihoods of the majority of rural populations in Nepal still remain impoverished. Consequently, many villagers are out-migrating to urban areas and emigrating to foreign lands, such as the Gulf region and other labour-importing countries, such as Malaysia and South Korea, in search of employment prospects. The scale of out-migration and emigration is such that it has significantly influenced agricultural production and productivity, leading to an increasing trend of domestic food shortages. Nepal, which was once a food exporter, is now a net importer of food items.

To understand Nepal's rural economy, it is essential to review the multiple dimensions of livelihoods that can improve the qualities of life of people in rural areas. The rural economy of Nepal is intertwined with different livelihood aspects including education and health, agriculture, forestry, migration and so on. Though development agencies have made their efforts to address different development challenges from their perspectives, the integration of sectoral problems is largely missing in efforts to address livelihoods—an issue of interdisciplinary nature. Evidence suggests that all disciplines that are related to livelihoods should be reviewed collectively in efforts to improve the livelihood situations of poor people in a coordinated manner. Too often, separate disciplines have treated livelihood issues independently, following their own lines of specialisations creating a divide between scientific disciplines and development agencies (Ness & Golay, 1997). This separation is a major problem for addressing livelihood related problems linking across disciplines such as agriculture, forestry, bio-diversity, environment, tourism, gender, energy, health, equity and rural development. Similarly, several documents are available on these disciplines in Nepal and elsewhere, but their connection to livelihoods has not been well articulated. Without documenting such resources, development planners, decision makers, students of development study, teachers, academics, and politicians cannot get a good grasp on how different knowledge networks and themes interact with each other to collectively contribute to livelihood systems —an important pillar of sustainable development.

This book is an endeavour to articulate knowledge networks from various disciplines, which collectively contribute toward sustainable livelihood systems, especially for rural Nepal. The book deals with many emerging knowledge fields and their interconnections that have a strong bearing on rural livelihoods and agriculture in Nepal including soil fertility management, plant genetic resources, transgenic crops management, commercial production of tree fruits, proper use of agro-chemicals, utilising organic wastes and alternative sources of plant nutrients, sustainable livestock production, biodiversity and other environmental issues. Other crosscutting themes related to livelihoods include tourism, gender, energy, health and international trade issues. This book aims to provide some new concepts beyond the contents of many available textbooks and articles related to sustainable livelihood systems in Nepal.

The World Commission on Environment and Development (WCED) defined sustainable development (WECD, 1987) as: "meeting the needs of the present generation without compromising the needs of the future generations." In line with this definition, a livelihood system can only be sustainable when it can cope with and recover from current stresses and shocks, and at the same time, it can enhance its capabilities and assets both for the present and for the future without undermining the sustainability of available natural resources (Carney, 1998). When we consider an individual household unit, one's livelihood includes assets, activities and access that are required for a living (DFID, 1999; Ellis, 2000; Scoones, 1998). As shown in Figure 1, sustainable livelihoods system comprise the assets (natural, physical, human, financial and social capital) and processes (policies and institutions) that influence access to and use of livelihood assets that together determine livelihood outcomes (DFID, 1999; Ellis, 2000).

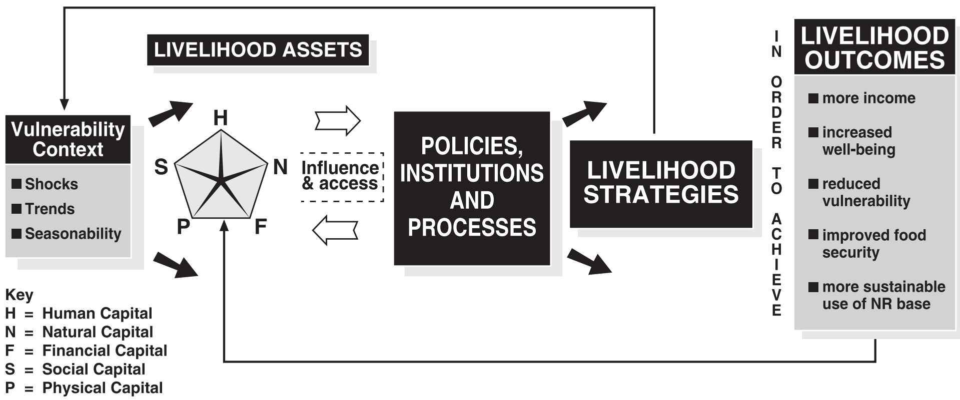


Figure 1: Sustainable Livelihoods Framework (Source: DFID, 1999)

The strategies of livelihoods depend on welfare maximisation and risk reduction mechanisms that ensure secured provision of cash, food, savings and access to resources. Selection of livelihood strategies depends on use and access to required resources such as land, vegetation, cash, labour, technology and technical manpower. As a result of complex interactions between these resources and livelihoods, households change their strategy over their life cycles (Campbell, 1996). These strategies take the form of agricultural intensification, effective natural resource management involving local communities, sustainable livestock production, livelihood diversification and migration (Bryceson, 2000; Ellis, 2000; Hussein & Nelson, 1998; Scoones, 1998). Natural environmental change and human induced household changes (through gender empowerment, using alternative energy, implementing effective institutional policies, utilising evidence based preventive and curative health measures, addressing social determinants of health and implementing effective health insurance policies) (Johnson, 1997) affect capital assets and consequently livelihood strategies.

Policy and institutions often limit the level of livelihoods of people by defining who can gain access to capital assets and build the capacity of their household to transform one form of capital into another form for their livelihoods (Carney, 1998). A range of institutional processes determines access to capital assets (Carswell, 2000). Understanding how policies and institutions are formulated and how their practice in real world settings occurs provides a means of identifying constraints and opportunities.

In this book, the analytical framework (Figure 2) covers fourteen different knowledge networks in relation to the book's four themes, which contribute to a sustainable livelihood system. Since meeting the growing demand for food is the first step in maintaining livelihoods, increasing agricultural productivity sustainably is of primary importance. However, without understanding the causes, consequences and prospects of overall land management, it is not possible to increase agricultural productivity in a sustainable manner. A discussion of sustainable soil fertility management practices in Nepal can help our understanding of these dimensions. Again, utilising organic wastes and alternative sources of plant nutrients will further contribute to the management of soil fertility for sustainable agriculture. However, common plant diseases/pests, disorders and adverse stresses seriously hamper crops productivity. Thus, in order to protect crops from such risks and increase the crops productivity, application of new technologies such as transgenic crops for increased yield and disease/pest resistance need to be considered.

The number of inhabitants in urban areas of Nepal is rapidly increasing. At the same time, the life style of rural people has also changed due to the adoption of urban lifestyles. People in rural Nepal lack enough food (grains, fruits, vegetables and meat items). Similarly, regular intake of adequate fruits and vegetables for the majority of urban people is still not fully realised. This situation has not only aggravated the sufferings of people from poverty related illnesses, but also contributed to the prevalence of many chronic diseases. Addressing these issues is almost impossible without using high yielding crops and their varieties along with commercial production of fruits and vegetables. At the same time, it is critical to create awareness of the proper use of agro-chemicals for the sustainable production of crops as well as to protect the environment and minimise human health hazards. Farming systems in Nepal are interconnected through its three major components: crops, livestock and forests. Sustainability of these resources is essential for achieving sustainable livelihoods. Any imbalance between these resources creates adverse consequences on livelihoods. See Figure 2 for the scheme used in this book to connect knowledge networks, themes and livelihoods.

A better understanding of the context and changing dynamics of community forestry and the associated social capital along with user participation in community-based forest management will help to prevent some of the adverse impacts of various components affecting livelihoods. Also, understanding the influence of community based institutions and the role of rural development policies are equally important to identify their potential benefits and challenges for sustainable livelihood systems. Gender dynamics and associated frameworks to meet household energy demands are also important issues related to sustainable livelihoods.

In addition, Nepal has an enormous potential for tourism development, which can be an important pillar of economic development. Professional excellence for tourism management including mountain guiding can generate employment and revenue, which can enhance rural livelihoods. Since there is a limited understanding on these aspects, investigations on these issues can be a significant contribution to existing knowledge system in this area. One of the indicators of better livelihoods is better measurable health outcomes and vice versa. However, evidence suggests

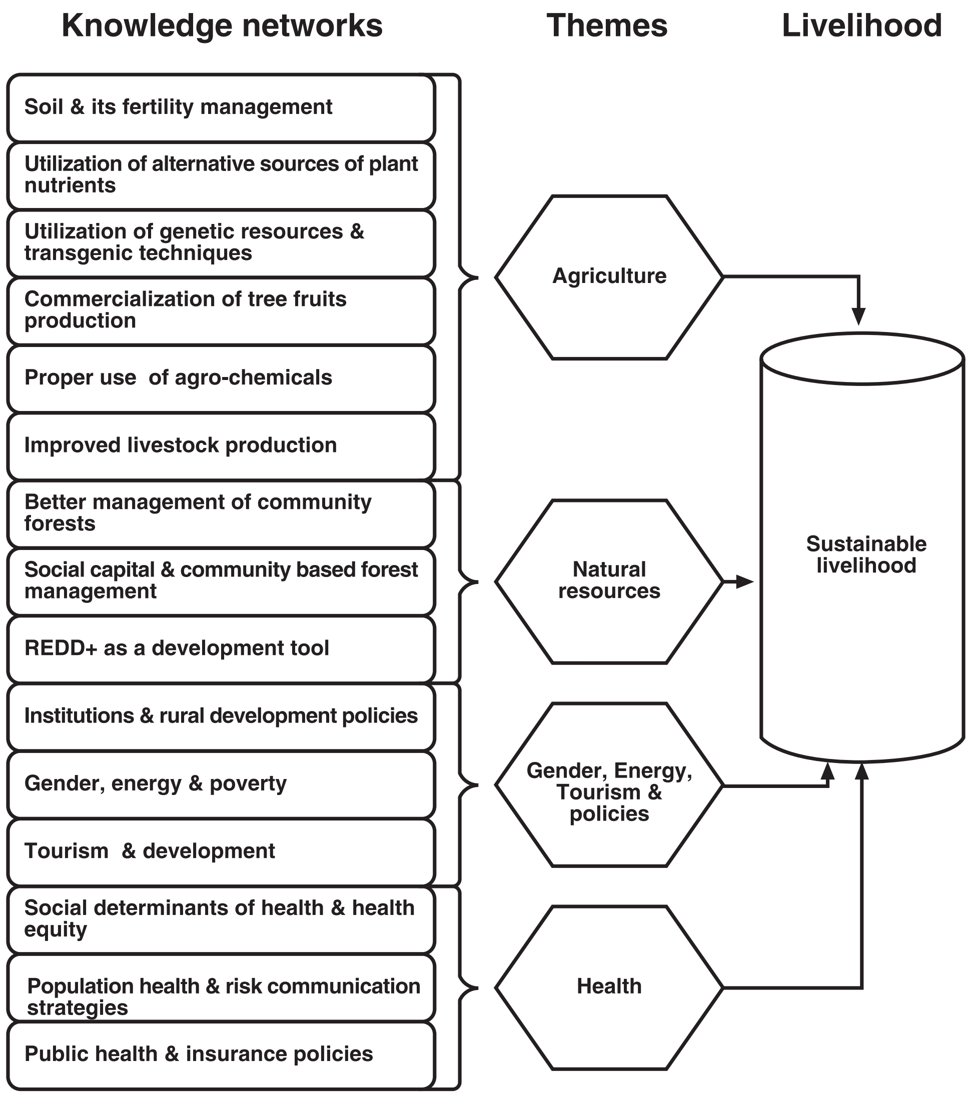


Figure 2: Analytical framework used for this book

that rural people in Nepal continue to suffer from a triple burden of mortality and morbidity from: communicable diseases, non-communicable diseases, injury, violence and disaster. A better understanding of their causes or the determinants can certainly help to make effective plans and implement preventive measures. As Nepal's landscape is dominated by difficult mountains and hills and lacks reliable transportation system, reaching people in need with better services has been difficult. Mobile health and health risk communication strategies can play important roles to prevent and manage illnesses, and effective health insurance policies can further contribute towards better health care service strategies.

## 2. Overview of the book

In this book, fifteen chapters are divided into four different themes with contributions by 36 authors from Canada, USA, Australia, United Kingdom, Switzerland and Nepal, who have professional expertise and international experience in their fields. Each manuscript was prepared with topic-specific evidence reviews and rigorous research drawing on available scientific evidence. Each chapter was carefully scrutinised and included based on their insights to help sustain the livelihood systems in Nepal.

Each paper (on topics listed in Figure 2) was thoroughly reviewed by the network editorial team before being sent to external experts for blind peer reviews. After the authors incorporated the reviewers' comments, the chapters were further scrutinised by theme editors and core editorial team members. It is believed that the contributions from the individual experts with national and international experience will help in the promotion and furtherance of sustainable livelihood systems in Nepal.

## 3. Theme I: Sustainable Agriculture

As Nepal's economy mainly relies on agriculture, the role of sustainable crop production (SCP) is critical. SCP involves management of soil, water, genetic resources (crops and their varieties) and biotic and abiotic stresses in a way that crop productivity is sustained without harming the ecosystem or natural environment. Currently, agriculture in Nepal has been challenged by numerous natural and human-induced causes leading to unwarranted and un-sustainable systems of production. This sector faces several problems such as degradation of productive lands and loss of soil fertility; increased pest problems; contaminated soil, water and air due to the increased and inappropriate use of agro-chemicals; loss of agro-biodiversity; loss of biodiversity and degradation of genetic resources; labour intensive and uneconomical production practices; and the decreasing attraction towards the agriculture sector. Covering all of these issues, the first theme presents six papers, which address the pathways to improve management practices for soil, crop pests, crop genetic resources, ruminants, with emphasis on market oriented production systems.

Chapter 2 outlines the key factors that are responsible for land degradation and soil fertility decline, and suggests best management practices to enhance sustainability of soil fertility in Nepal. From their thorough research, Subedi, Dhital and Tripathi outline the key factors that are responsible for soil fertility decline such as soil erosion, increased cropping intensity, use of high yielding varieties demanding more nutrients, and reduced organic input in soil. They also discuss the best management practices suitable for subsistence and semi-commercial agriculture production systems. The chapter also focuses on an integrated plant nutrients management approach that augments all available means of soil, nutrients, crop and agronomic management practices in order to obtain optimum yield and to sustainably manage soil fertility.

In Chapter 3, Bhattarai and Dhakal expand the scope of soil fertility improvement, discussing the alternative sources of plant nutrients, which are locally available, but are currently under-utilised. The authors highlight how the shift of agricultural practices from subsistence to semi-commercial production systems has taken place in recent years and how this increases the demand of plant nutrients. Highlighting the many negative impacts of current practices, the authors emphasise how better management of alternative sources of plant nutrients helps to harness sustainable production of crops, without jeopardising soil fertility. Alternative and under-utilised sources of plant nutrients including utilising bio-solids, bio-fertilisers, vermi-compost and chicken manure in commercial-scale farming operations are also introduced. This approach can be beneficial to maintain better livelihoods through increasing economic and environmental sustainability.

In Chapter 4, Lohar, Panthee, Joshi and Adhikari further expand on plant genetic resources and outline various approaches to crop improvement including the possible use of transgenic traits in crop improvement in Nepal. They argue that while the agriculture sector in some industrialised countries, particularly in the USA and Canada, have used genetically modified crops such as maize, soybean, canola and cotton for increasing their productivity, a debate has emerged as to whether or not Nepal should adopt such technology. Discussions on these issues can be beneficial in order to identify real opportunities and challenges. In this context, consideration should cautiously be taken keeping the subsistence nature of Nepal's agriculture and the need for its sustainability in mind. The authors summarise the overall status of plant breeding and propose a possible role for transgenic crops as a way to increase productivity of Nepal's major crops, but without ignoring the potential threats. The authors put forward the idea of second generation biotechnological tools that are expected to be relevant in Nepal, not only for sustainable food production, but also for health benefits. A possible scenario of using herbicide tolerant and insect resistant transgenic crops in Nepal has also been discussed relating to the experiences of India and China.

In Chapter 5, Subedi, Walsh, Khatiwada and Acharya expand their ideas from crop production to the prospect of developing a commercial fruit tree production system in Nepal. Urging the need for commercial production, they emphasise that the transformation of agriculture in Nepal is almost impossible unless farming operations grow beyond subsistence levels. To make the agricultural sector more attractive and profitable, guiding farming practices towards a market-oriented production system is imperative. Based on the synthesised evidence, they further elaborate that commercialisation or market-oriented production of tree fruits can greatly help Nepal's farmers to prosper. Among the different fruits grown in Nepal, citrus fruits are cultivated on a larger scale, and it has huge potential for further expansion in the scale of production. They also propose the commercialisation of the fruit farming, linking fruit production with domestic, regional, and international markets through the value chain system, including improved production and post-harvest practices. An approach of combining fruit production with village tourism is proposed as a potential enterprise for improving the rural economy.

Narrowing the focus, in Chapter 6, Subedi, GC, Pandey and Adhikari present a current scenario of the proper use and challenges of agro-chemicals in Nepal. Also, the authors identify the causes and consequences of pesticide use and misuse in Nepal by examining the pathways of human exposure to pesticides as well as its hazardous effects both on human health and the environment. Based on the synthesised evidence, the authors highlight that current practices of using agro-chemicals are highly hazardous for human health and the environment. The authors suggest practical measures to minimise the misuse of agro-chemicals. In order to minimise the hazardous impacts of agro-chemicals, the authors suggest public awareness on responsible use of agro-chemicals as well as a wider scale adoption of an integrated pest management approach, a strong regulatory system for registration, sale, and compliance for agro-chemicals including pesticides, fertilisers and plant growth regulators/hormones.

Besides sustainable crop production, sustainable livestock production is equally important for rural livelihoods. In Chapter 7, Rasali underlines the importance of improved ruminant production for sustainable livelihoods in Nepal. He argues that indigenous ruminant breeds continue to dominate Nepalese livestock production. Although ruminants play a dominant role for livelihoods in rural Nepal, their potential is not fully explored. The ruminant production across all ecological zones is hampered by the increasing deficit in biomass production to feed them. The author emphasises the need for genetic improvements to local breeds with the desired characteristics. This chapter concludes that livestock production should be developed as an enterprise through improved breeds combined with scientifically tested management practices (feeds and feeding and veterinary care).

## 4. Theme II: Natural Resource Management

Natural resource-based livelihood strategies are the pervasive feature of the rural economy in Nepal, where the majority of people depend on subsistence farming. Forests make a significant contribution to hill farming systems by providing indirect inputs such as grazing land, grass and fodder trees, and bedding materials for animals. In addition, non-timber forest products such as herbal plants, fruits, and root foods are an important base for sustaining livelihoods as well as a way to generate income and employment for the rural population. Research articles under this theme explore the number of issues such as the role of social capital and equity, and aspects of sustainable natural resource management. Building social capital between economically heterogeneous population groups as well as areas with diversified caste is one of the critical aspects of natural resource management. This social asset helps to collectively preserve the natural resources and equitably distribute the benefits among community members without compromising the sustainability of resources. Recent recognition of community forestry (CF) as a carbon sink by the United Nation has opened a door for local people to receive monetary benefit through the UN's Reducing Emissions from Deforestation and Forest degradation (REDD+) program. It provides another possible contribution to improving livelihoods in rural areas, but there are several challenges to overcome.

In this perspective, Sharma, Regmi and Bastakoti in Chapter 8 discuss community forestry (CF) in Nepal in the context of a changing rural landscape. The authors argue that CF has been a focus for several decades in Nepal and is globally recognised for its ability to conserve forests, and continue to support local livelihoods. However, a debate on the scope and prospects of CF in response to changing rural landscapes in Nepal still remains unanswered. To fill this gap, the authors conducted a study to answer the following three questions: How is CF evolving in relation to changing forest-people interfaces?; How is the rural landscape changing over time?; and, How can CF be more relevant to changing rural dynamics? The authors emphasise that there is a need for reorientation of the conceptualised uses of forests and forestlands, and greater policy sensitivity towards poverty and hunger among rural Nepali people. The authors suggest further participatory action-oriented research that explores CF land production processes, institutional mechanisms and market arrangements that may help increase the relevance of CF for leveraging livelihood options in Nepal.

In Chapter 9, Bhim Adhikari and Di Falco further add the value of social capital in relation to forest management. They draw upon empirical evidence for the links between caste (traditional, albeit rapidly changing, social status) and participation of households in terms of social capital and the relationships between heterogeneity and participation in community-based forest management using Nepal as a case study. Based on their analysis, they argue that the relationship between caste heterogeneity and social capital formation is non-linear, which follows an inverted U shape. However, this pattern is very general and applies only when the caste groups are considered individually. They also emphasised the importance of linkages between institutional and social structure and performance of community based groups for the optimal policy design towards sustainable livelihoods.

Reducing emissions from deforestation and forest degradation and other benefits (REDD+) is one of the large-scale mechanisms proposed to combat climate change, biodiversity loss and rural poverty by the United Nations Framework Convention on Climate Change (UNFCCC). In this context, Nepal is in its experimental stage and has completed some pilot projects in selected districts. In Chapter 10, Dhital, Shrestha, Gautam, Rijal and Shrestha have analysed REDD+ as a development tool to improve rural livelihoods in Nepal. The authors have analysed the procedural development of REDD+ programs and presented critical issues of REDD+ and carbon trading that are important for local livelihoods. They conclude that the technical aspect of carbon accounting, verification and monitoring is an important aspect for careful planning and to negotiate fair REDD+ benefits to local livelihood.

## 5. Theme III: Rural development: Gender, Energy, Tourism and Policies

Rural development in the framework comprises many cross cutting aspects such as gender, energy, tourism and policies, which are the fundamental factors to be considered for sustainable livelihoods. Rural people face numerous livelihood challenges. To overcome these challenges, multi-pronged development strategies are needed. However, these strategies cannot produce results until individual resource levels remain constant, and they constantly lack the technical knowledge to implement the diversified livelihood strategies for their own benefit. The research papers under this theme examine different perspectives which include: How do institutions and rural development policies link to promote sustainable livelihoods?; How do gender, energy and poverty determine rural livelihood?; What components are needed to promote the tourism sector in Nepal and what aspects can be helpful to maximise the professionalism (performance excellence) in Nepal, thereby helping to improve livelihoods?

Krishna Adhikari, in Chapter 11, expands the discussion given previously in Chapter 9 on the role of community based organisations (CBOs) through institution building at the grassroots level and searches for answers to the following questions: How have CBOs evolved over time?; How do they grow?; and What are the patterns of their sustainability? In this context, Adhikari argues that before the 1980s, rural development initiatives in Nepal failed initially to make an impact as they often disappeared without creating any viable local institutions as soon as donor funding was stopped. However, after the 1980s, CBOs were induced as the vehicle for community development. Still, CBOs tend to shrink in terms of membership, activities, participation and resources as they grow older. He suggests that the government and development agencies need to promote CBOs for their sustainability in order to support rural livelihoods.

In Chapter 12, Mahat explores the roles of gender, energy and poverty on human development, which is directly associated with rural livelihoods. She uses Amartya Sen's freedom as a development model to understand the limitations put on the Nepali rural women's freedoms due to excessive workload, energy poverty and social systems. This chapter uses the rural household as the unit of study. Based on the exploration, the author emphasises that energy poverty has multidimensional implications on human development, particularly on the wellbeing of rural women in Nepal. Collection of biomass materials, and using them for cooking has a significant adverse impact on women's workload and their health, which has hindered their capabilities and opportunities for participating in economic and other social activities. This has also restricted rural women's freedom for achieving their own wellbeing and the family as a whole, and as a result that of their community. The author suggests alternative options that could help to address both energy poverty as well as financial poverty, increasing the capacity of women as well as their freedom, overall enhancing their sustainable livelihoods.

In Chapter 13, McDonald, Dahal, Tyshenko, Sloan and Sharma explore another facet of rural livelihoods associated with tourism and development derived through performance excellence and mental readiness of Sherpa mountain guiding in Nepal. Based on an internationally-tested, standardised operational-readiness assessment tool, the authors conducted preliminary research in Nepal focussing on Nepali mountain guides, climbers and mountaineering stakeholders to identify the practical implications and the capacity for an "Operational Readiness Assessment". Of the three major readiness factors rated by mountaineering experts—physical, technical and mental—mental readiness was the one that showed the greatest perceived contribution to successful performance. The authors also explored the preferred vocabularies to adapt the operational-readiness Interview Guide and potential 'watch items'. They also demonstrate that the findings of this research align very well with the sustainability plans in Nepal to advance tourism-development through building human-resource capacity, quality and performance.

## 6. Theme IV: Health

The World Health Organization (WHO) underscores that health is, "a state of complete physical, mental and social wellbeing and not merely an absence of disease or infirmity" (WHO, 1946); it is both a resource for, as well as an outcome of, sustainable development. As good health is a major resource for social, economic and personal development, it is an important dimension to measure the quality of life. Health as an ingredient of human capital is a vital element in achieving sustainable livelihoods and interacts with sustainable agricultural production, natural resource management, and the dynamics of rural development. The research papers under this theme contribute to the social determinants of health and health equity, mobile health and health risk communication strategies to improve non-communicable disease risk factor awareness, and reforming health insurance policies in Nepal.

Dahal and Subedi, in Chapter 14, add another dimension of wellbeing: social determinants of health (SDH) and health equity, which directly contribute to sustainable livelihood systems in Nepal. The authors answer the following questions: What were the Government's commitments to take action on SDH?; What is Nepal's position with regards to health outcomes across the globe and in South Asia?; What are the causes and risk factors for premature deaths and disabilities of people in Nepal?; How are the shifts in disease burdens in Nepal changing?; Why are social determinants of health important when addressing the existing burden of disease?; and, What are the key social determinants of health that are applicable to Nepal? The analysis shows that the origin of the burden of diseases, disabilities and premature deaths are primarily due to living conditions. However, the majority of people in Nepal are not aware of this burden and possible solutions. The authors propose some important recommendations to help overcome the identified burden of diseases.

In Chapter 15, Tyshenko focuses on the increasing burden of disease and deaths from non-communicable diseases (NCDs): cardiovascular diseases (CVD), cancers, chronic obstructive pulmonary disorder (COPD) and chronic respiratory diseases, and diabetes. The author reviews NCD risk factors and highlights the barriers to health communication goals, which include redirecting already scarce health resources towards the problem of NCD risk factor awareness. He introduces a cost-effective strategy complementary to the World Health Organization's 'best buy' options on how to overcome these issues. The author suggests that achieving necessary health communication is a daunting task as Nepal has a large proportion of its population living in rural and remote areas with limited access to health care services. As a way forward to address NCD risk factors, a scalable communication strategy combined with mobile Health (mHealth) technologies is suggested to deliver innovative low-cost solutions.

In Chapter 16, Shrestha highlights the importance of reforming health insurance policies for effective health care services to community groups in Nepal. The author reviews the existing health insurance policies, especially community based health insurance schemes and assesses their effectiveness. Identifying the limitations of existing health insurance policies, the author argues that the existing community health insurance schemes are not effective. A new health insurance model is proposed to reform health insurance policy that better spreads risks and helps people in times of need. The proposed model can reform the health care services addressing the flaws in the existing community health insurance schemes in Nepal.

## References

Bryceson, D. (2000). Rural Africa at the cross roads: Livelihood practices and policies. *ODI Natural Resource Perspectives, Number 52.* London: Overseas Development Institute.

Campbell, B. (1996). *The Miombo in transition: Woodlands and welfare in Africa. Bogor:* Center for International Forestry Research.

Carney, D. (1998). Implementing the sustainable rural livelihoods approach. IN D. Carney (Ed.) *Sustainable rural livelihoods: What contribution can we make?* London: Department for International Development, pp. 3-23.

Carswell, G. (1997). *Agriculture intensification and rural sustainable livelihoods: A 'think piece'.* IDS Working Paper 64, Brighton: Institute of Development Studies.

DFID (1999). *Sustainable livelihoods guidance sheets.* London, Department for International Development.

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries.* Oxford: Oxford University Press.

GoN/NPC (2014). *Thirteenth plan (Fiscal year 2014/2015/2016)(in Nepali).* Kathmandu: Government of Nepal, National Planning Commission.

Hussein, K. and Nelson, J. (1998). *Sustainable livelihoods and livelihood diversification.* IDS Working Paper Number 69, Brighton: Institute of Development Studies.

Johnson, C. A. (1997). *Rules, norms and pursuit of sustainable livelihoods.* IDS Working Paper Number 52, Brighton: Institute of Development Studies.

Ness G. D. & Golay, M. V. (1997). *Population and strategies for national sustainable development.* A guide to assist national policy makers in linking population and environment in strategies for sustainable development. IUCN/EARTHSCAN/UNFPA, London: Earthscan Publication Limited.

Paluzzi, J. E. & Farmer, P. E. (2005). The wrong question. Development, 48(1), pp. 12-18.

Scoones, I. (1998). *Sustainable rural livelihoods: A framework for analysis.* Brighton: Institute of Development Studies.

WCED (1987). *Our common future. The world commission on environment and development. Oxford:* Oxford University Press.

# Theme I:
## Agriculture and Sustainable Livelihoods

2

# Sustainable Soil Fertility Management Practices for Nepal

Kalidas Subedi, Bishnu K. Dhital, and Bhaba P. Tripathi

## Abstract

Soil is the basis of crop production, and maintaining desired soil conditions and productivity should be the primary aim of sustainable agriculture. Declining soil fertility, leading to degraded agricultural soils, is regarded as one of the major challenges for agricultural production in Nepal. This article reviews the factors contributing to soil fertility decline and outlines the best management practices suitable for sustainable soil fertility management in Nepal. Several factors, namely nutrient mining and intensive cropping systems, soil erosion, depleting soil organic matter (SOM), imbalanced or indiscriminate use of chemical fertilisers and pesticides, degradation of natural resources and limiting organic inputs have been recognised as the key factors for diminishing soil fertility. Integrated plant nutrient management (IPNM), an approach of integrating all available means of soil, nutrients, crop and agronomic management so as to achieve locally optimum yield while maintaining desired soil fertility, seems to be the best approach for Nepalese farmers. The best management practices (BMPs) for the sustainable use of different components of IPNM, namely organic manures, biological nitrogen fixation, green manures and the recycling of crop residues, cover crops, strip cropping, mulching and judicious use of chemical fertilisers have been discussed. Farming practices combined with sustainable soil management approaches such as stall-feeding of livestock, growing more fodder and grasses in marginal lands, providing better soil coverage, improving the quality of farmyard manure (FYM), collection and utilisation of animal urine, increasing the production and improving the quality of compost, recycling of more organic matter into soil and need-based application of chemical fertilisers are suggested as the BMPs. It has been emphasised that in order to better adopt these soil and nutrient management practices by farmers, soil management interventions should be linked with income generating activities.

## 1. Introduction

Soil is one of the most important natural resources for agricultural production. Different workers and organisations have defined soil fertility in different ways. For example, Soil Science Society of America (SSSA) defines soil fertility as "the quality of a soil that enables it to provide nutrients in adequate amounts and in proper balance for the growth of specified plants or crops." Van Reuler and

Prins (1993) defined soil fertility as “the capacity of the soil to provide plants with nutrients, water and oxygen.” Farmers in Nepal have different criteria, and classify soil fertility as ‘fertile’ and ‘infertile’ soils based on the indicators such as soil colour, crop yield, quantity of farmyard manure (FYM) applied over years, water holding capacity of soil, soil hardness, response to applied manure, crop growth and height and so on (Desbiez et al., 2004). Since the most important factors affecting soil fertility include the presence of right quantities and forms of essential plant nutrients and their availability, soil moisture and good aeration. Soil fertility is therefore, the favourable conditions of soil that provides best growing environment with adequate availability of nutrients, water and oxygen to plants. Any negative changes of soil conditions that lead to reduced plant nutrients availability and unfavourable growing environments for the crop growth is soil fertility decline or soil degradation. Soil fertility decline has been a widely recognised problem in Nepal and farmers have realised this as a major constraint for increased agricultural production other than irrigation or water availability.

The objective of this chapter is to determine the factors contributing to the problem of soil fertility decline and land degradation in Nepal, and outlines the best management practices suitable for sustainable soil fertility management. This chapter is based on the review of published literature, web-based references and experiences of the authors. Several factors responsible for soil fertility decline are outlined. Similarly, the best management practices suitable for the sustainable management of soil fertility in the subsistence farming systems of Nepal are discussed.

## 2. Properties of soil

Soil fertility is dynamic in nature and agronomic and soil management practices determine the fertility improvement or decline. Sustainable soil fertility management is the practices of maintaining soil conditions in a way to increase crop productivity while improving or maintaining soil’s physical, chemical and biological properties. The properties of soil, essential plant nutrients, and best management practices for the sustainable management of soil are discussed.

Characteristics of soils vary typically depending on the nature of the parent materials, climate, vegetation and topography where a particular soil was formed. Soil formation is a dynamic process that occurs constantly under the influence of the environment where living organisms are continuously affected by changing conditions, including seasonal climatic factors (temperatures and precipitation) and human activities. As overall soil fertility is the sum of physical, chemical and biological properties of a soil, the inter-relationships among them determine the fertility of any soil. Sustainable soil management therefore, requires an understanding of the physical, chemical and biological properties and their relationships. These three properties of soil depend on various factors, namely parent materials, climate, topography, natural vegetation, soil management practices including tillage, manure and fertiliser amendments and types of crops grown. A brief introduction of the three soil properties is provided as follows.

### 2.1 Physical properties of soil

The physical properties of soil are the parameters that can be measured or assessed physically. These include soil texture (i.e. the relative proportions of the sand, silt and clay particles), soil structure (i.e. arrangement of individual soil particles), bulk density (i.e. proportion of the weight of a soil relative to its volume), compactness, porosity, soil colour and soil depth (horizons). These all influence the movement, retention and availability of water, air (oxygen) and nutrients in the soil. Soil physical properties also influence the root penetration and expansion and activities of soil micro-organisms. Desired soil physical properties are an essential component of sustainable soil management practice and these properties change over time mainly with the influence of climatic factors such as precipitation, temperature and wind, and human activities such as soil cultivation practices, organic matter amendments, fertilisation and irrigation practices.

### 2.2 Chemical properties of soil

This refers to the chemical characteristics of soils, such as soil reaction (soil pH), salinity, cation exchange capacity (CEC) and nutrient's concentration and their availability in soil. The soil reaction, which is expressed as soil pH, measures the acidity or alkalinity of soil. Soil pH affects the availability and toxicity of plant nutrients in soil. For example, availability of soil phosphorus (P) is highly pH dependent and the availability of most micronutrients is influenced by soil pH. In general, the higher the soil pH, the lower the availability of the majority of the micronutrients. Alkaline soils depress the availability of iron (Fe), manganese (Mn), zinc (Zn) and increases the ratios of Na/Zn and P/Zn in plant tissues (Mehrotra et al., 1986). On the other hand, aluminium (Al), Fe and Mn toxicity increases at lower pH (< pH 5). Soil pH also affects the quantity, activity and types of microorganisms in soils, which in turn influence the decomposition of organic residues in soil.

Soil salinity refers to the accumulation of excessive quantities of readily soluble salts, such as sodium chloride (NaCl), sodium sulfate ($Na_2SO_4$), magnesium sulfate ($MgSO_4$) and other similar salts in soil surface or root zone. Salinity occurs due to continuous discharge of saline ground water and high evaporation from soil and if the inherent soil or the source of irrigated water contains high salt concentration. Salinity also occurs due to increase in ground water table because of reduced evapotranspiration at the surface.

The CEC is a measure of the quantity of positively charged cations such as $Ca^{2+}$, $Mg^{2+}$, $K^+$, $NH^{4+}$ that can be absorbed by negatively charged particles and held by a soil. These cations in soil solution are attracted to the negatively-charged particles and are in dynamic equilibrium with the cations adsorbed on the surface of clay and soil organic matter (SOM). Nutrients composition and their availability in soil are determined mainly by the chemical properties of soil.

### 2.3 Biological properties of soil

Soil contains various types of living organisms such as bacteria, fungi, algae, actinomycetes, earthworms, nematodes, arthropods and other living creatures. The presence of such living organisms and their activities in soil are the biological properties of soil. The activities of such organisms, whether to make their food, movement in soil or creating a liveable habitat, all result in the breakdown of plant or animal residues, thereby adding SOM, increasing soil aeration and altering soil structure. Earthworms, insects, arthropods and rodents are considered as important soil fauna burrowing for water and air movement and for increasing organic residue in soil. Similarly, different types of fungi in soil help in the decomposition of cellulose and lignin of organic residues, thereby forming humus and soil aggregation.

Decomposition and mineralisation are the means by which plant nutriments held in SOM are released into the soil as inorganic forms (Jarvis, et al., 1996). Mineralisation is the process of transformation of organic matter (OM) into $NH_4+$ and $NO_3-$ forms of inorganic nitrogen (N) and several other elements by soil microorganisms. As a general rule, the more the activities of organisms in the soil, the more soil becomes healthier and fertile. Soil biological properties are also largely influenced by the human activities in soil, such as the addition of organic residues, tillage practices, use of agro-chemicals, burning of residues and flooding that result in degradation of their microenvironments and thereby influencing the population and activities of soil organisms.

## 3. Essential plant nutrients

Management of soil fertility and sustainable crop production requires an understanding of essential plant nutrients, their roles in plants and their dynamics in soil system. Higher plants require at least 16 nutrient elements for their growth and completion of their life cycle. These elements are also called 'essential nutrients'. Arnon and Stout (1939) first proposed the term 'essential nutrients', and for an element to be considered as an essential, it must meet the following three criteria:

i. The plant cannot complete its life cycle in the absence of this element,

ii. The function of an essential element cannot be replaced or compensated by another element, and

iii. The element is directly involved in the plant's growth and reproduction.

Among the essential plant nutrients, carbon (C), hydrogen (H) and oxygen (O) are considered as non-mineral elements and are derived from air and water (Jones & Jacobson, 2005a). The remaining 13 nutrients are classified either as macronutrients and micronutrients based on their relative amounts of requirements by the plants. Within the macronutrients, nitrogen (N), phosphorus (P) and potassium (K) are considered as 'primary nutrients' while calcium (Ca), magnesium (Mg) and sulphur (S) are called as 'secondary nutrients'. The micronutrients include boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn). Nickel (Ni) is a recently included micronutrient.

All essential nutrients have their specific and unique roles in plant growth. Although the deficiency symptoms of some of the nutrients are identical in certain ways, they can be distinguished. The typical deficiency symptoms on plant and conditions that favour the deficiency of a particular essential nutrient are summarised in Table 1.

Table 1: Essential plant nutrients, typical deficiency symptoms of various plant nutrients and favorable conditions that enhance their deficiency in plants.

| Nutrient | Forms absorbed by plants | Key roles in plant | Deficiency symptoms | Favorable conditions for causing deficiency |
|---|---|---|---|---|
| Nitrogen (N) | $NO_3^-$<br>$NH_4^+$ | Backbone component of all organic matter, constituent of chloroplasts and necessary for photosynthesis and amino acid/protein synthesis. | Pale green to yellowing progresses from the lower to the upper leaves and plants appear stunted, chlorosis and dropping of lower leaves | • Low supply of soil organic N or fertilisers<br>• Low mineralisation in soil<br>• Water logging and leaching of $NO_3^-$-N<br>• Loss through gaseous forms ($NH_3$ or $N_2O$) |
| Phosphorus (P) | $H_2PO_4^-$<br>$HPO_4^{-2}$ | Important for energy storage and transfer, part of RNA and DNA, required for root, fruit and seed development. | Purple margins or entire leaves especially during the early seedling stage. Slow growth, dark, blue-green to purpling of leaves and stem, delaying maturity and seed set. | • Low soil pH, and low test-P containing soils<br>• Low manure and fertiliser-P applied<br>• Cooler and wetter weather during planting reduces the mobility of P |
| Potassium (K) | $K^+$ | Needed for enzymes involved in photosynthesis and protein synthesis, translocation of photosynthates, improves disease resistance. | Yellowing to brown (necrosis) along the edge of leaf. These symptoms begin at the leaf tip and progress down the margin toward the leaf base. Plants (stems) become weak and may lodge, and size of fruits is reduced. | • Low test- K containing soils<br>• Under applied fertiliser K<br>• Cooler and wetter environments<br>• Soil compaction<br>• Excess N supply can lower K availability |

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|---|---|---|---|---|
| Calcium (Ca) | $Ca^{+2}$ | Constituent of cell wall, involved in protein synthesis and carbohydrate transfer. | Deficiency symptoms first appear on younger leaves. The leaf tips fail to separate from the whorl. This is often called 'laddering'. | • Low Ca-containing soils<br>• Calcium is often limited in acidic soils that receive abundant rainfall to leach Ca |
| Magnesium (Mg) | $Mg^{+2}$ | Constituent of chlorophyll and coenzymes, deoxyribonucleic acid (DNA) and transportation of nutrients and sugar within the plant. | Interveinal chlorosis first appears in older leaves. Chlorotic leaves generally turn reddish and develop spotted necrotic areas. | • More common in acidic and sandy soils that are prone to leaching and soils with high in K or Ca<br>• Mock or organic soils<br>• Cool, wet soils |
| Sulphur (S) | $SO_4^{-2}$ | Involves in photosynthesis, carbohydrate translocation, protein synthesis, disease resistance and drought tolerance. | Interveinal chlorosis of the young leaves emerging from the whorl. As the plant ages and the deficiency become more pronounced,entire leaves turn yellowish with greener veins, growth retards and maturity is delayed. | • Sulphur being a mobile and water soluble nutrient, leaching of S occurs with high rainfall<br>• Soils with low SOM or reduced mineralisation of organic-S<br>• Crop has poor root development |
| Boron (B) | $H_3BO_3$<br>$H_2BO_3$- | A component of the cell wall; plays important role in the pollen development and growth of pollen tube. | Severe B deficiency results in small, barren cobs in maize and grain set failure in other cereals like wheat, hollow pith in Cole crops and hollow heart in peanuts. | • Sandy soil, leached soils and calcareous soils are deficient in B<br>• Soils low in OM are deficient in B |

| | | | | |
|---|---|---|---|---|
| Chlorine (Cl) | $Cl^{-}$ | Component of chlorophyll molecules and involved in photosynthesis. | Chlorosis of younger leaves, wilting of plants and restricted growth, highly branched root systems. | • Chlorine deficiencies can occur on sandy soils in high rainfall areas or<br>• Soils derived from low-chloride parent materials |
| Copper (Cu) | $Cu^{+2}$ | Important component of several plant enzymes, chloroplasts, and involved in photosynthesis. | Yellowing, distortion and bleached younger leaves, multiple sprouts at growing points in trees, defoliation and dieback of twigs. | • Copper deficiencies are mainly reported on peat (muck) soils, and sandy soils with low in SOM<br>• Copper uptake decreases as soil pH increases<br>• Increased P and Fe availability in soils |
| Iron (Fe) | $Fe^{+2}$, $Fe^{+3}$ | Important in sugar translocation, carbohydrate and protein metabolism, nitrate and sulfate reductions and for pollination. | Severe Fe deficiencies cause low levels of chlorophyll, as a result leaves to turn completely yellow or almost white interveinal chlorosis and then brown as leaves. | • Soils that is high in pH (alkaline), low in OM and sandy in texture<br>• Cool, wet weather enhances Fe deficiencies<br>• High levels of available P, Mn and Zn |
| Manganese (Mn) | $Mn^{+2}$ | A part of plant enzymes and activates several metabolic functions, photosynthesis, water use, and disease control. | Inter-venial chlorosis with white/grey spots on the upper, new leaves, resulting in premature leaf drop. Necrotic areas develop on the cotyledons of dicot plants such as legumes | • Manganese deficiencies mainly occur on organic soils with high-pH or over-limed soils<br>• Leached sandy textured soils |

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|---|---|---|---|---|
| Molybdenum (Mo) | $MoO_4^{-2}$ | A component of various enzymes, protein synthesis and chlorophyll formation, N metabolism, and respiration. | Deficiency symptoms resemble with N deficiency as pale-green to yellow leaves and marginal chlorosis alongside and tip of blade and thick cupped leaves. | • Mo deficiency occurs under acidic conditions<br>• Sandy soils and soils low in SOM |
| Zinc (Zn) | $Zn^{+2}$ | Involved with synthesis of chlorophyll, RNA, protein and enzymes, also used for electron transfer. | Deficiency symptoms begin at the leaf base of the upper leaves and expand toward the leaf tip as interveinal chlorosis or a band of chlorotic tissue between the leaf edge and the midrib. | • Soils deficient in Zn<br>• Calcareous soils with pH >7.5 |

*(Sources: Information compiled from Sawye, J,E., 2000; Uchida, 2000; Jones & Jacobson, 2005a; Subedi & Ma, 2009; McCauley et al.,2009)*

## 4. Factors contributing to soil fertility decline in Nepal

Nutrient depletion in soils adversely affects soil quality and reduces crop yield and consequently poses a potential threat to world food security and sustainable agriculture (Tan et al., 2005). Similar to several other countries, soil fertility decline has been widely recognised as a limitation of crop production in Nepal (Subedi et al., 1989; Joshi et al., 1994; Pilbeam et al., 2005; Tripathi & Ellis-Jones, 2005; Acharya & Kafle, 2009). It has also become a major challenge for sustaining agricultural production. Hartemink (2006) outlined the conditions for declined soil fertility as nutrient depletion or nutrient mining (large removal of nutrients without little or no addition), acidification (decline in pH and/or an increase in exchangeable Al), loss of OM and increase in toxic elements (e.g. Al, Mn). Similar conditions are experienced in Nepal where several natural and man-made factors are responsible for declining soil fertility. The soil degradation in the mountain region is caused by the combined effects of severe soil erosion, landslides and nutrients depletion (Thapa & Paudel, 2002; Maskey et al., 2003). A Problem Tree (Figure 1) illustrates the causes of soil fertility decline in Nepal. Based on the problem tree, four major causes responsible for the overall decline of soil fertility in Nepal are: soil erosion, reduced organic matter or organic sources, nutrients mining and indiscriminate or imbalanced use of agro-chemicals. The contributing factors for each of these causes are discussed as follows:

## 5. Soil erosion

Soil erosion refers to the loss or removal of soil from one place to another by water, wind or any other means. Erosion of top soil is one of the major causes of soil fertility decline in Nepal (Maskey et al., 2003). The adverse effects of soil erosion are the loss of fertile top soil including SOM and plant nutrients at the source and flooding and sedimentation/siltation, damage of fertile land and physical infrastructures and water sources at the destination. Various estimates of soil erosion and nutrient loss have been reported. Gardner et al. (2000) estimated that soil loss through erosion from agricultural land in the Nepalese hills varied from 2 to 105 t/ha/yr. Gardner and Garrard (2003) reported a soil loss of 2.7 to 12.9 t/ha in a cultivated terrace due to runoff alone. In terms of nutrients loss, Carson (1992) estimated that a 5 t/ha soil loss is equivalent to a loss of 75 kg/ha of OM, 3.8 kg/ha of N, 10 kg /ha of K and 5 kg/ha of P in the mid-hills of Nepal. Nutrients depletion and soil loss due to soil erosion are worrying especially in the mountains of Nepal. Atreya et al. (2008) estimated that up to 90% of annual nutrients losses occurred during the pre-monsoon period in the mountains of Nepal. Although soil losses were greater through surface runoff, Acharya et al. (2007) demonstrated that the leaching from terraces was more serious in terms of nutrients losses. Based on these figures, the tentative amounts of nutrients loss from the soil each year can be estimated. Such a loss of surface soil and nutrients is continuous and the cumulative economic and environmental costs of soil erosion in Nepal are enormous.

The factors responsible for soil erosion are both natural and induced by human activities. The natural factors enhancing soil erosion include the fragile geographical formations with steep slopes and high rainfall. Seasonal pattern and torrential rain during the rainy season (monsoon) cause heavy loss of top soil in the exposed steep slopes leading to runoff, gulling and landslides in the hills while flooding and sedimentation in the plains.

Human activities induced soil erosion include encroachment of fragile lands for agriculture, road or other physical infrastructures, expansion of cultivation in marginal and steep lands, crop intensification with intensive tillage practices, deforestation, animal grazing in the sloppy lands, forest fire, inappropriate and unsuitable method and techniques used in infrastructures development such as road constructions. These activities have contributed to severe run-off leading to top soil loss and landslides.

## 6. Nutrients mining

Nutrient mining is the depletion or removal of plant nutrients from soil through harvested crop yields and/or crop residues. Soil fertility problems associated with human-induced nutrient depletion are widespread world-wide (Tan et al., 2005). Depletion of nutrients occurs when the nutrients removal exceeds the total nutrients available in the soil (i.e. liable nutrient pool of soil plus added nutrients). Agricultural lands in Nepal are highly intensified with double or triple crops in a year. In the foot-hills and Terai region for example, growing up to three crops in a year (e.g. rice-rice-wheat, rice-wheat-maize, or rice-vegetables- maize) is common. Similarly, where there is an assured irrigation and access to market, intensive cropping of high yielding crops and their varieties are practiced. In these intensive cropping patterns, removal of nutrients exceeds the available nutrients (those present in soil plus added) resulting in negative balance of nutrients. In addition to crop removal of nutrients, there is also a significant amount of nutrients lost through soil erosion and leaching. In mid-hill bariland terraces, Acharya et al. (2007) estimated that the losses of $NO_3$-N in leachate ranged from 17.3 to 99.7 kg/ha/year. From a long-term experiment at Bhairahwa, Regmi et al. (2002) reported a net depletion of K in a rice-rice-wheat system, even though recommended level of fertilisers were added in the system. Tirol-Padre et al. (2007) have also concluded that in the intensive cropping systems, the current practices of inorganic fertilisation alone was not sufficient to maintain the soil fertility.

## 7. Depletion of soil organic matter

Decreased SOM levels results in poor biological, chemical and physical properties of soil. Reduced SOM as a result of limited OM input into soil has been realised as one of the greatest challenges for sustainable soil management in Nepal. Loss of SOM occurs due to various reasons as outlined in Figure 1. Because crop residues are extensively used for animal feed, very little or no crop residues are returned to the soil. As a result, there is a negative balance in SOM after each crop cycle. There are also longer-term losses of SOM attributed to multiple cropping with intensive tillage practices. Many modern cropping systems combined with frequent tillage with small amounts of residue have resulted in reduced OM content of many soils (Bot & Benites, 2005). Burning of organic reissues and using dung as a fuel have also contributed to the negative effects on SOM.

The forest is an important source of nutrient flow for cultivated land (Pilbeam et al., 2000). Especially in the hills and mountains, farmers have limited access to fertilisers and are reliant on organic manure for soil fertility maintenance (Acharya et al., 2007). However, deforestation and shortage of family labour have resulted in limited fodder supply. As a result, livestock numbers per household has been declined (Subedi et al., 1989; Tripathi & Ellis-Jones, 2005; Acharya et al., 2007) and less FYM is added in the soil. Further losses of soil productivity can be expected if the current trend of declining livestock number continues. Similarly, in recent years, the agricultural labor per household has been reduced substantially because of schooling of children, outmigration and the younger generation being less attracted to a career in agriculture (Subedi et al., 1989; Tripathi & Ellis-Jones, 2005; Acharya et al., 2007). Such social changes have attributed to the reduction in the amount of manure produced and net OM added to the soil.

## 8. Imbalanced use of agro-chemicals

Increased cropping intensity and introduction of improved crops and their varieties demand more nutrients in the cropping system. For example, with the increased interest in vegetable and potatoes near urban centres and cultivation of high yielding crop varieties of cereals (rice, wheat and maize), chemical fertilisers and pesticides use has increased significantly in recent years. The incidences of soil pollution due to excessive and indiscriminate use of agro-chemicals have been reported in Nepal (Maskey et al., 2003; Giri et al., 2012). Chemical fertilisers are considered as less labour intensive for transportation and application. Where available, chemical fertilisers are used as an alternative source of plant nutrients, without taking into consideration of right types and/or appropriate application rates. The majority of farmers have low technical know-how and they apply excessive or imbalanced amounts of chemical fertilisers and pesticides without proper soil test recommendations or considering the actual nutrients requirements of the crop. In the absence of adequate organic manure, continuous and imbalanced use of agro-chemicals has resulted into soil degradations including reduced SOM, hardness (difficult to cultivate), acidification, micronutrients deficiencies, deterioration of soil and water qualities, and loss of agro-biodiversity.

Agricultural production in industrialised nations such as Europe, America and Australia are heavily dependent on inorganic fertilisers and pesticides use, crop residues are mostly left in the soil so that the SOM is maintained and nutrients mining is minimised. Crop residues also provide a cover for the top soil, minimising top soil erosion. The circumstances in Nepal are different where crop residues are almost entirely removed from the soil primarily for animal feed. The maintenance of SOM balance is therefore always a challenge.

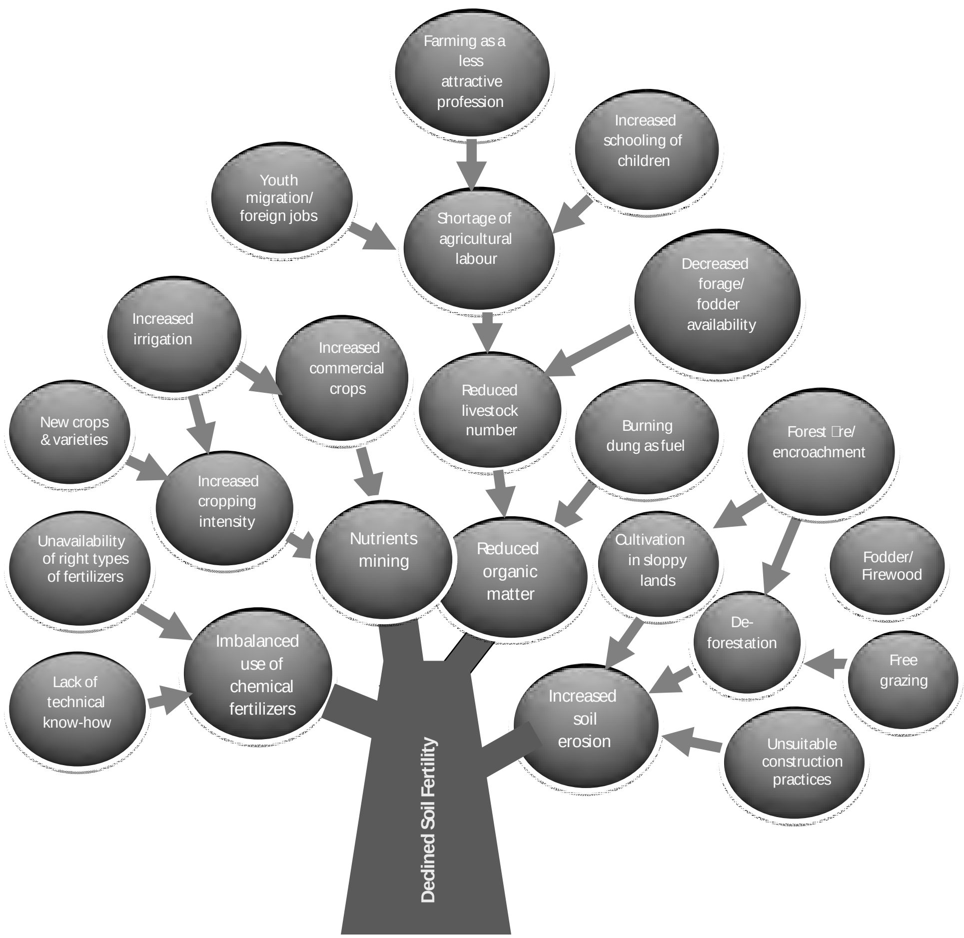


Figure 1: A problem tree showing causes of soil fertility decline in Nepal (Modified from Subedi et al., 2000).

## 9. Sustainable soil management

Sustainable soil management refers to the agronomic and soil management practices that optimise crop yield while maintaining soil health and environment in a longer run (Subedi & Ma, 2009). The sustainable approach of soil fertility management emphasises the best use of renewable resources, such as organic manures, nutrient cycling, increased nitrogen fixation, conservation tillage and irrigation practices so as to minimise soil and nutrients losses, and use of crop varieties and crop production practices that are based on local knowledge of farmers. The maintenance of SOM at a desired level should be the primary aim of sustainable soil management. Therefore, the sustainable soil management is to increase soil productivity without diminishing soil chemical, physical and biological properties, and without adverse effects on the environment.

Although sustainable agriculture is an often talked about subject in Nepal, the application of its principles into practice is inadequate. Our traditional practices of crop production were fully organic-based and sustainable. However, with the increased population pressure on limited agricultural land and with the changed social and economic contexts, the traditional practices are no longer able to sustain the food production required for an increased population size. A substantial shift has occurred in cultivation practices especially in last three decades with increased cropping intensity and introduction of improved crop varieties. The present agricultural practices, such as reduced organic input and indiscriminate use of agro-chemicals, are not sustainable. As a result, soils have been reported to be degraded with declined SOM, hardness, acidification, polluted with pesticides, and micronutrient deficiencies. In this section, best management practices (BMPs) for sustainable soil management are discussed.

## 10. Organic matter-foundation of sustainable soil management

A soil is a mixture of parent materials, organic residues, water and air. The organic component of soil is called as 'soil organic matter (SOM)', which is the natural carbon containing material, that is composed of living biomass of microorganisms, fresh and partially decomposed residues, and well-decomposed OM and highly stable organic material—which is also known as humus. Not all of the SOM is carbon; it contains approximately 58% C. Therefore, the term 'soil organic carbon' (SOC) refers to the total carbon in soil that is derived from the SOM. A conversion factor of 1.72 is used to convert SOC to SOM. Since SOM affects several soil functions and influences soil biological, physical and chemical properties, increasing SOM improves overall soil quality. Maintenance of desired levels of SOM is vital for the maintenance of proper soil fertility. Therefore, SOM is the foundation of sustainable soil management as it plays several positive roles in soil as follows:

i. **As a pool of plant nutrients:** Since SOM is derived from plant and animal residues, it contains all of the essential nutrients that plant tissues contain or require. Soil organic matter is a huge reserve of potentially mineralisable N, S, and several other nutrients. Therefore, accumulated OM in soil is a storehouse of plant nutrients. The stable organic fraction, which is also called 'humus' adsorbs and holds nutrients in a plant-available form. Upon decomposition (i.e. mineralisation), SOM releases nutrients in plant-available forms. Generally, SOC is highly correlated with organic N. Therefore, soils rich in SOC contain high total and available N.

ii. **Improves biological activities in soil:** Organic residues in soil are the main source food and nutrients for soil microorganisms. The higher the amount of SOM, the more is the biological activity in soil and the more soil becomes fertile and healthy.

iii. **Keeps soil stable:** Organic matter existing on the soil surface as raw plant residues helps protect the soil from the effects of rainfall, wind and sun. The humus contributes in bulk density and improves the aggregate stability of soil. Aggregation is important for good soil structure, aeration, water infiltration and thereby helps to minimise soil erosion.

iv. **Increases soil water holding capacity:** Organic matter increases the water infiltration and water and nutrients holding capacity.

v. **Buffers soil pH:** The SOM also buffers the pH and facilitates the availability of nutrients.

vi. **Sequester carbon in soil:** As SOM contains over 58% of C, it is the sequester (store) of C in the soil. The more SOM in soil, the more C is sequestered and vice versa.

From the sustainable soil management point of view, the rate of addition of OM from crop residues and manure must be at least equal to the loss of SOM through decomposition and erosion. If the rate of addition is less than the rate of decomposition, SOM will decline. Since the SOM is a dynamic component in soil, its amount in soil changes over time as various factors influence this dynamics. According to Matson et al. (1997), factors affecting the loss of SOM from agricultural soils include climate, soil type, tillage intensity and depth, crop rotation practices, amount of organic inputs, amount and quality of plant residue left on the soil surface, soil biological activities and extent of soil erosion. In terms of short-term SOM loss, the more a soil is tilled, the more SOM is broken down. Similarly, the warmer temperatures and moist environment hasten the rate of SOM breakdown.

## 11. Integrated plant nutrient management

Integrated plant nutrient management (IPNM) refers to the approach of integrating available sources of plant nutrients to meet the crop's nutrient requirements to achieve an optimum yield while maintaining desired soil fertility (FAO, 1998). This is an approach of sustainable soil management, which attempts to integrate all available means of soil and crop management to achieve locally optimum land productivity (Subedi & Sapkota, 2002). The IPNM relies on a number of factors, including appropriate nutrient application and conservation and the transfer of knowledge (Gruhn et al., 2000). All available and manageable sources of plant nutrients are considered to optimise crop yield while maintaining soil fertility and minimising the impact of these nutrient sources on environment. The aim of the IPNM should be always to keep the nutrients and SOM balance in positive while improving soil physical, biological and chemical properties.

Sustainability of cropping systems requires that nutrients removed from the soil are balanced by nutrient replacement so that soil fertility is maintained (Ma et al., 2006a). Although, organic manures have been the major sources of plant nutrients for crop production and sustaining soil fertility in the past, this alone cannot sustain the soil productivity and meet the demand of growing food production in Nepal. Similarly, chemical fertilisers alone cannot sustain long-term productivity on many soils, and organic materials/inputs are required to restore SOM levels and crop productivity (Syers, 1997). Enhancing sustainable food production will therefore, require integrated strategies for the use of various sources of plant nutrients in conjunction with improved soil, water and crop management practices (Keerthisinghe et al., 2003).

Farmers' nutrient management decisions influence the amount and form of nutrients used, the timing and method of fertiliser application, which in turn influences how much of a nutrient is used by the crop, how much is stored as a residual in the soil and how much becomes available as a potential water and air pollutant (Christensen, 2002). The IPNM should be viewed as balancing the output and input of plant nutrients in the farming system without diminishing soil qualities. Inputs include: the existing available pool of nutrients in soil, potential addition through mineralisation in soil, addition through manure and fertilisers, biological fixation and addition through water and sediments etc. The output are mainly crop removal and nutrients losses from soil through different pathways such as leaching, gaseous loss (volatilisation), denitrification, erosion and runoff. A nutrient balance quantifies the input of a particular nutrient to an area of land and subtracts from this output of the same nutrient from the same area of land (Stoorvogel et al., 1993).

In the IPNM system, soil, crop and plant nutrients are judiciously managed based on the existing decision environments such as cropping systems, soil properties, labour availability, market forces and social equity (Subedi & Sapkota, 2002). Therefore, before making any decision on the recommendation of manure and fertilisers application, farmers should consider soil properties (e.g. texture, SOM, residual nutrients), climatic factors (e.g. precipitation, temperatures), cropping systems (e.g. previous crops, tillage systems), crop variety grown (yield potential), and economic and market considerations (e.g. prices of produce and fertilisers). Several factors influence crop yield and nutrients requirement by any crop. The key principles of IPNM can be considered as: balancing SOM, increasing the efficacy of the applied manures and fertilisers and judicious use of chemical fertilisers as and when needed. This is a decision making process and needs some sort of exercise of nutrients budgeting. The IPNM should be implemented on a location-specific or on a cropping system basis, and in the context of Nepal, the Farmer' Field School (FFS) approach of extension has been demonstrated to be successful by the SSMP (Subedi & Sapkota, 2002). For a successful design and implementation of the IPNM, the following key steps have to be followed:

- **(i) Assessment of soil status:** Information on soil parameters such as SOM, pH, nutrients availability, texture, extent of nutrient losses through leaching and erosion are to be gathered through site visit, farmers experience and laboratory analysis, where possible. Simple field level test kits such as Nitrate Strips can be used for the tentative estimates of soil available N.

- **(ii) Setting of yield target:** Based on the availability of farm resources, expected yield levels for the crops under a particular production system are set.

- **(iii) Calculation of nutrient balance:** Based on the two estimates above, a nutrient balance (i.e. input-output) can be calculated which indicates how much and which nutrients are to be added. Consideration should be given for the balance of SOM.

**(iv) Listing available nutrient sources:** All available internal (farm level) and external (purchased) nutrients sources are to be considered.

**(v) Integrating all possible nutrient sources:** Based on the available sources of nutrients, the decision about which ones and when to apply is made.

**(vi) Determine the amount, timing and methods:** Of manure and fertilisers application for a given crop, cropping system and land type.

**(vii) Follow-up and monitoring:** Once manure and fertilisers are applied based on the above assessments, periodic monitoring of fields is important in order to address the in-season deficiencies if induced by temporal and spatial variability such as excess rainfall or drought and troubleshooting for such deficiencies.

In a field testing of IPNM practice in Nepal, Chapagain and Gurung (2010) reported that in a three year study, maize crop with IPNS practices increased grain yield by 64% compared to the local cultivar with farmers practice. The plots on IPNS also exhibited positive effects on the performance of millet, a subsequent crop in the cropping system.

A similar approach ‘integrated soil fertility management’ (ISFM) is also in practice elsewhere. Vanlauwe et al. (2010) defined ISFM as a set of soil fertility management practices that necessarily include the use of fertilisers, organic inputs, and improved germplasm combined with the knowledge of how to adapt these practices to local conditions, aiming at maximising agronomic use efficiency of the applied nutrients and improving crop productivity. This concept emphasises on management of inputs following sound agronomic principles. It focuses mainly on agronomic use efficiency, fertilisers combined with improved germplasms, proper combination of organic and inorganic inputs, and adaptation to the local conditions. The Site-Specific Nitrogen Management (SSNM) is also a similar concept in which N is managed based on the need of a specific field and crop growing conditions.

## 12. Components of IPNM

Integrated plant nutrients management, by name itself indicates to use various sources of plant nutrients to achieve target yield while maintaining soil fertility. Different sources of plant nutrients are available and generally more than one of these sources should be combined while making a nutrients management decision. The components of IPNM are considered for those sources that contribute for SOM, plant nutrients, soil conservation, balanced soil pH, and increased efficiency of applied nutrients. These can be as follows: organic manures, legumes in cropping systems, green manures, cover crops, mulching, strip cropping, hedge-rows/alley cropping, bio-fertilisers, chemical fertilisers, use of appropriate crops and varieties and balancing soil reaction.

### 12.1 Organic manures

Organic manures are the natural sources of SOM, containing all of the essential plant nutrient elements. Literarily, when any living things (plant or animal) die and decay, the resultant product is organic manure. Until the artificially synthesised chemical fertilisers were developed, manures and organic supplements were the major sources of plant nutrients and SOM (Subedi & Ma, 2009). Organic manures constitute significant sources of plant nutrients even in the industrialised countries. In the developing countries such as Nepal, the small-holder farms are heavily dependent upon organic sources of plant nutrients. The use of tree fodder and forage from forest area and grasses from terrace risers as animal feed ensures a net movement of N from non-agricultural land to agricultural land (Pilbeam et al., 2000).

Organic manures have several advantages such as: they serve as the carrier of plant nutrient and provide several of the essential nutrients, increase soil OM, enable soil to hold more water and also help improve the drainage in clay soils, they provide organic acids that help dissolve soil nutrients and make them available for the plants, nutrients from the organic manures release slowly in soil and supply nutrients over seasons; and they enhance the physical, chemical and biological properties of soils. A review of 14 field trials comparing the long-term (20 to 120 years) effects of fertilisers and manures on crop production and soil properties revealed that manured soils had higher content of SOM and numbers of microfauna than fertilised soils and were more enriched in P, K, Ca and Mg in top soils and $NO_3$-N, Ca and Mg in subsoil, and bulk density and higher porosity and aggregate stability than the fertilised soils (Edmeades, 2003).

Nutrients concentrations in the organic manure vary greatly depending on animal species, the size and age of the animal, type of ration fed to the animals, bedding materials, storage, processing, materials used for composting, and the season of the year. For example, manures from dairy cattle contain higher N than from beef cattle, broiler chicken litter contains higher N than layer hens and so on. Preparation practices such as covering manure with black plastic sheets resulted in faster decomposition and increased total N and exchangeable K (Tripathi & Ellis-Jones, 2005). The rate of manure or compost applied to fields depends on the crop being grown, soil test levels and nutrient composition of the manure or compost (Subedi & Ma, 2009).

FYM, generally a composted mix of animal dung, urine, animal bedding and household wastes, is an important source of nutrients for crop production in Nepal. Other sources of organic manure, although not significant, include poultry manure, hog manure and other animal feces, compost prepared from crop residues and other farm wastes, vermi-compost, oil cakes and biological wastes such as animal bones and slaughter house refuse. Poultry manure is increasingly being used in recent years with the increased poultry farming in Nepal.

The benefits of FYM are well established. Some imperial evidence also suggests there are benefits when it is used. In a long-term study in India and Nepal, Tirol-Padre et al. (2007) observed that after 15 years of organic amendment (i.e. FYM) soil carbon and N were increased significantly when compared to a control plot. However, the current practices of preparation, storage and application of FYM/compost are inappropriate in Nepal. As a result, their nutrients are not properly conserved, utilised and they pose certain environmental problems as well. There is a huge scope of increasing their quality and utilisation efficiency through proper management practices. For example, the value of cattle urine is poorly understood and in most cases, urine is lost unattended. More importantly, due to lack of stall-feeding system, significant amount of dung and urine are wasted.

Compost is the organic material derived from aerobic decomposition of recycled plant waste, manures, crop residues, bio-solids and animal shed waste such as left-over feeds. Composting manure is a useful method of producing stabilised product that can be stored or spread with little odour or fly-breeding potential (Fronning et al., 2008). Successful composting depends upon the sufficient availability of organic materials, water, manure and cheap labour (Bot & Benites, 2005). Where these inputs are guaranteed, composting can be an important method of sustainable and productive agriculture. It has ameliorative effects on soil fertility and physical, chemical and biological soil properties. Well prepared compost contains all the nutrients needed by plants and helps to maintain and improve soil fertility as well as to regenerate degraded soil. Nutrients in the compost are released by soil microorganisms through a decomposition process called mineralisation. This biological process is affected by variations in moisture, temperature, and the microbial species and their population present in the soil and the C:N ratio of the composting material. Preparation of compost solely from the organic residues is not well adopted in Nepal despite some efforts from agricultural extension programs. The reasons for not adopting compost making are mainly due to high labour requirements and crop residues or fodder residues being used as feed and/or bedding materials for animals. In real sense, FYM and compost are being used as substitutes in Nepal.

Most of the readily available N in FYM/compost is in the form of ammonia ($NH_3$) while that in poultry manure is in uric acid form (Misselbrook, 2004). The amount of N that will be available to a crop after manuring depends on the time and method of application. If not properly incorporated after application, the majority of available N will be lost through $NH_3$ volatilisation soon after application and by $NO_3$- leaching throughout the season. The practical measure to reduce the $NH_3$ losses after spreading is to incorporate the manure into the soil (Misselbrook, 2004; Jokela, 2004). The farmers in Nepal rarely follow such practice. Therefore, it is likely that a significant loss of NH occurs after manure application in the field.

The advantages of FYM/compost have been well established. Despite a major source of plant nutrients and SOM, there are however, some limitations for an increased use of FYM/compost in Nepal such as,

(i) High labour requirements for compost preparation and manures transportation,

(ii) Lack of adequate forage /fodder for cattle, or composting materials,

(iii) Free-grazing system of livestock leading to wastage of dung and urine,

(iv) Lack of proper manure preparation and utilisation practices such as not conserving urine, exposing manure pits and using un-decomposed manures,

(v) Improper application practices leading to nutrients losses such as not incorporating the manure soon after transport that results in volatilisation of nutrients.

In addition, there can be some environmental concerns such as odour, runoff and leaching of nutrients such as $NO_3$-N. Although, the environmental effects of using manure and composts have never been considered critically in developing countries such as Nepal, the potential environmental concerns as raised in the industrialised countries can be as follows:

**(i)** **Nitrous Oxide ($N_2O$) emission:** Nitrous oxide ($N_2O$) is one of the major greenhouse gases (GHG) generated from agricultural sources. It has a global warming potential of 298 times greater than that of carbon dioxide ($CO_2$) and 25 times than that of methane ($CH_4$) over a 100-year time horizon (IPCC, 2007). It accounts for approximately 5% of atmospheric GHG effect globally (Hutchinson et al., 2007).

**(ii)** **Nitrate ($NO_3$-N) leaching and water quality:** Excessive rates and inappropriate methods of application or inefficient use of manures can have adverse effects on groundwater through leaching of soil $NO_3$-N. High $NO_3$- levels in groundwater can cause algal blooms through eutrophication and are harmful to aquatic organisms.

**(iii)** **Phosphate in surface water:** The transport of P in runoff is a major source of surface water contamination. Transport of P from the manure and its likelihood to move in the environment is influenced by rainfall, soil erosion, surface runoff, and wind, as well as the rate, timing, form, and method of application, along with the site location on the landscape affect (Lemunyon & Gilbert, 1993).

### 12.2 Legumes in cropping systems

Integration of various food, forage or vegetable legumes either in the crop rotations or as intercropping with the existing crop is a common traditional practice in Nepal. The advantages of legume incorporation in a cropping system is well understood even in the subsistence farming systems in terms of improved soil fertility (biologically fixed N), diversity in food values, nutrition, forage and farm income. Most of the legume species have a symbiotic relationship with certain bacteria and fix N from the atmosphere. Although Nepalese framers mostly incorporate legumes in the cropping systems, but they are not adequately integrated in all geographical locations and cropping systems.

The common cereal + legume intercropping system in the hills of Nepal are maize + soybean, maize+ beans, maize+cowpeas, wheat + fieldpeas, and barley + fieldpeas. Relay planting of lentil (*Lens culinaris*) before rice harvest is also gaining popularity in Terai and river basins. Cereal crops can benefit from the residual N from legumes as well as the in-season N fixed by the companion legumes when grown in the intercropping system. Farmers have realised the benefits of such systems and empirical evidence has also demonstrated that these systems are beneficial than the growing these crops individually (Subedi, 1997; Subedi, 1999).

The biological $N_2$ fixation potential of legumes is well established. In an on-farm survey of various legume crops grown in different agro-ecologies of Nepal during 1994-1999, Maskey et al. (2001) reported that N derived from $N_2$ fixation was estimated to be 62% in soybean to 87% in grasspeas. Estimates of total N fixed (including roots) were 59 kg/ha (mash bean; *Vigna mungo*) to as high as 153 kg/ha (groundnuts; *Arachis hypogaea*). It is estimated that the portion of the N available to the following crop is usually about 40 to 60% of the total amount contained in the legume (Sullivan, 2003). Total N fixed and their economic values are huge especially for the subsistence farming systems in Nepal where the use of inorganic fertilisers is constrained. Moreover, in the subsistence farming systems, inclusion of legumes will play an important role in diversifying crops and ensuring improved household food security.

There is a scope of further integration of different legume species in the farming system such as using forage legumes in terrace risers and marginal lands so as to produce nutrition forage/fodder as well as to conserve soil and increase land productivity. Excessive use of chemical fertilisers, lack of crop specific Rhizobium inoculums, limited seed supply of legume species, and farmer's preference for cereals are some of the reasons limiting wider adaptation of legumes in Nepal.

**12.3 Green manures**

Green manuring is a practice of incorporating plants whether grown in the same field or brought from elsewhere while they are green for the purpose of manuring. Literally, any plant species can be used as a green manure crop, however; species vary considerably in their adaptation, green manuring values and nutrients composition (Subedi & Ma, 2009). The desirable traits for green manure crops are: leguminous species, plants with succulent tissues, fast growing and plant parts not suitable for other uses (e.g. forage/fodder). Green manure crops can be used as in-situ green manure (i.e. grown in the same field and incorporated *in-situ*) or green leaf manure (i.e. lopping from plants or trees from the same field or from outside and then incorporating them into the soil). Several species of plants, preferably legumes such as Dhaincha (*Sesbania sp.*), sunhemp (*Crotalaria juncea*), rice bean (*Vigna umbellate L.*), velvet bean (*Mucana deeringina*), jackbean (*Canavalia ensiformis*), lablab bean (*Dolichos lablab*), red clover (*Trifolium pratense*), cowpea (*Vigna unguiculata*) and several other leguminous species are considered good for green manuring, although certain non-legume species such as Ashuro (*Adhatoda vasica*), Titepati (*Artemisia vulgaris*), and several other indigenous plant species have also superior green manuring properties (Subedi, 1997). Azola (*Azola pinnata*) as a green manure is being used in rice fields but not to the extent it could have been. All green manures have a positive effect on soil biological properties, plant nutrition and crop yield parameters (Tejada et al., 2008). In addition, green manures are reported to be useful in weed suppression, moisture conservation, and protection of soil from erosion (Fischler & Wortmann, 1999).

Although, green manures have the potential of substituting most of the N requirements of succeeding crop in the rotation, there are some limitations for a wider scale adoption of green manures such as: an *in-situ* green manure crop has to substitute a crop in the intensive cropping systems such as in the three-crops rotation, some of the leguminous species such as Sesbania have altitudinal limitation for adoption in the mid and high hills, different priority for use such as forage or fresh pod or grain production (in case of cowpeas, ricebean and other food legumes), sometimes the seeds of green manuring crops are expensive or not easily available and high labour requirement for the cut-and-carry system of green manuring. For an intensive cropping system without substituting a crop in the rotation, Subedi (1998) demonstrated that rice bean and Sesbania planted as a relayed planted under maize crop and incorporated before rice transplanting in a maize-rice-wheat system produced equivalent rice yield to chemical fertilizer applied plot without affecting companion maize yield. Green manures have a potential to substitute part of the total nutrients requirements in an IPNM system but one should not expect green manures as an entire source of plant nutrients.

### 12.4 Cover crops

Cover crops refer to the growing of any plant species for the purpose of covering soil surfaces to protect soil from erosion and to trap the nutrients that may be lost due to leaching, without affecting the main crop. Similar to green manures, cover crops can be annual, biennial, or perennial herbaceous plants grown in a pure or mixed stand during all or part of the year (Sullivan, 2003). Cover crops can be legumes such as hairy vetch (*Vicia villosa Roth.*), alfalfa, crimson clover (*Trifolium incaratum* L.); peas (*Pisum sativum* L.) and others, and non-legume plant species such as wheat, oat, rye (*Secale cereale*) and barley. Cover crop can be grown during the off-season (i.e. when there is no crop in the field) or underneath the crop. When cover crops are planted to reduce nutrient leaching following a main crop, they are often termed as ‘catch crops’ (Sullivan, 2003). Gardner and Garrard (2003) recommended that maintenance of some form of ground cover is advisable if soil erosions are to be minimised in the hills and mountains of Nepal.

The key benefits of cover crops include: reduction in erosion by anchoring soil and lessening the impact of raindrops and conserve soil, trapping of post-harvest $NO_3$-N in soil that is prone to leaching, weeds suppression, improve water infiltration into soil, thereby conserve soil moisture and increase water recharge in the soil, leguminous species contribute to atmospheric N fixation thereby reduces the amount of fertiliser N requirement, benefit to soil microbes and beneficial organisms and addition of valuable SOM and reduce soil compaction (Bittman et al., 2004; Snapp et al., 2005; Andraski & Bundy, 2005; Bot & Benites, 2015). Relay planting of different crops such as soybean, cowpeas (*Vigna unguiculata*), velvet beans and finger millet (*Eleusine coracana*) under maize crop are traditional practices in the hills of Nepal, which also help to conserve soil and trap N loss. All cover crops have the potential to provide great benefit to the soil; however, selection of right types of cover crops suitable for the system is important. Crops with intensive rooting system that grow fast and produce large amount of residues are considered to be more useful as cover crops.

## 12.5 Mulching

Mulches are materials placed on the soil surface to protect it against raindrop impact and erosion, and to enhance its fertility (FAO, 1998). Mulching is a practice of covering soil surface with some organic (e.g. organic residues or live mulch) or inorganic materials such as plastic sheets. This is a traditional practice in the subsistence farming systems of Nepal and farmers have been using mulch in certain cash crops such as ginger, colocasea, sweet potatoes and certain vegetables and fruits. There are three principal mulching systems as,

(i) *In-situ* mulching systems: plant residues left on the soil after harvest;

(ii) *Cut-and-carry mulching systems:* dried or green plant residues are brought from elsewhere and used as mulch; and

(iii) *Plastic mulch:* use of black plastic as a mulch is gaining popularity in commercial vegetables and fruits production. Plastic mulch increases soil temperatures, preserves soil moisture by preventing evaporation and checks weeds germination and growth.

The purpose of using mulch provides several benefits such as: conserving soil moisture, preventing weeds' growth, protecting soil from erosion, moderating soil temperature and adding OM and nutrients into the soil (Subedi & Ma, 2009). Mulching can have huge benefits for soil management especially in the sloppy lands such as in the hills and mountains of Nepal (e.g. barilands), where loss of soil and plant nutrients is a major challenge. Atreya et al. (2008) reported that mulching reduced the annual loss of SOM by 52%, annual total N loss by 46%, annual available $P_2O_5$ by 32%, and annual exchangeable $K_2O$ by 53% in a maize-mustard (*Brassica campestris*) cropping system in the hills of Nepal. Mulching is particularly valuable where a satisfactory plant cover cannot be established rapidly when erosion risk is greatest (FAO, 1998). Farmers who conventionally burn crop or organic residues instead of returning them to the soil should use them as mulch. Use of mulch becomes more relevant in vegetables, fruits, gardens or horticulture crops than in cereals grown in large plots. The major limitation of using mulch is the greater labour demand for cut-and-carry systems. Growing suitable plants around the farm such as live fences, terrace risers and marginal land can reduce the labor requirement. Use of plastic mulch is expensive but can be beneficial for the high value crops production such as off-season vegetables.

## 12.6 Strip cropping

Strip cropping is the practice of growing crops in strips or bands arranged against the slope of land. The strips of crops in slope serve as barriers for erosion by reducing run-off and increasing infiltration, thereby reducing soil erosion in sloppy lands. Acharya et al. (2008) in a study conducted in the sloped land system of Nepal found that the low-input strip crop technologies were effective in conserving soil and water through the sieve-barrier effect and found it can provide much potential to maintain the overall sustainability of sloped land use. Farm income was also increased as a result of incorporating strips of ginger (*Zingibre officinale*) in the maize based system in the sloppy terraces.

### 12.7 Hedge-rows/Alley cropping

Hedge-row intercropping or alley cropping is a system of growing mainly leguminous crops or nitrogen-fixing plants as hedges between the main crop rows and incorporation of pruned biomass into the soil. The benefits of hedge-row system are to: conserve soil by minimising soil erosion and nutrients leakage/runoff, add SOM and plant nutrients and lift nutrients from deep soil to the surface. This system is also known as sloping agricultural land technology (SALT), or contour hedge-row intercropping system. It has gained some attention in subsistence farming systems of tropics, e.g. Africa and Latin America, especially in the sloped lands, but has not been common in Nepal. The adoption of this practice is low, mainly because of high labor requirements and priority of lopped biomass as a fodder. Although it is not commonly adopted by farmers, some research is being under taken. Chapagain and Gurung (2010) used hedge-row in subsistence farming and found that hedge-row system with Napier (*Pennisetum purpureum*), sun hemp and pigeon pea (*Cajanus cajan*) on terrace edges and risers has been accepted practices for soil conservation as well as supplying forage.

### 12.8 Bio-fertilisers

Bio-fertilisers are substances produced through biological process that have significant nutrient or soil conditioning value, therefore can be used as sole source of fertiliser (e.g. fresh or processed composts), or substances that contains living microorganisms which, when applied to soil, seed, or plant surfaces, colonises the rhizosphere or the interior of the plant and promotes growth by increasing the availability of nutrients to the host plant (SSSA, 2011). Bio-fertilisers add nutrients in soil through the natural process of fixing atmospheric N, solubilising P and stimulating plant growth through the synthesis of growth promoting substances. In a subsistence production system like in Nepal, bio-fertilisers can contribute significantly towards reducing the use of expensive chemical fertilisers. A detailed description of the use of bio-fertilisers and other alternative sources of plant nutrients and their potentials in Nepal is devoted to a separate chapter.

### 12.9 Chemical fertilisers

Chemical fertilisers are the artificially manufactured sources of plant nutrients. In modern day agriculture, chemical fertilisers are a major source of plant nutrients. Agricultural production in the absence of fertilisers would not have met the growing food demand for the alarmingly increasing population (Subedi & Ma, 2009). Since the 1960s, additional nutrients applied through fertilisers have been responsible for 55% of the yield increase in developing countries (FAO, 1998). In the present circumstances, food production in Nepal without chemical fertilisers would not be achievable as the traditional sources of nutrients will not be enough to sustain the increased production requirement. The advantages of chemical fertilisers as compared with organic manures are that they provide high concentration of nutrients in a small volume thus reducing the cost of transportation and application, provide specific nutrientsand show quick response to crop.

Chemical fertilisers have also certain disadvantages such as: they provide only certain plant nutrients and make no contribution towards soil fertility improvement, require continuous use of chemical fertilisers without considering SOM and nutrients balance leads to soil degradation, require cash to buy fertilisers and often lead to excessive and unwarranted use of chemical fertilisers have huge negative impacts on environment.

Generally, the use of fertilisers in Nepal has increased over the years with the growing popularity of modern agriculture (Shrestha, 2010). Although some farmers in accessible areas of Nepal have been using excessive amounts of fertilisers leading fertiliser misuse, the use of fertilisers is very limited in majority of the areas of Nepal. The reasons for a limited use of fertilisers are mainly: unavailability of fertilisers in required time, lack of cash to purchase by the resource poor farmers, ever-changing government policy on subsidies and the expensive price of fertilisers and their transport because of poor or no transport facilities, unavailability of required types of fertilisers and lack of technical know-how of the proper use of fertilisers.

The Agriculture Perspective Plan (APP) has recognised fertiliser as the second most important input for increased crop production and productivity after irrigation. Total fertiliser (actual plant nutrients) used in the country in the APP base year (1994-95) was expected to be 101,000 t and the target set to achieve in 2014-15 was 628,000 t or 130.5 kg nutrient/ha/yr. The fertiliser consumption status of the year 2011-12 shows only 43.31 kg fertiliser per ha (not the nutrient) which is far below than the target set by APP-1995.

Chemical fertiliser should be one of the key components of IPNM, but using fertilisers alone cannot be sustainable. In addition to the nutrients supplied by other components as described above, the remaining portion of the total nutrients requirement should be complemented through chemical fertilisers. Our experience as well as the experimental results have shown that the combination of organic and inorganic sources of plant nutrients gives the best result for crop yield and sustainable soil management. For example, Bhattacharya et al. (2008), in a long-term (30 year) experiment under a wheat-soybean rotation in the Indian Himalayas have demonstrated that a combined use of FYM+NPK (inorganic fertilisers) treatment increased SOC, total N, Olsen P, and exchangeable K by 47%, 31%, 13% and 73%, respectively as compared to NPK applied through inorganic fertilisers alone.

Nitrogen is the most required plant nutrient supplied through the chemical fertilisers. Low use efficiency of applied nitrogenous fertilisers is a major concern elsewhere. Application of N fertilisers without a soil test can contribute to either $NO_3$- leaching and polluting ground and surface waters, or not supplying enough nutrients for economic yield (Heckman et al., 1995). Weather events can lead to substantial leaching, runoff, or denitrification of applied N in soil. Therefore, proper management practices are important to prevent farmers from applying excess fertilisers and increasing the risk of leaching loss of especially $NO_3$-N. Fertilisers should be added according to the crop needs to minimise ground and surface water pollution and maximise crop production.

There are different ways to minimise the $NO_3$- leaching in the ground water. Residual soil nitrogen (RSN) is the amount of inorganic N that remains in the soil at the end of growing season after crops have been harvested. It is estimated as the difference between all N-inputs (fertiliser N, manure-N, biological fixed-N and atmospheric N deposition) minus output (N removed in crop harvest, N losses through $NH_3$ volatilisation and denitrification), assuming that mineralisation and immobilisation are generally balanced (Durby et al., 2007). Adjustment of N rates to the amounts of RSN present shortly before planting can contribute to efficient N-use (Schroder et al., 2000). A history of excessive N application may decrease the response of subsequent crops to fertilizer N due to greater release from non-available N forms, most likely as a result of increased mineralisation of crop residues and recently formed SOM (Stevens et al., 2005).

The IPNM emphasises the judicious amount of fertilisers to complement the nutrients that are inadequate from other sources of nutrients to achieve a target yield, but without diminishing the soil quality, especially the SOM. Under the IPNM system, no single rate or a blanket recommendation of chemical fertilisers should be made for diverse production systems. Any recommendation should take into consideration of several factors such as manures and fertilisers used in the previous season, crops in rotations, tillage practice, crop/variety grown, yield goal, SOM content, economic considerations (costs of fertiliser, labour and produce, etc.), water availability (irrigated vs. non-irrigated), and nutrients supply from other sources such as FYM or compost, green manures and others. Similarly, a decision on type of fertiliser(s) to use depends on the availability of fertilisers, relative cost of fertilisers, soil texture, and soil pH (Subedi & Ma, 2009). Recommendation of other nutrients such as P, K, S and micronutrients should be based on the soil tests, and consideration should be made for the P and K build up in soil and micronutrients toxicities due to over-application or improper application practices.

### 12.10 Use of appropriate crop/varieties

Although choice of appropriate crop or varieties may not directly contribute to nutrients management, however, it should be considered as one of the components of IPNS because choice of crops and their variety should be matched with the soil fertility conditions and nutrients availability. For example, in a situation where chemical fertilisers are not accessible, locally adopted crop and existing varieties may perform better than newer high yielding verities. Promotion of high value crops such as vegetables in farming system stimulates farmers to care for their land and soil fertility (SSMP, 2002). It was observed that farmers were motivated to improve their soils if they saw benefits of cash from their land. Chapagain and Gurung (2010) observed better result of IPNS program when an improved variety of maize was included in the IPNS package than a local variety. Therefore, combining high value crops or improved crop varieties with sustainable soil management will encourage farmers to manage their soil sustainably.

### 12.11 Balancing soil reaction

Soil reaction or soil pH greatly influences the availability of plant nutrients in soil. Therefore, any soil and nutrients management practices should be taken into consideration of balancing soil pH to a desired level. Choice of crop, manures, fertilisers, and soil amendment such as liming or use of gypsum where required, should be considered in the soil management package as a whole for the IPNM.

## 13. Conclusion and recommendations

Our experiences and information gathered from various sources have indicated that agricultural soils in Nepal are degraded and soil fertility is in a declining trend because of high soil and nutrient losses, inadequate nutrient replenishment and inappropriate cropping and soil management practices. Increased nutrient mining, soil erosion, reduced organic input (including recycling of crop bio-mass) in soil, and imbalanced or indiscriminate use of fertilisers and pesticides have been identified as the key factors responsible for soil fertility decline. With the current state of these challenges, increasing or sustaining food production without degrading soil and environment seems to be a big challenge in Nepal. Nevertheless, adoption of IPNM approach as a tool of sustainable soil management can help to improve soil fertility and sustain land productivity without adverse impacts on environment. The following approaches need to be adapted with high priority at the policy and growers level for the sustainable soil management in Nepal.

(i) **Minimise soil erosion:** Soil erosion is one of the major causes for degradation of agricultural soils in Nepal. Reduction of soil erosion through proper cultural practices and maintenance of some form of ground cover is essential. The soil surface should be disturbed as little as possible. For this, best management practices to prevent soil erosion such as use of mulches and cover crops, planting trees and perennial hedges in sloppy lands where appropriate, abandoning cultivation in steep slopes, and strictly controlling free-grazing practices particularly in hill slopes. Infrastructure developments such as road construction and urban development projects should consider the soil conservation practices side-by side.

(ii) **Increase organic matter in soil:** Depletion of SOM is a great concern in Nepal. Crop residues removed or SOM depleted should be compensated with the addition of FYM/Compost or other sources of SOM such as green manures or cover crops where applicable. Ways to increase the amount of OM recycling such as crop residues for manure, promoting agro-forestry practices to increase biomass or fodder availability should be promoted.

(iii) **Improve manure preparation and utilisation practices:** FYM/compost are still the major sources of plant nutrients and soil amendments in Nepal. Improper preparation, storage and application practices of FYM/composts have resulted in low quality of manures and poor use efficiencies. Experiences have shown that both amount and quality of the manure can be improved through better practices such as increased fodder availability with planting nutritious fodder trees and grasses along the terrace risers, marginal lands and practicing stall-feeding system, collection/conserving and utilisation of urine, covering FYM/Compost pits, and incorporating FYM/compost immediately into the soil. Although it seems to be a radical proposition, controlling the free-grazing system of livestock with a stall-feeding system would be indispensable in Nepal for the sustainable management of lands.

(iv) **Integrated plant nutrients management:** Where organic sources alone are not adequate, organic and inorganic (chemical) sources of plant nutrients should be combined according to the IPNM approach. Similarly, adopt agronomic, crop/variety and irrigation practices that are suitable for sustainable soil management practices. It is important to note that all of the above stated components such as green manures, mulch, cover crops, and hedge-rows may not completely replace FYM or chemical fertilisers but can significantly help to build soil fertility and reduce or complement the amounts of other sources such as chemical fertilisers.

(v) **Link soil fertility management with income generation:** Sustainable soil management practices are well adapted and their values are better realised only where such interventions are combined with cash generating activities such as high value crops production that motivate farmers to adopt such technologies. It has been shown that promotion of high value crops such as vegetables in farming system stimulated farmers to care for their land and soil fertility (SSMP, 2002). It is certain that farmers are motivated to improve their soils if they see benefits of cash from their land.

(vi) **Capacity building:** For the better adaptation of the sustainable soil management practices, there should be a strong training/extension and awareness programs in order to encourage a large number of farmers to adopt the improved practices. Similarly, there is a need of proper extension tools to enable farmers to quickly understand and take up improved soil fertility management practices.

## References

Acharya, A. K., & Kafle, N. (2009). Land degradation issues in Nepal and its management through agroforestry. *Journal of Agriculture and Environment,* 10: pp.115-123.

Acharya, G. P., McDonald, M. A., Tripathi, B. P., Gardner, R. M., & Mawdesley, K. J. (2007). Nutrient losses from rainfed bench terraced cultivation systems in high rainfall areas of mid-hills of Nepal. *Land Degradation and Development,* 18: pp. 486-499.

Acharya, G. P., Tripathi, B. P., Gardner, R. M., Mawdesley, K. J., & McDonald, M. A. (2008). Sustainability of slopping land cultivation systems in the mid-hills of Nepal. *Land Degradation and Development,* 19: pp. 530-541.

AICL. (2013). *Annual Programme and Budget,* FY 2069/70. Kathmandu: Agriculture Inputs Company Ltd. Head Office.

Andraski, T. W., & Bundy, L. G. (2002). Using the pre-sidedress soil nitrate test and organic nitrogen crediting to improve corn nitrogen recommendations. Agronomy Journal 94: pp.1411-1418.

Andraski, T. W., & Bundy, L. G. (2005). Cover crop effects on corn yield response to nitrogen on an irrigated sandy soil. *Agronomy Journal,* 97: pp. 1239-1244.

APP, (1995). *Nepal Agriculture Perspective Plan (1995/96 – 2014/15)*. Main Document. Kathmandu: Agricultural Projects Services Centre, and Washington D.C.: John Mellor Associates, Inc.

Arnon, D. I. and Stout, P. R. (1939). The essentiality of certain elements in minute quantity for plants with special reference to copper. *Plant Physology,* 14: pp. 371-375.

Atreya, K., Sharma, S., Bajracharya, R. M., & Rajbhandari, R.P. (2008). Developing a sustainable agro-system for central Nepal using reduced tillage and straw mulching. *Journal of Environmental Management,* 3: pp. 547–555.

Bausch, W. C., & Duke, H. R. (1996). Remote sensing of plant nitrogen status in corn. *American Society of Agricultural Engineers,* 39: pp. 1869-1875.

Bhattacharyya, R. Kundu, S., Prakash, V., & Gupta. H. S. (2008). Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean-wheat system of the Indian Himalayas. *European Journal of Agronomy,* 28: pp. 33-46.

Bittman, S., Hunt, D. E., & Kowalenko, C. G. (2004). Cover crops and relay crops. Pp. 89-94. In: S. Bittman and C.G. Kowalenko (Eds.), Advances in *Silage Corn Management.* Agassiz, BC, Canada: Pacific Field Corn Association.

Bot, A., & Benites, J. (2005). *The importance of soil organic matter: Key to drought-resistant soil and sustained food production.* FAO Soils Bulletin 80. Rome: Food and Agriculture Organization (FAO) of the United Nations.

Carson, B. 1992. *"The Land, the Farmer and the Future- A Land Fertility Management Strategy for Nepal".* ICIMOD Occasional Paper No. 21, Kathmandu: International Centre for Integrated Mountain Development (ICIMOD).

CBS. (2005). *Statistical Yearbook of Nepal,* 2005. Kathmandu: National Planning Commission, Central Bureau of Statistics.

CBS. (2011). *Statistical Yearbook of Nepal, 2009.* Kathmandu: National Planning Commission, Central Bureau of Statistics.

Chapagain. T., & Gurung G. B. (2010). Effects of integrated plant nutrient management (IPNM) practices on the sustainability of maize-based hill farming systems in Nepal. *Journal of Agricultural Science,* 2: pp. 26-32.

Christensen, L. A. (2002). *Soil, nutrient & water management systems used in US corn production.Agriculture Information Bulletin No.* 774, Washington D.C.: United States Department of Agriculture (USAID).

Desbiez, A., Matthews, R., Tripathi, B., & Ellis-Jones, J. (2004). Perceptions and assessment of soil fertility by farmers in the middle-hills of Nepal. *Agriculture, Ecosystem & Environment,* 103: pp. 91-206.

Drury, C. F., Yang, J. Y., De Jong, R., Yang, M. X., Huffman, E. C., Kirkwood, V., & Reid, K. (2007). Residual soil nitrogen indicator for agricultural land in Canada. *Canadian Journal of Soil Science,* 87: pp. 167-177.

Edmeades, D. A. (2003). The long-term effects of manures and fertilizers on soil productivity and quality: A review. *Nutrient Cycling on Agroecosystems,* 66: pp. 165-180.

Maskey, R. B., Sharma, B. P., & Joshi, M. (2003). Human dimension in sustainable land use management in degraded land areas of Nepal.In:*Open Meeting of the Global Environmental change Research Community. Montreal:* Global Environmental Change Research Community, pp. 16-18.

FAO (n.d.). *Plant production and protection division: Integrated Plant Nutrient Management (IPNM)*. [online] Available at: *http://www.fao.org/agriculture/crops/core-themes/theme/spi/scpi-home/managing-ecosystems/integrated-plant-nutrient-management/en/*

FAO. (1998). *Guide to efficient plant nutrition management. Rome:* Food and Agriculture Organization, pp. 18.

Fischler, M., & Wortmann, C. S. (1999). Green manures for maize-bean systems in eastern Uganda: Agronomic performance and farmers' perceptions. *Agro-forestry Systems,* 47:pp. 123-138.

Gardner, R. A. M. &, Gerrard, A. J. (2003). Runoff and soil erosion on cultivated rained terraces in the middle hills of Nepal. *Applied Geography*, 23: pp. 23-45.

Gardner, R. A. M., Mawdesley, K., Tripathi, B. P., Gaskin, S., & Adams, S. (2000). *Soil erosion and nutrients loss in the middle hills of Nepal* (1996-1998). ARS Lumle, Soil Science Division, NARC and Queen Marry and Westfield College, University of London, pp. 57.

Gruhn, P., Goletti, F., & Yudelman, M. (2000). *Integrated nutrient management, soil fertility, and sustainable agriculture: Current issues and future challenges.* Food, Agriculture, and the Environment Discussion Paper 32. Washington, D.C.: International Food Policy Research Institute.

Hartemink, A. E. (2006). Soil fertility decline: Definition and assessment. *Encyclopedia of Soil Science.Taylor and Francis,* pp. 1618-1621.

Heckman, J. R., Hlubik, W.T., Prostak, D.J., & Paterson, J.W. (1995). Pre-sidedress soil nitrate test for sweet corn. HortScience, 30: pp. 1033-1036.

Hutchinson, J. J., Grant, B. B., Smith, W. N., Desjardins, R. L., Campbell, C. A., Worth, D. E. & Verge, X.P. (2007). Estimates of direct nitrous oxide emissions from Canadian agro-ecosystems and their uncertainties. *Canadian Journal of Soil Science,* 87: pp. 141-152.

Jarvis, S. C., Stockdale, E. A., Shepherd, M. A., Powlson, D. S., & Donald, L. S. (1996). Nitrogen mineralization in temperate agricultural soils: Processes and measurement. *Advances Agronomy,* 57: pp. 187-235.

Jokela, W. E. (2004). Using solid manure: Vermont Experience. In: S. Bittman & C.G. Kowalenko, Eds., Advances in Silage Corn Management (pp.59). Agassiz, BC, Canada: Pacific Field Corn Association.

Jones, C., & Jacobson, J. (2005). *Plant Nutrition and Soil Fertility. Nutrient Management Module No. 2.* Montana State University Extension Services. 4449-2.

Joshi, K. D., Vaidya, A., Subedi, P. P., Bhattarai, S. P., Subedi, K. D., Rasali D., et al. (1994). *Soil Fertility System Analysis in Relation to Temperate Fruits Crops in the High Hill and Inner Himalaya Region of Western Nepal.* LARC Working Paper No. 94/50. Lumle (Nepal): LARC, and Reading (UK): Natural Resources Institute (NRI).

Keerthisinghe, G.; Zapata, F. & Chalk, P. (2003). Plant Nutrition: Challenges and Task Ahead. Paper Presented 26-28 March, 2003 in: *IAF-FAO Agricultural Conference.* Rome: Food and Agriculture Organization.

Lemunyon, J. L., & Gilbert, R. G. (1993). The concept and need for a phosphorus assessment tool. *Journal of Production Agriculture*, 6: pp. 449-486.

Ma, B. L., Subedi, K. D. & Liu, A. (2006). Variation in grain N removal associated with management practices in maize production. *Nutrient Cycling in Agroecosystem*, 76: pp. 67-80.

Maskey, S. L., Bhattaria, S., Peoples, M. B., & Herridge, D.F. (2001). On-farm measurements of nitrogen fixation by winter and summer legumes in the hill and Terai of Nepal. *Field Crops Research,* 70: pp. 209-221.

Matson, P. A., Parton,W. J., Power, A. G., & Swift, M. J. (1997). Agricultural intensification and ecosystem properties. Science, 277: pp. 504-509.

McCauley, A., Jones, C., & Jacobsen, J. (2009). *Plant Nutrient Functions and Deficiency and Toxicity Symptoms.* Nutrient Management Module No. 9. Montana State University Extension. 4449-9, May 2009.

Misselbrook. (2004). Using solid manures. In: S. Bittman & C.G. Kowalenko, Eds., *Advances in Silage Corn Management* (pp. 57-58).Agassiz, BC, Canada: Pacific Field Corn Association.

Pilbeam, C. J., Mathema, S. B., Gregory, P. J., and Shakya, P. B. (2005). Soil fertility in the mid-hills of Nepal: practices and perceptions. *Agriculture and Human Values*, 22: pp. 43-258.

Pilbeam, C. J., Tripathi, B. P., Sherchan, D. P., Gregory, P. J., & Gaunt, J. (2000). Nitrogen balance for households in the mid-hills of Nepal. *Agriculture, Ecosystem and Environment,* 79: pp. 61-72.

Regmi, A. P., Ladha, J. K., Pathak, H., Pasquin, E., Bueno, C., Dawe, D., et al. (2002). Yield and soil fertility trend in a 20-year rice-rice-wheat experiment in Nepal. *Soil Scence Society of America Journal*, 66: pp. 857-867.

Sawye, J. E. (2000). Potassium deficiency symptoms in corn. Integrated crop management. Iowa State University. [online} Available at: *http://www.ipm.iastate.edu/ipm/icm/2000/6-26-2000/kdef.html*

Schröder, J. J., Neeteson, J.J. Oenema, O., & Struik, P.C. (2000). Does the crop or the soil indicate how to save nitrogen in corn production? Reviewing the state of the art. *Field Crops Research, 66: pp.* 151-161.

Shrestha, R. K. (2010). Fertilizer Policy Development in Nepal. *The Journal of Agriculture and Environment,* 11: pp. 126-137.

Snapp, S. S., Swinton, S. M., Labarta, R., Mutch, D., Black, J. R., Leep, R., et al. (2005). Evaluating cover crops for benefits, costs and performance within cropping systems niches. *Agronomy Journal,* 97: pp. 322-332.

SSMP. (2002). Sustaining soil fertility: useful practices and methods in hill agriculture*. LEISA Magazine,* 18 (3), pp. 20-21.

SSSA (n.d). Soil Science Society of America: Available at: *https://www.soils.org/publications/soils-glossary/*

Stevens, W. B., Hoeft, R. G. & Mulvaney, R. L. (2005). Fate of nitrogen-15 in a long-term nitrogen rate study: I. Interactions with soil nitrogen. *Agronomy Journal,* 97: pp. 1030-1045.

Stoorvogel, J. J., Smaling, E. M. A., & Jansen, B. H. (1993). Calculating soil nutrient balance in Africa at different scales II. Supra-national scale. *Fertilizer Research,* 35: pp. 227-235.

Subedi, K. D. & Gurung, G. (1991) *Soil fertility thrust towards sustainable agriculture: An experience of Lumle Regional Agricultural Research Centre.* Technical Paper No. 91/4. Lumle: Lumle (Nepal): LARC.

Subedi, K. D., Gurung, G. B. Paudel, D. R. S. Gurung, K. J. Gurung, D. B., & Gurung J. B. (1989). *Traditional methods of maintaining soil fertility in the mid and high hills (1200–2100 m asl) of the Western Development Region of Nepal: Problems and potential.* Working Paper No. 3. LAC, Nepal: LARC.

Subedi, K. D, Jaishy, S. N., Subedi, T. B., Mandal, S. N. & Weber, G. (2000). *Trainers' manual on organic manure management*. Document No.39. Kathmandu: SSMP /Helvetas/ Intercooperation, (in Nepali).

Subedi, K. D. (1997). Indigenous green manures in Nepal: Farmers' local knowledge agrees with formal experimental results. *ILEIA Magazine,* 13 (3), 16-17.

Subedi, K. D. (1998). Relay-planted green manures as a substitute for inorganic fertilizers for rice in the intensive cropping systems in Nepal. *Tropical Agriculture,* 75: pp. 422-427.

Subedi, K. D., & Ma, B. L. (2009). Corn crop production: Growth, fertilization and yield. In: A.T. Danforth, Ed. *Corn crop production: Growth, fertilization and yield.* New York: Nova Science Publishers.

Subedi, K. D., & Sapkota, G. P. (2002). Integrated plant nutrient management (IPNM) in maize: Pilot testing of IPNM with farmers in Sindhupalanchowk. In: N.P. Rajbhandari, K.K. Ransom, K. Adhikari, & A.F.P. Palmer Eds., *Sustainable maize production systems for Nepal.* Proceedings of a Maize Symposium held December 3-5, 2001. Hill Maize Research Programme. Kathmandu: HMRP, CIMMYT, pp. 163-169.

Subedi, K. D., Tripathi, B. P., Maharjan, P. L., & Weber, G. W. (2000). *Trainer' manual on soil ecology and sustainable soil management.* Document No. 26. Kathmandu: SSMP/Helvetas/Intercooperation.

Sullivan, P. (2003). Overview of cover crops and green manures. *Appropriate Technology Transfer for Rural Areas (ATTRA)* [online]. Available at: *http://www.attra.ncat.org.*

Syers, J. K. (1997). Managing soil for long-term productivity. *Philosophical Transactions of the Royal Society of London (B),* 352: pp. 1011-1021.

Tan, Z. X., Lal, R., & Wiebe, K. D. (2005). Global soil nutrient depletion and yield reductions. *Journal of Sustainable Agriculture,* 26: pp. 123-145.

Tejada, M., Gonzalez, J. L., Garcia-Martinez, A. M., & Parrado, J. (2008). Effect of different green manures on soil biological properties and maize yield. *Bioresource Technology,* 99: pp. 1758-1767.

Thapa, G. B, & Paudel, G. S. (2002). Farmland degradation in the mountains of Nepal: A study of watershed with and without external intervention. *Land Degradation & Development,*13: pp. 479-4963.

Tiro-Padrem, A., Ladha, J. K., Regmi, A. P., Bhandari A. l., & Insbushi, K. (2007). Organic amendments affect soil parameters in two long-term rice-wheat experiments. *Soil Science Society of America Journal,* 71: pp. 442-452.

Tripathi, B. P. & Ellis-Jones, J. (2005). The use of biophysical and socioeconomic tools in soil fertility and organic matter. In: M. Stocking, H. Helleman, & R White, *Eds.Renewable natural resources management for mountain communities.* Kathmandu, Nepal: ICMOD. pp. 179-190.

Uchida, R. (2000). Essential nutrients for plant growth: nutrient functions and deficiency symptoms. In: J.A. Silva & R. Uchida, Eds. *Plant nutrient management in Hawaii's soil: Approaches for tropical and subtropical agriculture Manoa:* University of Hawaii, Manoa. pp 31-35.

Van Reuler, H., & Prins,W. H. (1993). Plant Nutrients and food production. In: H. van Reuler & W.H. Prins, Eds*.The role of plant nutrients and sustainable food production in sub-Saharan Africa* Plonsen & Looijen, Netherlands: Wageningen, pp. 179-190.

Vanlauwe, B., Chianu J., Giller, K. E., Merckx, C, Mokwunye, U., Pypers, P., et al. (2010). Integrated soil fertility management: operational definition and consequences for implementation and dissemination. Paper presented 1–6 August 2010 in: *World congress of soil science, soil solutions for a changing world.,* Brisbane, Australia. Published on DVD.

3

# Utilising Organic Wastes and Alternative Sources of Plant Nutrients for Sustainable Agriculture in Nepal

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## Abstract

Subsistence oriented traditional agricultural practices in Nepal largely follow conventional approaches for soil fertility management. Conventional methods for soil fertility management rely primarily on use of compost and farmyard manure (FYM) as the main sources of plant nutrients. Recently, a shift from subsistence to semi-commercial production systems required changes in soil fertility management practices, which involved indiscriminate use of inorganic fertilisers, a decreasing trend of FYM and compost availability, and increasing use of poultry manure for crop production. More recent trends of commercial farming include crop intensification, use of high yielding varieties and specialised farming e.g. commercial vegetable and cash crops production. These are nutrient hungry production systems and currently dependent solely on inorganic fertilisers. Excessive nutrients depletion by these intensive production systems imposes severe consequences for soil fertility management, including increasing cost of fertilisers, and degradation of chemical, biological and physical properties of soil leading to loss of overall soil fertility and the appearance of severe micronutrients deficiencies in a number of crops. A far reaching and sustainable approach includes building integrated soil fertility management together with the use of under-utilised sources of plant nutrients such as bio-fertiliser technologies and recycling of organic residues, and enhanced composting (such as vermi-composting). Manufacturing of fertiliser products (granules, pellets, briquettes) from plant, animal and human wastes, and optimising the use of these products as alternative fertilisers are needed. The economic and environmental benefits from these products can be harnessed for sustainable production of crops, without jeopardising soil fertility and the environment. Achieving this result should be considered a priority goal for sustainable agriculture. This paper describes the scope of the alternative sources of plant nutrient management and their production and scaling-up for a wider adaptation in Nepal.

# 1. Introduction

This chapter outlines the need for alternative sources of plant nutrients to facilitate long-term sustainable crop production in Nepal. This chapter is based on a review of published literature and web-based resources. In addition, the experiences of the author's expertise with on-going projects in this field in Nepal are also incorporated where appropriate.

## 1.1 Use of fertiliser in Nepal

The Nepalese economy is predominantly agriculturally based, with more than two-thirds of the population engaged in this sector for their livelihoods. Agriculture contributes 35% to gross domestic product (GDP) (MOAD, 2011). The majority of the farmers are small landholders with an average farm size of < 0.5 ha. Nepalese agriculture is predominantly subsistence oriented and follows mixed farming systems where crops, livestock and agro-forestry are integrated. The share of livestock in GDP is 12%. Traditionally, agricultural production systems in Nepal were primarily based on livestock manure as the major source of plant nutrients; this interdependency among crops, livestock and forest resources is still prevalent. Access to chemical fertilisers in the hill and mountain farming communities, especially to the resource-poor farmers, is very limited. Hence, Nepalese farming systems are basically forced to be a semi-organic system in nature.

This scenario, however, is changing because of increased commercialisation of farming and crop intensification. Some traders first introduced chemical fertiliser in the form of ammonium sulphate to Nepal from India in the 1950s. The import of fertilisers from India and international markets was formalised with the establishment of the Agriculture Inputs Corporation (AIC) in 1966. After that, the use of chemical fertiliser started to rise especially in the Terai region where its use is four times higher than in the hills (IDL Group, 2006). However, public sector involvement in fertiliser supply and distribution could not develop a sustainable mechanism for effective supply. Fertiliser has been always a political commodity ever since the establishment of AIC. There has always been instability in fertiliser policy; on and off in subsidies, lack of transparency and irregularity in procurement of fertilisers. Adequate supply and distribution of quality fertiliser at reasonable prices at the right time in all geographical regions has always been a big challenge for the government. There is ever growing frustration among the farmers due to unavailability of adequate quantity of quality fertilisers at reasonable prices during the cropping season.

## 1.2 Status of fertiliser use in Nepal

Chemical fertiliser is a critical input for increasing crop yield. Besides supplying crop nutrients, it also enhances the efficiency of other inputs such as irrigation and good quality seeds. Taking into account its importance, fertilisers use has been envisaged as a main driver for rapid economic growth in the 20 year Agriculture Perspective Plan (APP, 1995). The APP has planned to increase the use of major nutrients: Nitogen (N), Phosphorus (P) and Potassium (K) as NPK from 31 kg nutrients/ha in the base year (1995) to 131 kg /ha by 2015. Recent surveys and studies show that the current level of fertilisers use in Nepal is in the range from 50 to 60 kg nutrients/ha (OPM, 2003; ANZDEC, 2002), which is less than 50% of the recommended level of fertiliser input by the APP.

Nearly 75% of the agricultural land in Nepal is in the hills and mountains, which lacks reliable road networks for transportation of chemical fertilisers. In most areas, fertilisers are carried either by porters or by draft animals such as donkeys and yaks, incurring significant cost of transportation. The reasons for the higher consumption of fertiliser in the Terai are: ease of access, proximity to India (for access) and lower fertiliser prices (ILD Group, 2006). This suggests that the use of fertiliser increases with improvement in access to fertilisers and lower cost.

The fertiliser option for Nepalese farmers encompasses a number of difficulties such as poor supply, inferior quality, increasing cost and adverse effects on soil fertility. The major environmental implications with the use of inorganic fertilisers in Nepal are now described.

## 1.3 Disadvantages of using inorganic fertilisers

Although chemical or inorganic fertilisers are considered as a vital input for crop production, there are several disadvantages in using them. The commonly recognised disadvantages of chemical fertiliser use in Nepal are briefly described as follows:

### *1.3.1 Water pollution*

Nitrate ($NO_3$-) released from nitrogenous fertiliser is prone to leaching and run-off, which cause contamination of surface water and ground waters. Such contamination can cause problems for natural habitats and human health.

### *1.3.2 Heavy metal contamination*

Common agricultural grade inorganic fertilisers such as phosphate usually contain impurities such as fluorides, cadmium and uranium (Mortvedt, 1996). These potentially harmful impurities can be removed; in high-grade fertiliser, however, there is a significant increase in cost.

### *1.3.3 Fertiliser dependency*

Supply of fertiliser products in Nepal has been very erratic. Because of the hygroscopic nature of many fertilisers and need of cash investment for fertilisers, growers generally prefer to buy fertilisers only few days prior to application. Unavailability of fertilisers in required types and quantity combined with greater dependency for fertiliser under such uncertainty of supply can be detrimental for farming.

### *1.3.4 Soil acidification*

Continuous use of acidulated fertilisers such as ammonium sulphate generally contributes to accumulation of soil acidity in the soil, which progressively increases aluminium toxicity and soil degradation that negatively affects plant growth.

### *1.3.5 Trace mineral depletion*

Since fertilisers supply only one or a few nutrients, continuous use of chemical fertilisers alone can lead to depletion of other micronutrients in the soil. Recent trends of increased micronutrient deficiencies in crops are the result of continuous and imbalanced use of chemical fertilisers and nutrient mining due to increased cropping intensity with high nutrient demanding crops. For example, in many parts of Nepal, soil deficiencies of boron, molybdenum, zinc, copper, manganese and iron have been reported. Boron deficiency in soil causes large yield losses in vegetables and wheat in Nepal.

### *1.3.6 Over-fertilisation*

Over-fertilisation can be detrimental causing ‘fertiliser burn’ resulting in drying out of the leaves and damage or even death of the plant (Moore, 2001). Fertilisers vary in their tendency to burn roughly in accordance with their salt index. Fertiliser burn can be severe when soil moisture is limiting after fertiliser application.

### *1.3.7 High energy consumption*

Manufacturing of chemical fertilisers requires a large amount of energy. Fossil fuels such as petroleum, natural gas and coal, which are limited resources, are utilised for manufacturing of nitrogenous fertilisers. The cost of natural gas can be up to 90% of the cost of ammonia production. IFA (2002) reports that the production of ammonia consumes about 5% of global natural gas consumption, which is nearly 2% of world energy production. Therefore, in a country such as Nepal, manufacturing of chemical fertilisers requires a large amount of energy and will be very expensive. This is one of the reasons why fertiliser manufacturing plants are not found in Nepal.

### *1.3.8 Contribution to climate change*

Nitrogenous fertilisers in the soil-water system can be converted by soil bacteria into nitrous oxide ($N_2O$), which is considered a major greenhouse gas. It has the global warming potential 310 times that of $CO_2$.

### *1.3.9 Impacts on mycorrhizas*

High fertiliser levels may upset symbiotic relationships between plant roots and mycorrhizal fungi (Carroll et al., 2004). Association of mycorrhizal fungi in a number of crops confers drought tolerance, improves phosphorus acquisition by the plant root and enhances root health.

### *1.3.10 Long-term sustainability*

Resources used in the production of nitrogenous fertilisers are non-renewable; hence, fertiliser production processed in this way is unsustainable for Nepal. Potassium and phosphorus are sourced from mines and again such resources are limited.

In spite of numerous limitations of fertilisers use as listed above, Nepalese agriculture in general and food security in particular is largely dependent on the use of fertilisers. Appropriate alternatives need to be developed for sustaining, and enhancing soil productivity, crucial for increasing the productivity and quality of agricultural produce in Nepal. The strategic vision to overcome the over-dependency on inorganic fertiliser should be based on two main themes: improvement in the fertiliser use efficiency and development of alternative fertiliser products from organic resources. Prospects and methods for developing alternative fertiliser products based on organic resources are discussed in the following section.

## 2. Alternatives to inorganic fertiliser

Declining soil fertility is considered to be one of the major limitations for increased productivity and food security in Nepal. Current level of dependency on inorganic fertilisers, declining use of organic sources of nutrients (FYM and compost), and limited and imbalanced use of other mineral fertilisers is inadequate for supporting all of the plant nutrient requirements of the country. Conventional sources of plant nutrients alone are not adequate in meeting the total nutrients required for sustainable crop production in Nepal. Therefore, additional sources of plant nutrients, especially those currently under-utilised, need to be explored for sustainable production systems.

There are wide ranges of alternative sources of plant nutrients that can be explored. These are based on microbial products (bio-fertilisers), recycling of organic wastes from plant, animal and human sources (e.g. green biomass, poultry manure bio-solids, and wastewater), and a large number of mineral sources (ore and mine by-products), which are currently being used in limited scale, but their potentials have not been fully utilised. Although there are certain limitations (technologies, costs, and market) on their wider use in Nepal, the drivers for holistic use of all possible fertiliser options are becoming more and more favoured options due to increasing cost of inorganic fertilisers, greater environmental regulation and the need for complete fertilisers to maintain long term soil fertility.

Based on the current statistics of Nepal, we present a scenario of how the alternative fertiliser options can provide a sustainable solution for managing soil fertility issues in Nepal. Let us take poultry manure as an example case study for use as an alternative source of nutrients. Based on 2012 poultry statistics in Nepal, there were about 58 million broilers, 6 million layers and 1 million parent birds (Bhattarai, 2011). These birds produce about 0.3 million tonnes of poultry manure in a year. About 150 g of manure is produced by each bird per day, yielding a total of 1,275 tonnes on a daily basis (yearly 465,375 tonnes) producing 0.465 million tonnes in a year of fresh and about 0.3 million tons of dry manure. Fresh poultry manure contains as high as 9% N. However, it is highly volatile during the composting process. If it is assumed that the processed poultry manure contains only 4% N, then the total N from poultry manure will be about 12,000 tonnes (0.3 million tonnes x 0.04).

Currently, Nepal has about 2.4 million ha of arable land, of which only about 26% is irrigated (Devkota, 1999). Based on this figure, the N supply from poultry litter alone is sufficient to provide about 5.05 kg N/ha of arable land and about 20.5 kg N/ha of irrigated land.

Organic waste production from plant-based products in Nepal is estimated to be 2.5 million tonnes per year (Pokhrel & Virarahghavan, 2005). With the 0.4% N in the organic wastes, the total N from this source will be equivalent to N outputs from the poultry industry. Another major source for plant nutrients can be from bio-solids in Nepal.

With these figures, it is safe to estimate that for each hectare of irrigated land, the N contributions from poultry is about 20.5 kg, from organic waste can be about 20.5 kg, and from bio-solids about 10 kg. Incorporation of effective legumes can add as much as 50 kg N/ha, and an additional 10 kg/ha can be from the bio-fertilisers. This calculation clearly shows that as much as 111 kg/ha N equivalent can be added into the soil through alternative fertiliser sources, if these options are well integrated into the farming systems in Nepal. This amount brings a substantial quantity of available NPK and soil carbon that not only supports the nutrients demand of the current season crop, but also contributes significantly toward building the base of soil carbon and soil fertility that has important bearings on the sustainability of crop production and soil health.

Several other countries around the world have made great achievements in developing alternative fertiliser products, as was the case for Cuba after cuts in Soviet supplies were brought about by the collapse of the Soviet Bloc in 1989. This involved using various sources of organic and inorganic materials, adding-value to soil and processing and developing methods for improving the efficiency in their use in crop production. The potential alternative sources of plant nutrients suitable for Nepal are discussed in the following sections.

## 2.1 Bio-fertilisers

Bio-fertilisers are substances produced through biological processes with significant nutrient value that can be used as an effective source of nutrients. These contain living microorganisms which, when applied to soil, seed, or plant surfaces, colonise the rhizosphere or the interior of the plant and promote growth by increasing the availability of nutrients to the host plant (SSSA, 2011). Unlike manures and fertilisers, bio-fertilisers add nutrients to the system through the natural process of atmospheric fixation of N or by making nutrients available through the process of mobilisation and solubilisation for phosphorus (P). Some of these species also stimulate plant growth through the synthesis of growth-promoting substances. The microorganisms in bio-fertilisers also restore the natural nutrient cycle and build soil organic matter (OM), that support healthy plant growth and soil health, which are fundamental for sustainable soil fertility. Therefore, bio-fertilisers can contribute significantly towards reducing the use of chemical fertilisers and can play a significant role in Nepal for enriching soil fertility and fulfilling plant nutrient requirements in a sustainable way.

### *2.1.1 Types of bio-fertilisers*

There are several types of bio-fertilisers sources including bacteria, fungi and algae. Based on their mode of nutrient synthesis or release in soil or plant, bio-fertilisers can be categorised into different groups, which are summarised in Table 1.

**Table 1.** Types of bio-fertilisers based on their sources and functions.

| Group | Type of micro-organisms |
|---|---|
| Nitrogen fixing | Symbiotic e.g. *Rhizobium sp., Anabaena;* |
| | Free-living e.g. *Azotobacter, Azospirillum* |
| Phosphorus solubilising | *Bacillus magaterium* var. *phosphaticum, Bacillus circulans, Pseudomonas striata, Penicillium sp., Aspergillus awamore* |
| Phosphorus mobilising | *Arbuscular mycorrhiza* e.g. *Glomus sp., Scutellospora sp., Sclertocystis,Gigaspora sp., Ectomycorrhiza e.g. Laccaria sp., Pisolithus sp.* |
| Silicate and zinc solubilising bio-fertilisers | *Bacillus sp.* |
| Plant growth promoting bio-fertilisers | *Pseudomonas fluorescens* |

*Rhizobium* sp., the symbiotic N fixing bacteria, is the important group among the micro-organisms used as bio-fertilisers. Rhizobia fix atmospheric N (40 to 250 kg N/ha/yr) symbiotically in the roots nodules of host legume plants (Motghare & Gauraha, 2013). Rhizobia can also be utilised through the growing of leguminous plants as green manure which add N through fixation as well as through the decomposition of the N-rich legume biomass in the soil.

Azolla is a free-floating water fern that can fix atmospheric N in association with bluegreen algae (BGA) *(Anabaena azollae)*. The BGA belonging to a general genus, *Nostoc, Anabaena, Tolypothrix* or Aulosira fix atmospheric N and are used as inoculants for upland and low-land paddy rice fields. *Anabaena* in association with *Azolla* contributes upto 60 kgN/ha/season and also enriches soils with OM (Stewart et al., 2005). Azolla as a bio-fertiliser is commonly used in rice farming systems in South and South-East Asia.

Free-living N fixing bacteria such as *Azotobacter, Azospirillum* and *Clostridium* sp. also fix N in the non-legume crops such as rice, wheat, barley, millet and cotton. These are not as common as Rhizobia but they have a potential of N fixing in the non-legume crops. *Azotobacter* sp. have been used in cereals (e.g. wheat and barley), cotton, potatoes and vegetables while Azospirillum inoculations are recommended mainly for use in sorghum, millets, maize, sugarcane and wheat.
Phosphate-solubilising bacteria (PSB), such as *Pantoea agglomerans* strain P5 or *Pseudomonas putida*strain P13 can solubilise the insoluble phosphate from organic and inorganic phosphate sources (Erisman et al., 2008). Due to immobilisation of phosphate by mineral ions such as $Fe^{2+}$, $Fe^{3+}$, Al and $Ca^{2+}$ or organic acids, the available phosphate ($H_2PO_4$-) in soil that is absorbed by plants, can be as low as 20% of added P fertiliser.

### *2.1.2 Bio-fertiliser as a viable option for Nepal*

Bio-fertilisers such as *Rhizobium, Azotobacter, Azospirillum* and *BGA* have been in use for a long time in Nepal. *Rhizobium inoculant* is used for legumes. Bio-fertiliser options are low cost, easy to transport, compatible with other alternative fertiliser resources and continuous application is not required for a number of species. Bio-fertilisers are eco-friendly and cost-effective organic agro-inputs and advantages of using them can be as follows:

- Bio-fertiliser is low cost and can be used by small and marginal farmers, locally.Rhizobial bio-fertiliser can fix as much as 50-150 kg N/ha/year.
- It is free from pollution hazards.
- Some bio-fertilisers, such as BGA can increase rice yields by 10 to 45% and leave about 40-50 kg/ha N in the soils for subsequent crops (Venkataraman, 1972). In addition, benefits from algalisation is about 25 to 30 kg N/ha per cropping season in rice fields.
- Cyanobacteria secrete growth-promoting substances such as auxins (e.g. IAA, IBA, NAA), amino acids, proteins and vitamins. They contribute to organic matter in soils. Cyanobacteria can grow and multiply under a wide range of pH (6.5-8.5). Hence, they can be used as a potential tool to reclaim saline or alkaline soils because of their ameliorating effect on the physio-chemical properties of soils.
- Azotobacter and Azospirillum, besides supplying N to soil, secrete antibiotics, which act as pesticides.
- Mycorrhizas increase the longevity of feeder roots and surface area of roots by forming a mantle and spreading mycelia into the soil and in turn enhance the rate of absorption of macro and micronutrients and water from the soils. Seven types of mycorrhiza have been classified based on types of relationships with the hosts (Marks, 1991).
- Mycorrhizas also play a key role for selective absorption of immobile (P, Zn and Cu) and mobile (S, Ca, K, Fe, Mn, Cl, and N) elements to the plants (Tinker, 1984). Vesicular Arbuscular mycorrhizal (VAM) fungus reduces the plant response to soil stresses caused by high salt, drought, and toxicity associated with heavy metals, mine spoils and minor element (e.g. Mn) deficiency.

### *2.1.3 Limitations with bio-fertilisers in Nepal*

The benefits of bio-fertilisers far outweigh those of inorganic fertiliser. However, there are certain limitations for a wide scale adoption of such technologies in Nepal. The key limitations include: unavailability of appropriate inoculums, preservation and transport of inoculums, poor technical knowledge of farmers, cost of production, lack of commercial operations and slow effects on crops. These issues should be addressed in order to utilise the potential of bio-fertilisers.

## 2.2 Plant based organic wastes

Addition of organic manures to the soil improves biodiversity (soil life), long-term soil productivity and contributes as a repository for $CO_2$. Organic matter increases the abundance of soil organisms by providing food and nutrients for them.

Drivers for organic fertiliser are positive. More recently, use of organic fertiliser is on the rise as consumers and growers are choosing environment-friendly products. Organic fertilisers such as compost and worm castings break down slowly into complex organic structures (humus) which improve the soil by increasing water and nutrient holding capacity. In general, nutrient content in organic fertiliser is low and much less readily available to plants than with inorganic fertilisers. Hence, all organic fertilisers are classified as 'slow-releasing' fertilisers, and therefore, cannot cause fertiliser burn (Zublena et al., 1991).

Organic matter and organic fertilisersarise from a wide range of sources. Modern lifestyles produce increasing amount of green or organic wastes in many countries. Khatiwada et al. (2013) reported that nearly 2.5 million tonnes of organic waste (based on the daily per capita production of 0.5 kg solid waste with 53% dry matter by 26 million people) is produced in Nepal, which can be potentially used for sources for organic fertiliser production. Organic wastes are produced more in rural areas is high as these areas produce a large quantity of crop waste. A number of options are available for converting this waste into fertiliser products. The common and affordable methods include composting, vermi-composting, using waste as mulching materials and production of biochar from organic waste streams.

### *2.2.1 Vermi-compost*

Vermi-compost is the manure produced by decomposing organic residues by earthworms. Earthworms have been commercially utilised for large scale recycling of wastes such as household and farming wastes. Various species of earthworms are utilised for composting wastes that produce vermi-casts and vermi-liquor as fertiliser. These products are emerging as potential organic fertilisers in recent years and they are becoming choice fertiliser for many growers. However, about one kg of earthworm is required for complete ingestion of an equal amount of waste per day. Hence, a large-scale vermi-composting facility is required for the utilisation of large quantities of organic waste.

Organic fertilisers developed from these various wastes are bulky and expensive for long distance transport. Hence, decentralised facilities for composting have been advocated for as shown in Figure 1 below.

**Figure 1:** Vemi-composting structures, swag for small-scale composting (left), pits for medium-scale and benches for large-scale composting (right). (Photos courtesy of Vermi-crobe International)

### *2.2.2 Vermi-liquor*

Vermi-liquor is extracted liquid from vermi-casts. It is rich in nutrients hence can be utilised as liquid fertiliser both in soil and hydroponics. It has already been used as top dressing fertiliser.

### *2.2.3 Improved composting*

Large-scale anaerobic digesters are available for the production of high quality compost from organic waste materials. Poor quality compost is a major concern for the composting industry and users of compost. Modern digester design allows control and precision in composting hence high quality compost can be achieved by the use of such facilities.

## 2.3 Poultry litter and animal waste processing

Organic fertilisers are also generated from naturally occurring organic materials arising from bird and animal industries (e.g. FYM, chicken litter, animal manure, worm castings, compost, seaweed and bone meal) or naturally occurring mineral deposits (e.g. saltpeter). Unprocessed poultry litter and cattle manure often create environmental and disposal problems. However, developing fertiliser products from animal wastes, such as manure and bones through controlled processing into granulated fertilisers or phosphate-rich bone meal has great potential.

The poultry industry in Nepal has seen steady and continuous growth and is consolidating rapidly. The average size of farms is increasing and the industry is well distributed in different Development Regions in Nepal. Our previous estimate showed that poultry manure alone amounts to about 0.3 million tonnes in Nepal annually. This sum will increase further as the poultry industry expands. The livestock produce more than this amount. FYM is produced in quantity in the countryside; it is the main source of traditional nutrient in Nepal. Recently, there has been a considerable growth in poultry farming in the country. Management of this product has been a big challenge considering the growing poultry industry. The unprocessed application of poultry manure is common in Nepal where nutrient loss through N leaching and volatilisation is a major problem. Appropriate composting, drying and granulation of poultry manure not only prevents the manure from nutrient loss, but also creates space and time and reduced transportation cost for the farmers in the hills and mountains.

Poultry manure, whether processed or unprocessed, is still a bulky fertiliser. If granulation facilities can be developed in each region, granules will be available for all regions. This will improve the availability of manure and reduce the transport cost for fertiliser distribution. Extensive field trials will be required to evaluate the effects of the granulated products on crop performance. Recently, a poultry litter granulation plant has been installed in Chitwan, Nepal and the granulated products are available in the trade name of ‘Biomal’ for use by growers. The schematic that underpinned the granulation project is presented in Figure 2.

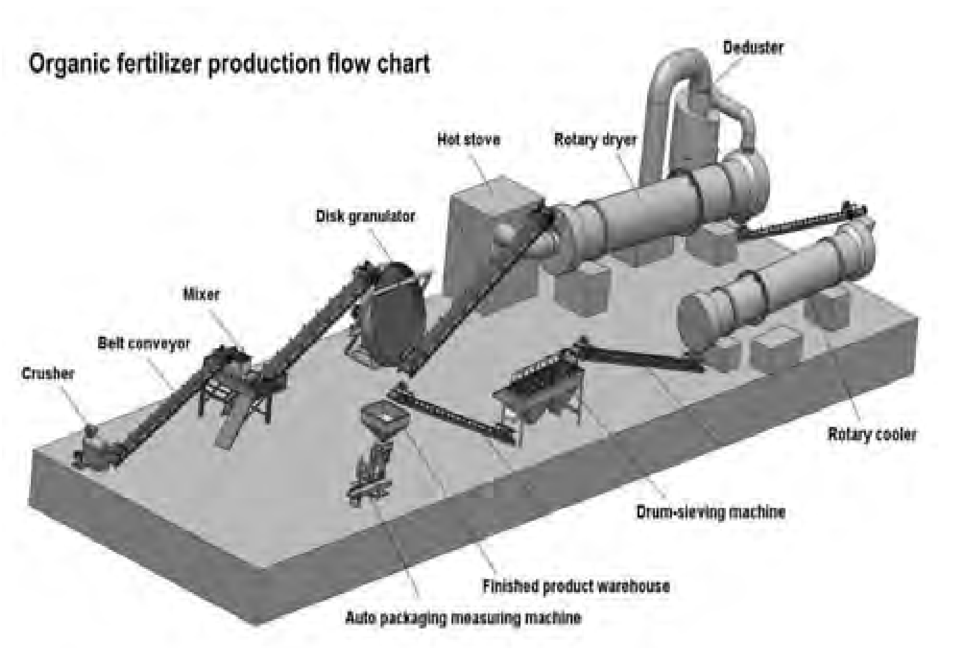


Figure 2: Continuous feed, rotary drum type poultry manure granulation plant
(Source: Wang et al., 2006)

## 2.4 Urban wastes and sludge

Urban waste and sludge can also be another important source of plant nutrients if properly utilised. Human waste as well as animal urine can be converted to high value liquid fertiliser. The conversion is performed by adding magnesium to the urine. The use of urine as fertiliser has the benefit that it contains a large amount of P, and takes away the burden from sewage systems and treatment of wastewater for recycling.

Processed human excreta and recycled sludge (bio-solids) are gradually becoming acceptable as fertilisers provided they are processed to meet quality standard and are free of pathogens. Industrial pollutants in sewage sludge could prevent its recycling as a fertiliser. Country-specific environmental regulations prohibit use of sewage sludge in organic agricultural operations due to industrial pollution, pharmaceuticals, hormones, heavy metals, and other factors. In Nepal, population concentration is in a few major cities and it is easy to collect increasing amounts of sludge in the cities where its disposal pose major challenge. Developing facilities and infrastructures for processing of sludge to fertiliser products can be viable options when developing alternative fertiliser products. Although social and cultural barriers can limit its use, alternative application, such as using sludge in tree crops and cereals and not in fresh vegetable, can be an option.

### 2.5 Other untapped sources of fertiliser

Mineral products such as mined powdered limestone, rock phosphate and sodium nitrate are inorganic compounds, which are energetically intensive to harvest and are approved for organic agriculture. Other organic complexes such as humic substance have also been used as effective compound having substantial nutrient value and therefore are a form of fertiliser. A large number of such products are now available on the market shelf and many of them reach the home garden and hobby farming. However, opportunities exist for developing such products in the future for application in large-scale agriculture.

The amount of nutrients recycled through alternative-fertilisers can potentially supplement the demand currently fulfilled by the inorganic fertilisers in Nepal. There are different alternative fertiliser processes and the choice of options depends on the type of waste material and level of technology available. Use of compost has been known for its positive effects on soil sustainability for a long time. However, its use in commercial agriculture is low due to high costs associated with transport and application. Latest development on processing and granulation of manure/compost provides a new opportunity to expand the use of bio-fertiliser in agriculture.

Fertiliser products from organic sources are presented in various forms. The most typical form is solid stage as granules, pellets, agglomerate, briquettes and powder. The second most common form is liquid. Advantages of liquid fertiliser are its immediate effect and wide coverage. There are also slow-release fertilisers (e.g. Tablets and Spikes from Manutec) which reduce the problem of ‘burning’ the plants due to excess N. Polymer coating of fertiliser ingredients gives tablets and spikes a 'true time-release' or 'staged nutrient release' (SNR) of fertiliser nutrients. Processing of waste and value adding by granulations products and nutrient fortifications are highly recommended. These are only examples and do not represent a comprehensive list of bio-fertiliser options. Bio-char from waste and mixed with plant and animal organic wastes has been seen as a new opportunity in many developed countries, e.g. in Australia, branded as carbon smart fertiliser, and this may be an option in the future for Nepal.

## 3. Conclusion

The traditional sources of plant nutrients, mainly FYM and compost are not sufficient to meet the growing demand of plant nutrients in Nepal. Therefore, use of chemical fertiliser is an increasing trend and its demand is very high. However, there are several institutional, economical and technical limitations with the total dependency on chemical fertilisers. Therefore, it is necessary to seek other sources of plant nutrients for the sustainable crop production and maintenance of soil fertility in Nepal. There is ever growing realisation of economic and environmental significance of alternative fertiliser products in Nepalese agriculture among farmers, social workers, extension agents, and policy makers. It is time that the private sectors and the government develop strategic plans, design business opportunities and promote alternative fertiliser production in the country to reduce the dependency on chemical fertilisers. Establishment of industries dedicated for the development of alternative fertiliser products is a need of the day.

There are now readily available options for processing of these waste streams to formulate fertiliser products so that the quality, nutrient value and transportability of these materials can be improved for large-scale transport, application and adoption by farming communities. Processing techniques that lead to the products such as granules, agglomerates, and briquettes have been suggested. An integrated approach on alternative fertiliser research, development and industry support along with on-farm application trials are suggested to make significant impact of alternative fertiliser technologies for sustainable soil management in Nepal.

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## References

ANZDEC (2002). *Nepal agriculture sector performance review* (ADB TA No. 3536-NEP): *Main report prepared for MOAC and Asian Development Bank.* New Zealand: ANZDEC Limited.

Bhattarai, T. C. (2011, April 6). Nepal: The poultry industry. Meat trade news daily. *My Republica*.

Carroll, S., Steven B., & Steven, D. (2004). Ecology for gardeners. Cambridge: Timber Press. ISBN 9780881926118.

Devkota, L. N. (1990). Deciduous fruit production in Nepal. In: M. K. Papudemetrious & E. M. Herath, Eds., *Deciduous fruit production in Asia and the Pacific.* RAP Publication 1990/10. Rome: Food and Agriculture Organization.

Jan Erisman, W., Sutton M. A., Galloway, J. Klimont, Z. & Winiwarter, W. (2008). How acentury of ammonia synthesis changed the world. Nature Geoscience, 1 (10), pp. 636.

Häussinger, P., Reiner Lohmüller, & Allan M. W. (2000). *Ullmann's encyclopedia of industrial chemistry,* Volume 18. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA., pp. 249–307.

IDL Group, (2006). APP *Implementation status report (Vol 1): Main Report prepared for the Government of Nepal.* Kathmandu: NARMA Consultancy Pvt. Ltd.

IFA (2002). Statistics, fertilizer indicators, details, raw material reserves. (2002–10). [online]. Available at: www.capitalco.com.au/Portals/0/Docs/Fertiliser_Chemical/Fertiliser.pdf

Khatiwada, N. R., Thapa, A. & Shakya, S. M. (2013). Biomass utilization for waste treatment and energy production: A review in the context of Nepal. Paper presented on March 7, 2013 in: the proceedings of *Current status and future perspective of waste biomass utilization in Nepal,* Kathmandu: SchEMS.

Lawrence, F. (2004). Not on the label. London: Penguin. p. 213.ISBN 0-14-101566-7.

Lemunier, M., Cédric, F., Sandrine, R., Houot S., Dantigny P., Piveteau P., & Guzzo J. (2005). Long-term survival of pathogenic and sanitation indicator bacteria in experimental biowaste composts. *Applied and Environmental Microbiology,* 71 (10), pp. 5779–5786.

MOAD (2011). Ministry of Agriculture Development, Government of Nepal, Kathmandu.

Moore, G. (2001). *Soilguide: A handbook for understanding and managing agricultural soils.* Perth: Agriculture Western Australia. pp. 161–207.

Mortvedt, J. T. (1996). Heavy metal contaminants in inorganic and organic fertilizers. *Fertilizer Research*, 43, pp. 51-61.

Motghare, H., & Gauraha, R. (2006). *Bio-fertilizers - Types & their application.* [online]. Available at: *http//:www.krishisewa.com/cms/articles/organic.../115-bio-fertilizers.html*

OPM (2003). *Nepal Fertilizer Use Study. A study funded by the UK Department for International Development (DFID), Kathmandu:* Oxford Policy Management (OPM) and Ministry of Agriculture and Cooperative (MOAC).

Pandey, S. P. (2013). Role of Fertilizer in Transforming Agriculture in Nepal. Paper presented on September 25-27 in: *Agricultural transformation in Asia: Policy options for food and nutrition security.* Siem Reap, Cambodia: Non-resident Nepali Association.

Pant, D. B. (2013). *Study on the status and energy content of municipal solid waste of Butwal municipality.* A Dissertation Submitted to Central Department of Environmental Science, Tribhuvan University Kathmandu, Nepal.

Pokhrel, D. & Virarahghavan, T. (2005). Municipal solid waste management in Nepal: practices and challenges, *Waste Management,* 25, pp. 555-562.

Stewart, W. M., Dibb, D. W., Johnston, A. E., & Smyth, T. J. (2005). The contribution of commercial fertilizer nutrients to food production. *Agronomy Journal,* 97, pp. 1–6.

Tennakoon, N. A., & Hemamala, B. S. D. (2003). Nutrient content of some locally available organic materials and their potential as alternative sources of nutrients for coconut. *COCOS,* 15, pp. 23–30.

Venkataraman, G.S. (1972). *Algal Fertilizer and Rice Cultivation:* Today and Tomorrow. New Delhi: Printers and Publ. pp 75.

Wang, F. Y., Ge, X. Y., Balliu, N. I. T., & Cameron N. I. T. (2013). Optimal control and operation of drum granulation processes. *Chemical Engineering Science,* 6, pp. 257-267.

Zublena, J. P., Baird, J. V. & Lilly, J. P. (1991, June). *Soil facts - Nutrient content of fertilizer and organic materials.* North Carolina Cooperative Extension Service. Retrieved on 3 January 2013.

4

# Application of Plant Breeding and Transgenic Crops for Sustainable Agriculture Development in Nepal

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## Abstract

History has witnessed the role of plant breeding and crop improvement in revolutionising world agriculture. More recently, advances in biotechnology and molecular genetics have enabled transgenic modification of crop plants for specific traits such as yield potential, plant architecture, disease resistance, stress tolerance and health benefits, making crop improvement more efficient and realisable. While the agriculture sector in some industrialised countries, particularly in the USA and Canada, have been using transgenically modified crops, such as maize, soybean, canola and cotton for increasing agriculture productivity, in Nepal the adoption of such crops is still a matter of discussion and debate. Any discussion on the use of modern plant improvement techniques, particularly transgenic modification, cannot ignore the subsistence nature of Nepal's agriculture and the need for its sustainability. In this article, we present the overall status of plant breeding and a possible role of transgenic crops in increasing productivity of major crops in Nepal. The utilisation of modern crop improvement and transgenic crops are discussed in the light of potential benefits and threats in the Nepalese context for sustainable food production.  Second generation biotechnological tools have been included in the discussion that are expected to be relevant not only for sustainable food production, but also for health benefits. A possible scenario of using transgenic crops in Nepal has been presented based on available data and experience for herbicide tolerant and insect resistant transgenic crops in neighbouring India and China. We conclude that conventional plant breeding aided by modern tools of biotechnology will play a vital role to enhance the crop yield and agricultural productivity in Nepal. A transgenic crop, in spite of its rapid adoption in some countries, has to be considered cautiously to safeguard food security and genetic diversity.

## 1. Introduction

In about 11,000 years history of crop domestication, several direct or indirect selections of crops resulted into the current forms of various crops (Jauhar, 2006). Over the period of human civilisation, we used our skills and knowledge of crop production to nourish ourselves, which ultimately helped to develop agriculture industry. Therefore, it can be argued that agriculture is one of the oldest industries that human being had to develop for their survival. The art of plant breeding started with crop domestication and developed along with human civilisation (Redding 1988). However, the scientific basis of plant breeding began with the rediscovery of laws of genetics, which is the basis of plant breeding (Allard 1960; Jauhar 2006). Since the inception of Mendelian genetics, it has been utilised to improve crop varieties for various traits of interest. Breeding objectives have been to improve crop plants for various aspects of food, feed and fiber production. These aspects include plant architecture, disease and insect resistance, yield potential, product quality (structural or compositional quality), plant height, harvest quality and ease of mechanisation. With the looming threat of global climate change, crop variety needs for a specific area is likely to be changed. Those objectives may include drought tolerance, heat tolerance, combating to emerging new pests, or the combination of all the above factors. Since climate change is inevitable, plant breeding will have to address these challenging and confounding objectives sooner than later.

Conventional plant breeding for sexually propagated species involves hybridisation followed by selection from a segregating population, which began in Neolithic era by hunter-gatherers and it is still a powerful method (Allard 1960). Over the time, different methods of plant breeding have been developed, but the basic principle of ‘selection from a segregating population’ remains the same. Widening the genetic base of variation and finding the efficient ways of identifying the traits of interest are vital to increase the chances of success in the breeding efforts. Different breeding methods were employed at different times to increase the genetic variation followed by selection.

Mutation breeding were used during the 1920s. Chemical mutagenesis and irradiation methods were developed as mutagens. These mutagens were used more extensively after 1940. However, it could not replace traditional hybridisation method. Although mutation breeding produced more than 1,500 varieties of a number of crops ranging from staple crops to ornamentals (Kharkwal et al., 2004), the numbers of varieties from mutation breeding were far less than those from the conventional breeding.

Manipulation of ploidy level (chromosome engineering) including aneuploidy (variation of a single chromosome) was thought to be the best approach to solve many problems of agriculture during the 1940s and 1950s. During this period, cytogenetics was booming. Many plant breeders developed aneuploid lines for different crops including wheat *(Triticum aestivum* L.*)* and tomato *(Solanum lycopersicum* L.*)*. This was helpful to localise certain genes on a particular chromosome. Later in the 1970s, tissue culture including callus culture and somaclonal variation, micro-propagation, wide hybridisation followed by embryo rescue, another culture, double haploidy and other aspects of in vitro cultures were developed and thought to be the important aspect of plant breeding (Baenziger et al., 2006). Consequently, a significant emphasis was placed in these areas. While it took a significant share of the research resources and industry interest, they could not replace the traditional plant breeding method. However, these techniques became very useful tools for the conventional breeding methods and almost became integral parts of breeding programs. These methods, however, were found to be more useful in perennial crops including fruits, ornamental and trees where regular hybridisation followed by selection is practically difficult because of their long life cycle.

With the development of genetic transformation techniques in 1980s, a number of transgenic crops were developed in various parts of the world. Although it has been a subject of controversy and debate, it offers a promising technology to solve the number of problems which otherwise can be highly challenging with the conventional breeding methods. Since 'FlvrSavr' tomato with long shelf-life was launched in 1994 as a first transgenic crop, several crops including Bt (*Bacillus thuringiensis*) cotton *(Gossypium hersetum L.)* and maize *(Zea mays L.)* for certain insect resistance, and Roundup (glyphosate) ready soybean *(Glycine Max L.)* and canola *(Brassica napus L.)* have been commercialised (James, 1998). Currently, transgenic cotton, soybean, maize and canola are commercially grown in North America and several other countries. Several new biotechnological advances have been made that are being employed in private as well as public plant breeding institutions throughout the world (Lusser et al., 2012). With the development of molecular markers in the 1980s, it has revolutionised the plant breeding process. Molecular markers are fragments of DNA sequences with a similar segregation and inheritance pattern of a gene, but they do not confer a trait like a gene. They are closely associated with traits of interest. The environment affects most of the economic traits in plants and it is difficult to identify the plants phenotypically for given traits. The molecular markers, however, are not affected by the environment and provide a powerful tool in selecting individual plants in a breeding program. In recent years, the development of molecular markers of different types has reshaped the plant breeding methods. These markers help mapping and fine-mapping of genes on the genome in addition to facilitating marker-assisted selection (MAS). The MAS can increase the precision and efficiency of selection, and reduce the breeding time.

The objective of this chapter is to present the perspective of modern crop improvement techniques including transgenic crops and their potential benefits and threats to sustainable food production in Nepal. The contribution and usefulness of conventional as well as transgenic modification of crops for agricultural advancements are discussed based on the review of literature as well the experience of the authors in the area of genetic improvement of food crops.

## 2. Role of plant breeding in global food security

Contribution of plant breeding to food production in the past should be judged based on historical facts. It can be discussed in terms of improvements in yield and quality, disease and insect-pest resistance, and seed or fruit composition. Increase in crop yield is the most important aspect for growers. Hence this is used as an example in the discussion of contributions to plant breeding. The average maize yield in the USA was 1,966 kg/ha in the year 1930 which more than tripled to 7,130 kg/ha in the year 2010 (Economic Research Service, 2014). The main reason for such gains was due to the exploitation of hybrid vigour. The duration from 1930 to 1970 is regarded as the period when the benefits of conventional breeding were realised. During this time, hybrid vigour was exploited in maize and yield increase in other cereals was simply by conventional breeding methods (Khush, 1999). Contrary to this outcome, the rate of crop improvement differed from country to country. For example, the rate of yield improvement of wheat in Nepal over the last 50 years was not comparable with other developing countries (Figure 1).

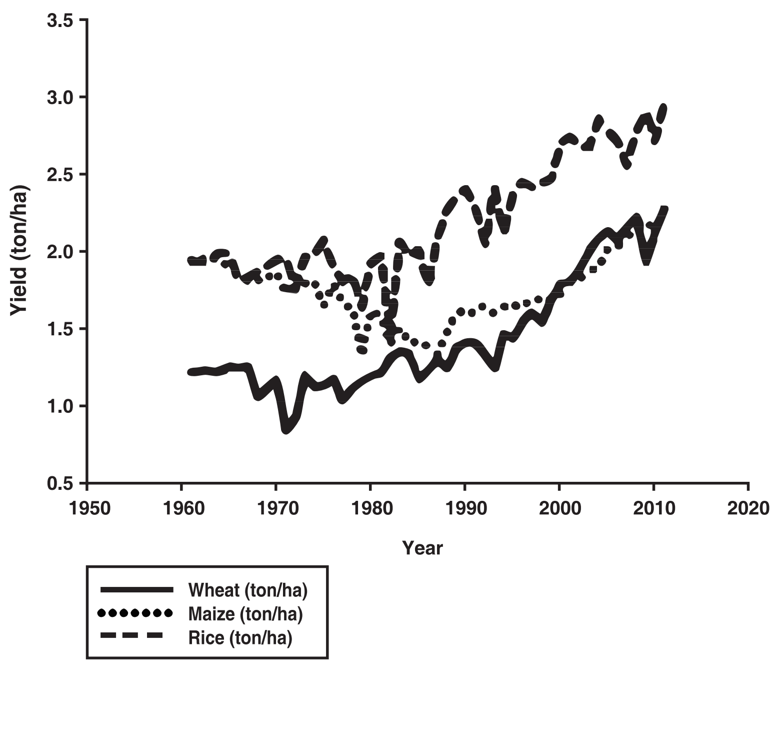
Deployment of dwarfing genes in wheat and rice in the 1960s brought about the Green Revolution in certain countries in Asia. The development of dwarf wheat, which did not involve any biotechnology or molecular breeding, resulted in a significant increase in crop production, particularly in the Indian Sub-continent. The overall food production increased substantially and once ‘food deficit’ countries became ‘food surplus’ countries within a short time. This avoided the predicted famine in South Asia in the 1970s due to a rapid increase in the population, but a very slow increase in food production. It led some researchers to conclude that production as such may not be a problem rather equitable distribution may be a challenge to alleviate poverty (Borlaug, 1997).It is important to note that up to 90% of the production is attributed to the improved varieties (Bruins, 2009) highlighting the importance of genetic gain through plant breeding.

The projected food demand of the world by 2025 and the required yield increase of major cereals to meet this demand is presented in Table 1. This shows that there will have to be a significant yield increase of staple crops. All the better cropland of the world is now cultivated and there is no more farming land available to increase the production. Therefore, increased food and feed production must come primarily from the land that is now under cultivation. There will be an important role of plant breeding to increase the production to keep pace with any population growth. In a survey conducted over 188 countries on major cereal crops showed a general trend of yield increase was found in most of the countries (Hafner, 2003). More specifically, maize and wheat production increased by 62 and 43 kg/ha/year, respectively, but rice production increased only by 6 kg/ha/year. However, a decreasing trend in productivity was observed in about 10% of the countries. It has been estimated that food production will have to be increased by about 70% by 2050 to meet the food demand of the world (FAO 2009; FAOSTAT 2005). The yield increase in major crops has reached a plateau; therefore, some novel plant breeding techniques will need to be developed to meet these targets. The conventional plant breeding supplemented by modern biotechnological tools will have the capacity to achieve this goal (Jauhar, 2006).

**Table 1:** A projected production and required yield of major cereal crops to meet the food demand of growing population by 2025 (Source: FAOSTAT, 2005).

| Crop | Projected production in 2025 (billion ton) | Required yield in 2025 (ton/ha) |
|---|---|---|
| Wheat | 1,200 | 4.4 |
| Rice | 1,030 | 5.3 |
| Maize | 1,070 | 5.8 |
| Barley | 350 | 4.1 |
| Sorghum | 180 | 2.6 |
| All cereals | 3,970 | 4.5 |

An optimistic view has been painted by Borlaug (1997). He proclaimed that crop yields could still be improved by 50-100% in most countries of the South Asia, east Europe and Latin Americas, and by 100-200% in African countries by utilising the existing genetic resources. However, he realised that it would be extremely challenging to achieve the yield gains in China, North America and Western Europe where yield gains have already reached a plateau for most of the crops.



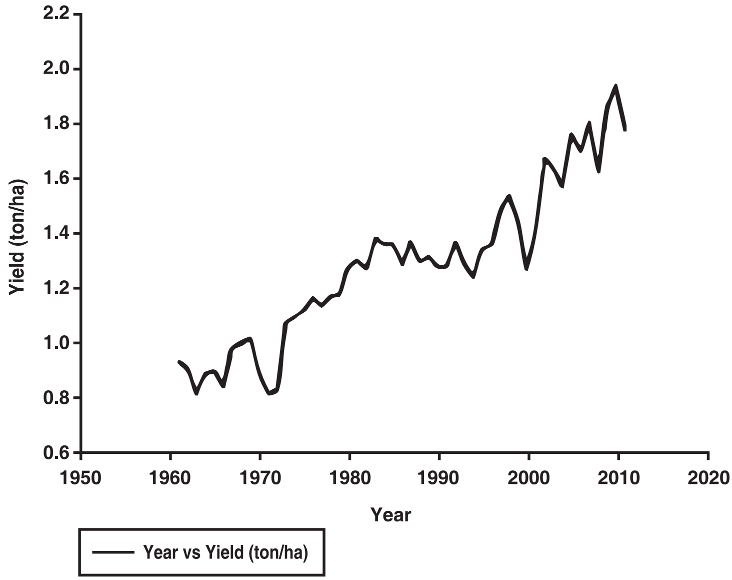



**Figure 1:** Contribution of plant breeding in improving the major crops. (A) Average yield of wheat in developing countries since 1961 and (B) Average yield of rice, wheat and maize in Nepal at the same period (Source: FAOSTAT, 2012).

## 3. Role of plant breeding in Nepal

The average annual growth rate of cereal production in Nepal is much lower than the population growth rate, indicating a real problem in meeting food needs of the country. At the current growth rate, Nepal will face consistent food deficits at the national level even when growing conditions are favourable.

As realised by the Green Revolution in the 1970s, agricultural research using mainly plant breeding can play a significant role in increasing food production, thus lowering food prices for food-insecure households and increasing farm incomes for the rural poor. Improvement to increase the crop production can be realised by adoption of improved varieties, utilisation of high levels of inputs such as inorganic fertilisers, timely control of insect-pests, plant disease control, improvement in irrigation facilities, and the implementation of supportive government policies.

In Nepal, systematic plant breeding began during the 1960s at the public level. The Nepal Agricultural Research Council (NARC), a government agency responsible for crop improvement is mainly working with open pollinated and inbred varieties, it is still heavily reliant on the Consultative Group on International Agricultural Research (CGIAR) centres and other national crop research programs for breeding germplasm. Although NARC has produced more than 200 varieties of cereals in this period, more current varieties are not adopted by farmers. So far, NARC has released over 140 varieties of rice, maize and wheat of which, only 60% of the functional varieties are in demand for rice, and only one third in case of maize and wheat. For example, over 85% of the foundation seed demand for rice was for the varieties released before 1995. This was 75% for maize and around 36% for wheat (Joshi et al., 2012; Witcombe et al., 2013).

Although hybrid maize production started many decades ago in the US, it was only recently approved by the National Seed Board in Nepal (Joshi et al., 2012). Consequently, private companies registered three maize hybrids recently. Although the National Seed Policy (NSP) of 1999 opened up research on genetically modified organisms (GMOs) and transgenic technologies following biosafety rules and regulations, no GMOs have been tested or released for cereal varieties in Nepal (Acharya, pers com.). Plant Variety and Farmers Rights Protection Bill with the provision of Plant Breeders' Rights that is compatible with international norms has been recently formulated, but it is yet to be approved by the government.

There is a wide gap between the potential yield at the research level and yield obtained at the farmer level. According to the NARC, the average yield reported for some of the improved varieties of rice, for example, is as high as 7.9 t/ha and most of the improved varieties yield more than 4.0 t/ha, which is much higher than the average yields reported in Figure1. A similar situation was found for both wheat and maize varieties. It shows that the cereal production in Nepal can be easily doubled by narrowing this gap by adopting modern varieties and improved cultural practices. Recently, some private seed companies and small seed enterprises (SSEs) have been emerging as important producers and suppliers of seeds of major food crops in Nepal. One of the recently established seed companies also has research components. Similarly, private companies from the neighbouring countries have already registered for selling hybrid maize and rice varieties in Nepal. This indicates that the environment for competition and creation of crop innovations will progress further in the future. However, it remains to be seen how these new varieties serve small land-holders in Nepal (Joshi et al., 2012).

Private companies or national and international non-government organisations (NGO/INGO) will play a role in meeting the demands of hybrid seeds. However, currently the private sectors are in their infancy hence the public sector will have to take a leading role in providing novel technologies for growers until the private sectors become strong. In the present world, technology may not be a problem, but its availability and use in right time by right people will be the major limitation.

## 4. Limitations of conventional and molecular plant breeding

Despite the significant contribution of conventional plant breeding in agriculture, as discussed above, there are limitations in achieving the stipulated objectives. The major limitations of conventional breeding include the difficulty of correctly identifying the traits of interest and the long time requirement for developing a variety. Conventional breeding, based on the phenotypic selection, takes a large amount of space and time to identify a genotype with the combination of desirable traits. With the availability of technology and competitiveness among private companies for the better product in the shortest time possible, it is essential to use the available technology such as genome-based selection and marker-assisted selection. The molecular breeding tools will help to shorten the overall variety development and release time.

Molecular breeding has been used routinely in industrialised countries whereas it is yet to be introduced in several developing countries because of their limited technological capacity (Varshney et al., 2005) and a lack of resources. We believe that, molecular breeding will be an integral part of conventional breeding eventually even in developing countries including Nepal. Molecular breeding is adopted mainly to increase the efficiency and precision of crop improvement (Chapotin & Wolt, 2007). It has been found to be useful to reduce the breeding cycle if used in combination with the conventional breeding. However, there are a number of limitations of this approach that should be taken into consideration as follows:

i. **Cost:** One of the major concerns is cost involved in the development of molecular markers associated with the trait of interest (Dreher et al., 2003; Morris et al., 2003). It is expensive to develop molecular markers that can be effectively used in a breeding program. However, technology is changing and less expensive techniques are likely to be available in the future.

ii. **Usefulness across the populations:** When molecular markers are developed, a limited number of genotypes or population with narrow genetic background are used. This may lead to the situation in which the markers may not be cross transferable across the populations (Foolad & Panthee, 2012). This limits their usefulness; however, the development of locus-specific markers may address this issue in the future.

iii. **Nature of the traits:** Most of the economic traits are quantitative—controlled by several genes. The development of molecular markers is relatively easy for traits controlled by few major genes, but it is extremely challenging for quantitative traits.

iv. **Changing technology:** The molecular marker technology is rapidly changing as there is a lot of emphasis on the research at molecular or DNA level in various parts of the world. This will require new expertise, equipment and software to keep up with the advancements to employ the technology successfully.

## 5. Current state of transgenic crops around the world

Since the first field trial in the USA and France that took place in 1986 with transgenic tobacco *(Nicotiana tabacum)* containing a marker gene (James & Krattiger, 1996), the field trials and commercial adoption of transgenic crops have continued. The People's Republic of China was the first country to allow commercialisation of transgenic plants by introducing a virus-resistant tobacco variety in 1992 (James, 1998). In 1994, the European Union approved a tobacco strain engineered to be resistant to the herbicide bromoxynil, making it the first genetically engineered crop marketed in Europe (MacKenzie, 1994). The first transgenic crop to be approved for production and marketing in the USA was FlavrSavr tomato in 1994 (Bruening & Lyons, 2000). The genetic modification allowed the tomato to delay ripening after picking.

Compared to 1990s, currently as many as 11 genetically modified (GM) crops are under commercial cultivation in 27 different countries (James, 2013). In 2013, a record 18 million farmers, in 27 countries planted 175 million ha of transgenic crops (James, 2013). Transgenic traits are the fastest adopted crop technologies in the history of modern agriculture, a 100-fold increase in area planted from 1.7 million ha in 1996. Even though, the list of transgenic crops under development is large, currently only four crops namely, soybean (47%), maize (32%), cotton (15%) and canola (5%) contribute to more than 99% of total transgenic crop area in the world. The current transgenic crop traits in commercial application include herbicide tolerance, insect resistance, disease resistance, modified fatty acid content, modified starch content, reduced nicotine content, increased shelf-life, delayed fruit softening and modified flower colour (Table 2). Despite this diversity, currently almost entire transgenic crop area is limited to herbicide tolerance and insect resistance traits. Outside USA, the Bt cotton tops the list.

Based on data from the European Commission, development and commercialisation (2009), transgenic crops is mostly driven by private industries (Figure 2). Out of 91 different transgenic crops, 85 were developed and marketed by private industry organisations either alone or in partnerships. Monsanto topped the list with 23 products alone or with a partner.

**Table 2.** Commercialised transgenic crops with their transgenic traits, Center for Environmental Risk Assessment (CERA, 2012)

| Crop | Phenotypic Trait |
|---|---|
| Alfalfa *(Medicago sativa)* | Herbicide tolerance, modified fatty acid content, fertility restoration |
| Carnation *(Dianthus caryophyllus)* | Increased shelf-life, herbicide tolerance, modified flower color |
| Chicory *(Cichorium intypus)* | Herbicide tolerance, fertility restoration |
| Cotton *(Gossypium spp)* | Resistance to Lepidopteran pests, herbicide tolerance |
| Creeping Bentgrass *(Agrostis stolonifera)* | Herbicide tolerance |
| Flax *(linseed) (Linum usitatissimum)* | Herbicide tolerance |
| Lentil *(Lens esculenta)* | Herbicide tolerance |
| Maize *(Zea mays)* | Herbicide tolerance, Lepidopteran and Coleopteran insect resistance, enhanced lysine content, modified alpha amylase, mannose metabolism, hybridisation system, drought tolerance |

| Crop | Phenotypic Trait |
|---|---|
| Melon *(Cucumis melo)* | Delayed ripening |
| Papaya *(Carica papaya)* | Resistance to papaya ringspot virus |
| Plum *(Prunus domestica)* | Resistance to plum pox virus (PPV) |
| Polish Canola *(Brassica rapa)* | Herbicide tolerance |
| Potato *(Solanum tuberosum)* | Resistance to Colorado potato beetle, potato leaf roll luteovirus, potato virus Y, altered starch composition |
| Rice *(Oryza sativa)* | Herbicide tolerance, golden rice (enriched with vitamin A) |
| Soybean *(Glycine max)* | Herbicide tolerance, modified seed fatty acid content, resistance to lepidopteran pests |
| Squash *(Cucurbita pepo)* | Resistance to watermelon mosaic virus, zucchini yellow mosaic virus, cucumber mosaic virus |
| Sugar Beet *(Beta vulgaris)* | Herbicide tolerance |
| Sunflower *(Helianthus annus)* | Herbicide tolerance |
| Tobacco *(Nicotiana tabacum)* | Herbicide tolerance, reduced nicotine |
| Tomato *(Solanum lycopersicum)* | Increased shelf-life, delayed softening, resistance to lepidopteran pests |
| Wheat *(Triticum aestivum)* | Herbicide tolerance |

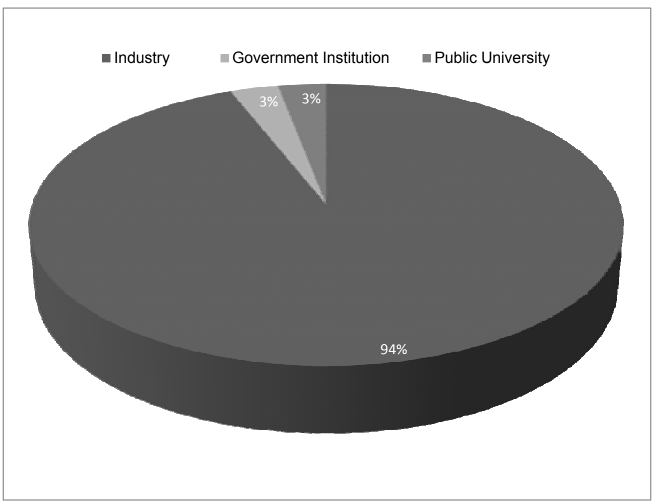



**Figure 2:** Contribution of three different sectors in the development of transgenic crops (Source: Stein & Rodŕiguez-Cerezo, 2009)

The USA continues to be the leading country with 69 million ha of transgenic crops planted followed by Brazil (30.3 million ha) and Argentina (23.7 million ha) (James, 2011). In Asia, India (10.6 million ha) and China (3.9 million ha) are the two major adopters of transgenic crops. In India, Bt cotton is the only transgenic crop grown, while in China, adoption of virus resistant papaya and Bt poplar is increasing in addition to Bt cotton (James, 2011). It is noteworthy that both India and China have not yet adopted any transgenic crops.

In spite of the adoption of transgenic crops by several countries around the world, there is a guarded excitement and acceptance of this technology by general public and governments. The major issues of concern are biosafety and food security. Concerns of biosafety include issues, such as the effects of transgenic crop products on human and animal health, biodiversity and environment. Therefore, the transgenic crops need to go through a rigorous testing process set by a country. The industrialised nations are more concerned with biosafety issues than food security and the regulatory processes and requirements are more geared towards testing the effects on health and environment. The regulatory process and compliances are controlled by legislation and well established in the USA, Canada, Australia and the European Union. In the USA, for example, government agencies such as Environmental Protection Agency, Food and Drug Administration and United States Department of Agriculture are responsible for the regulation of transgenic crops/products.

In the less-industrialised countries, there is either a lack of a holistic approach to transgenic crop regulation or the approach is not implemented completely. The Philippines was the first ASEAN (Association of South East Asian Nations) country to legislate the control of transgenic crop technologies, and has adopted the similar legislation processes used in the USA (James & Krattiger, 1996). Other countries, such as Brazil, Chile, China, Costa Rica, Cuba, India, Mexico and Thailand have operational field testing regulations. However, the implementation of the regulations and product stewardship may not be up to the task. The rapid emergence of cotton bollworm resistance to Bt cotton in India and China underscores the need for a careful adherence to stewardship guidelines, such as using refuge and crop rotations in order to get the full benefits from transgenic crops (Nemana, 2012; Stolte, 2012). These guidelines can be difficult to follow for small farmers making it nearly impossible to enforce them in less-industrialised countries. This will lead to problems as seen with Bt cotton in China and India.

Food security is an issue of concern mainly for the less-industrialised nations. In these countries, there is a prevalence of small farmers with inadequate resources and farming in general is at subsistent level. Any crop failures in such countries mean food deficits and political instability. The food security concern stems from several situations, such as: dependence on a foreign company for seeds, loss of local crop diversity and ultimately unavailability of locally adapted/produced seeds when needed, increased risk of crop failure due to monoculture, dependence on complementary technology such as herbicide for herbicide tolerant crops and increased cost of farming and debt-burden particularly for small farmers.

The two neighbouring countries of Nepal have been cautious in growing transgenic crops for food. Although China gave biosafety approvals to phytase maize and Bt rice in 2009, the commercial approval is not yet granted. Chinese scientists and regulators are more concerned with the introduction of transgenic rice than transgenic maize. China is the largest producer and consumer of rice in the world and several observers fear that introducing transgenic rice could endanger the food supply and the environment. The consequences would be unthinkable if large-scale cultivation of GM rice were not properly regulated in China (Qiu, 2008). However, some others argue that using GM rice is the only way to meet the growing food demand. If transgenic rice is introduced in China by a foreign owned company, it can effectively control the production of such an important crop. One way China wants to avoid this problem of seed control by foreign companies is by developing her own transgenic rice.

Although the Government of India is more accepting of transgenic crops, it is ongoing public pressure that is keeping the cultivation of transgenic food crops off the fields. Despite the public pressure, about 88% of India's cotton is transgenic crop with Bttrait. In 2010, India imposed a moratorium on Bt brinjal field trials. In October 2012, a Scientific Committee appointed by the Supreme Court of India advised a 10-year moratorium on all Bt food crop trials (Asian Scientist, 2012). The committee recommended overhauling all regulatory processes to ensure transgenic crops present no risk to human health and the environment. However, India's top regulatory body —Genetic Engineering Appraisal Committee (GEA— has recently endorsed confined field trials by multi-national seed companies of certain crops including wheat, rice, maize and cotton indicating India continues to argue for a wider and liberal adoption of transgenic crops, including food crops.

## 6. Scope of transgenic crop traits in Nepal

Often transgenic crop traits are classified as 'input' or 'output' traits. If a trait alters inputs needed to produce the crop, it is an 'input' trait, such as herbicide tolerance, insect resistance, disease resistance, drought tolerance and increased nutrients utilisation efficiency. On the other hand, if a trait alters the produce quantitatively or qualitatively, it is an 'output' trait, such as protein content or quality, fatty acid content, starch composition and yield. Among the input traits, herbicide tolerance and insect resistance were the first two widely adopted transgenic traits. Herbicide tolerance and insect resistance were combined in the same genotype to accomplish, 'stacked traits' wherein a farmer can manage both weeds and insects using the same variety (Martino-Catt & Sachs, 2008). However, repeated use of a single mode of herbicide action led to the development of herbicide tolerant weeds. Similar situations occurred with the use of insect resistant crops where insects developed resistance to the transgenic gene products (toxins).

These problems are being managed by combining different modes of action in the same variety. The herbicide tolerant and insect resistant traits are also called the first generation transgenic traits. More complex traits such as drought tolerance, nutrient utilisation, nutritional quality or high yield potentials are called next generation or second generation traits.

In Nepal, usually farmers' access to agricultural inputs is not assured and the level of use is low. Official statistics report only 19 kg fertiliser/ha/year on cereals in Nepal (Gulati et al., 2010). In the case of such low input agriculture, 'input' traits such as insect resistance, disease resistance, efficient nutrients utilisation, drought tolerance, heat tolerance, cold tolerance, hypoxia/anoxia tolerance etc. can provide a big relief to farmers. Herbicide tolerance, even though an input trait, still requires the use of herbicide as an input, and therefore, may not be as important as the other traits mentioned earlier. Since a large portion of the agricultural produce is consumed by farmers themselves and malnutrition is prevalent, output traits enhancing nutritional quality and yield will be equally important in Nepal. Golden Rice, that produces β-carotene—a substrate for vitamin A, could be one of such transgenic products to alleviate night blindness and xerophthalmia (dryness of eyes), common problems associated with Vitamin A deficiency in developing countries (Tang et al., 2009).

According to 2008 World Bank estimates, only about 28% of agricultural land in Nepal is irrigated. Untimely rain, flood and drought conditions significantly impact crop production. For example, maize yield was reduced by up to 70% (Newar, 2012) and rice yield by 15% (Oryza.com newseditor, 2012) due to drought conditions in 2012 compared to the previous year. Therefore, abiotic stress tolerance in general and drought tolerance in particular, would be of big benefit to Nepalese farmers. Similarly, insect and disease resistance would also be beneficial by reducing pesticide use and crop loss. Table 3 lists some important crops, area planted, transgenic traits available and the traits that would be useful in Nepal. Tomato is the second most important vegetable crop in Nepal after cauliflower, if potato is excluded as a vegetable crop (Anonymous, 2011). Every year tonnes of tomato crop is wasted in transit and storage due to its short shelf life. Use of delayed ripening and senescence traits in transgenic tomato varieties can significantly prevent the post-harvest losses of tomato.

**Table 3.** Some important transgenic crops currently available around the world that may be useful in Nepal.

| Crop | Transgenic traits | Traits significant to Nepal |
|---|---|---|
| Cotton *(Gossypium hirsutum* L.*)* | Herbicide tolerance, insect resistance *(Bt)* | Insect resistance |
| Maize *(Zea mays* L.*)* | Modified alpha amylase, mannose metabolism, hybridisation system, Colepteran and Lepidopteran resistance, herbicide resistance, drought tolerance | Insect resistance, drought tolerance |
| Papaya *(Carica papaya)* | Viral disease resistance | Viral disease resistance |
| Plums *(Prunus domestica)* | Viral disease resistance | |
| Canola *(Brassica napa)* | Herbicide tolerance | |
| Potato *(Solanum tuberosum* L.) | Coleopteran resistance, viral resistance, modified starch/ carbohydrate, herbicide resistance, late blight resistance | Viral disease resistance, late blight resistance |
| Rice *(Oryza sativa L.)* | Anti-allergy, lepidopteran insect resistance, herbicide resistance, vitamin A (Golden Rice) | Insect resistance, Golden Rice |
| Soybean *(Glycine max L.)* | Herbicide tolerance, modified oil/fatty acid, Lepidopteran resistance, | None |
| Tomato *(Solanum lycopersicum L.)* | Delayed ripening, senescence, delayed fruit softening, cucumber mosaic virus resistance | Delayed ripening and senescence |
| Wheat *(Triticum aestivum L.)* | Herbicide tolerance | None |

(Source: FAOSTAT, 2012)

## 7. Transgenic crop traits

Significant benefits from growing transgenic crops such as herbicide tolerance and insect resistance have been reported. For example, the herbicide tolerance in any crops implifies weed control because weeds can be killed using non-selective herbicides. Thus, farmers can get weed-free crops resulting in a higher crop yield.

Globally, transgenic crop traits increased farm income by $33.8 billion from 1996 to 2000 (Brookes & Barfoot, 2008). The use of herbicide tolerant soybean contributed $17.5 billion with about 4% reduction in herbicide use. Similarly, maize contributed $13.2 billion with a reduction of 136.6 million kg of insecticide active ingredient used due to insect resistant maize and cotton (Brookes & Barfoot, 2008) during this five year period. However, conflicting reports have been emerged on the pesticide use trend in transgenic crops. A study from Washington State University concluded that herbicide tolerant crop technology led to a 239 million kg increase in herbicide use in the USA between 1996 and 2011. However, insect resistant Bt crops resulted in reduced insecticide applications by 56 million kg (Benbrook, 2012). Due to the continuous use of glyphosate in herbicide resistant crops in the US, at least 40 weed species have developed resistance towards this herbicide. Similarly, corn borer has developed resistance to the Bt toxin indicating the limitations of transgenic crops in preventing insect damage.

Although the area under transgenic crops is increasing, it is still only a small percentage of global farmland (3.4% of all farmed area). There is increasing opposition of transgenic crops by the public and consequently hesitation by seed companies to invest in this technology, especially in Europe and Australia. Some of the recent developments in transgenic research activities as given below reflect the increasing trend of public opposition towards transgenic crops.

- The complete withdrawal of Badische Anilin- und Soda-Fabrik (BASF) from the EU market due to failure to capture the market share for the GM industrial starch altered potato ‘Amflora’
- A ban on commercial growing of GM crops in seven EU Member States
- GM crops are only grown in five out of 27 EU Members Sates in 2012
- A reduction in area of GM maize grown in four of the six countries where it is grown
- A steep decline in the number of GM test site applications in Europe from over 100 in 2009 to 41 in 2012.

In America, GM crops resistant to the weed killer glyphosate (Monsanto brand name Roundup) remain the lead product followed by insect-resistant crops (Bt crops). In Australia, only Bt cotton and Roundup Ready canola are allowed to grow commercially in certain areas.

In India, adoption of Bt cotton has increased yield by up to 31% and decreased number of insecticide sprays by 39% leading to an 88% increase in profitability (James, 2011). However, concerns have been raised by many farmers because despite increase in crop yield the net returns decreased due to increase in the cost of production (Nemana, 2012). Additionally, aphids replaced cotton bollworms in Bt cotton crops requiring farmers to spray expensive insecticides. Suicides of hundreds of debt-ridden Bt cotton farmers in India made news nationally and internationally indicating a problem in the Bt farming system. A news report in November 2012 reported a 40% reduction in cotton yield in the state of Maharashtra due to the failure of Bt cotton (Pawar, 2012). This was the third year in a row that Bt cotton failure was being reported in Maharashtra. In 2012, the Indian Union Ministry of Agriculture had issued an internal advisory to the cotton-growing states, which suggested that farmers were in an economic crisis since shifting to Bt cotton. "The spate of farm-related suicides in the year 2011-12 has been severe among Bt-cotton growers," it added (Singh Brar, 2012). Maharashtra government banned the sale and distribution of Bt cotton seeds by Maharashtra Hybrid Seeds Company (Mahyco), a partner of US multinational Monsanto, in the State for supplying inferior quality seeds on August 9, 2012 (Annonymous, 2012).

**Table 4.** A possible scenario of adoption of transgenic crops and its effect on current agricultural practices in Nepal.

| Transgenic crop requirement | Current practices | Expected scenarios | Primary effects | Consequences |
|---|---|---|---|---|
| Seed should be purchased for each crop each season | Farmers save their own seed | Increased seed cost | Moral hazard, increased farming cost | Social problems: financial stress, psychological problems, family and social instability, farmer suicides, long term effect on culture and food choices |
| Altered and new germplasm | Locally adapted germplasm | Poor adaptation of foreign developed transgenic crop variety, loss of or static local germplasm | Crop failures, changed focus of public agriculture programs, increased cost of farming | Environmental problems: changed soil properties, altered insect and disease population, herbicide and insect tolerance, loss of crop diversity |
| Follow prescribed cultural practices strictly | Flexible cultural practices | Rules such as refuse and crop isolation area not followed | Resistance development, expectation of high crop returns | National problem: food security, farmer compensation, altered focus of national breeding programs, external influence, political instability, extra regulation and stewardship |
| Stewardship | No need for stewardship | Poor attention to isolation, area planted | Mixing or contamination of transgenic crops with conventional crops | Financial problems: increased farming cost, risk to export market, increase in debt, financial stress, risk to small rural banks, increased interest rate |

## 8. Precautions in using transgenic crops

There are several benefits of growing transgenic crops in terms of increased productivity and reduced cost of production. In Nepal, the majority of the farmers are small land holders and their farming practice is at subsistence level. They have little knowledge of these transgenic crops and extra regulatory process. There are certain requirements for growing transgenic crops and failure to adhere to these practices can result in consequences as outlined in Table 4. The expected scenarios and their primary effects leading to consequences are based on examples of barren maize cobs from growing Monsanto seeds in Nepal, cotton boll worm resistance to Bt cotton in India and China, and herbicide tolerance in US and Canada. The most important considerations while adopting a transgenic crop in Nepal are summarised below:

- The cost of production will increase as farmers buying expensive seed will feel 'obliged' to buy other expensive inputs to realise the benefits offered by the transgenic seed. Failure of this investment due to drought or any other reasons can have disastrous consequences, especially for small farmers. As most farmers in Nepal are small landholders, the impact will be huge extending to the whole community.

- The crop varieties with transgenic traits may not be adapted to the local growing environments, which are more diverse and variable than in industrialised countries. This can lead to crop failures as observed in some hybrid maize trials in Nepal.

- Due to small acreage, development of transgenic crops for specific locations may not be profitable for seed companies in Nepal and such crop varieties which are not adapted to local growing conditions can enter into Nepal from other countries. The adoption of 'smuggled' transgenic crops can escape regulatory compliance, stewardship and proper agronomic practices leading to consequences listed in Table 4.

- Often the government will have to compensate farmers for the crop failure resulting from untested technologies. Alternatively, new transgenic traits will have to be bred into locally adapted cultivars probably by the government agencies, thus diverting the focus away from more pressing problems faced by farmers. A large-scale adoption of transgenic crops will result in loss of on-farm genetic diversity forever. Problems that arise due to not following the guidelines of the technology and stewardship such as planting of refugia or isolation crops can also lead to severe consequences. This will affect food availability which can affect political stability in Nepal.

Thus, there are many factors that need to be considered for formulating regulations for adopting a transgenic crop technology in Nepal. The best approach would be to make approval decisions on an individual basis. Transgenic crops have been in the market of several countries for more than 15 years and plenty of knowledge and experience are available on both the positive and negative sides of this technology. Therefore, Nepal should learn from the lessons of other countries in formulating the strategy and regulations, should it chooses to adopt transgenic seed technology.

## 9. Conclusion

Plant breeding has contributed enormously to the food security of the world and it will continue to play an important role in the future. Nepal has not been able to fully utilise the benefits of plant breeding as much as it could have been. For example, attempts are being made to commercialise hybrid maize in Nepal recently, but this technology has been in use for about 80 years already. In the future, all possible and available technologies should be considered for use to increase the crop productivity. For example, molecular marker technology can be utilised to increase the efficiency of conventional plant breeding. In Nepal, legislations and regulatory processes are not yet developed for transgenic crops. Nor is there conclusive evidence for the benefits of growing such crops for sustainable crop production in a country like Nepal. Additionally, there is a general lack of education on growing and handling transgenic crops among farmers and consumers in Nepal. Therefore, a hurried decision to adopt transgenic crops may not be in the best interest of Nepal. As a guideline, crops that are not staples and do not have a large indigenous genetic diversity can be considered for transgenic trait technology as a first step. As the regulators and the farmers gain more experience with the transgenic technology, crops with higher risk and reward could then be considered.

## References

Allard, R. (1960). *Principles of plant breeding.* New York: Wiley.

Anon. (2011, February 16). Nepal produces veggies worth Rs 45 billion annually. *The Kathmandu Post.*

Anon. (2012, August 9). Maharashtra bans Bt cotton seeds. *Times of India.*

Anon. (2012). Nepal 2012-13 rice production estimated to drop 15%; government fixes minimum prices.*Oryza.*[online]. Available at: *http://oryza.com/content/nepal-2012-13-rice-production-estimated-drop-15-government-fixes-minimum-prices*

Anon. (2012, October, 29). Scientific committee advises halt to indian Bt brinjal trials. *Asian Scientist.* [online]. Available at: *http//:http://www.asianscientist.com/*

Baenziger, P. S., Russell, W. K., Graef, G. L., & Campbell, B.T. (2006). Improving lives: 50 years of crop breeding, genetics, and cytology (C-1). *Crop Science,* 46, pp. 2230-2244. DOI: 10.2135/cropsci2005.11.0404gas.

Benbrook, C. (2012). Impacts of genetically engineered crops on pesticide use in the US- The first sixteen years. *Environmental Sciences Europe,* 24, pp.24.

Borlaug, N. E. (1997). Feeding a world of 10 billion people: The miracle ahead. *Biotechnology & Biotechnological Equipment* 11, pp. 3-13.

Brookes, G., & Barfoot, P. (2008). Global impact of biotech crops: Socio-ecoomic and environmental effects, 1996-2006. AgBioForum, 11, 21-38.

Bruening, G., Lyons, J. (2000). The case of the flavr savr tomato. *California Agriculture,* 54, 6-7. DOI: DOI: 10.3733/ca.v054n04p6.

Bruins, M. (2009). The evolution and contribution of plant breeding to global agriculture. Presented in: SECOND WORLD SEED CONFERENCE: *Responding to the challenges of a changing world: The role of new plant varieties and high quality seed in agriculture, Rome: FAO Headquarters.* pp. 18-31.

CERA. (2012). GM *crop database, ILSI Research Foundation.* Washington D.C: Center for Environmental Risk Assessment (CERA).

Chapotin, S. M. & Wolt, J. D. (2007). Genetically modified crops for the bioeconomy: Meeting public and regulatory expectations. *Transgenic Research,* 16,pp. 675-688. DOI: 10.1007/s11248-007-9122-y.

Dreher, K., Khairallah, M., Ribaut, J. M., & Morris, M. (2003). Money matters: Costs of field and laboratory procedures associated with conventional and marker-assisted maize breeding at cimmyt. *Molecular Breeding,* 11, pp. 221-234.

FAO. (2009).*How to feed the world in 2050*. Rome: Food and Agriculture Organization of the United Nations.

FAOSTAT. (2005). *FAO Statistical Databases,* Rome: Food and Agriculture Organization of the United Nations, Statistics Division.

FAOSTAT (2012).FAO *Statistical Databases. Rome: Food and Agriculture Organization of the United Nations,* Statistics Division.

Fernandez-Cornejo, J, & Wechsler, S. (2014). Genetically engineered crops in the United States. *Economic Research Report,* No. 162. [online]. Available at: *http://www.ers.usda.gov/media/1282246/err162.pdf. Washington D.C.: United States Department of Agriculture.*

Foolad, M. R. & Panthee D. R. (2012) Marker-assisted selection in tomato breeding. *Critical Reviews in Plant Sciences,* 31, pp. 93-123.

Gulati, A., Ganesh-Kumar, A., Shreedhar, G., Pullabholta, H., Zhang, X., Sainju, M. M. &, Pant, B. D. (2010). *Ensuring food and nutritional security in Nepal. A report prepared for USAID Nepal.* New Delhi: International Food Policy Research Institute.

Hafner, S. (2003). Trends in maize, rice, and wheat yields for 188 nations over the past 40 years: A prevalence of linear growth. *Agriculture Ecosystems & Environment, 97,* pp. 275-283. DOI: 10.1016/s0167-8809(03)00019-7.

James, C. (1998). Global status and distribution of commercial transgenic crops in 1997. *Biotechnology and Development Monitor,* 35, pp. 9-12.

James, Clive. (2011). Global status of commercialized Biotech/GM crops: 2011. ISAAA Brief No. 43: Ithica, NY: International Service for the Acquisition of Agri-biotech Applications (ISAAA).

James, C. (2013). Global status of commercialized biotech/GM crops.ISAAA *Brief No.46.* Ithica, NY: International Service for the Acquisition of Agri-biotech Applications (ISAAA).

James, C. & Krattiger, A. F. (1996). *Global review of the field testing and commercialization of transgenic plants 1986 to 1995: the first decade of crop biotechnology.* Ithica, NY: International Service for the Acquisition of Agri-biotech Applications (ISAAA).

Jauhar, P. P. (2006). Modern biotechnology as an integral supplement to conventional plant breeding: The prospects and challenges. *Crop Science,* 46, pp. 1841-1859. DOI: 10.2135/cropsci2005.07-0223.

Joshi, K., Conroy, C., & Witcombe, J. (2012). *Agriculture, seed, and innovation in Nepal: Industry and policy issues for the future.*Washington, D.C.: International Food Policy Research Institute (IFPRI) and Cereal Systems Initiatives in South Asia (CSISA).

Kharkwal, M. C., Pandey, R. N., & Pawar, S.F. (2004). Mutation breeding for crop improvement, In: H. K. Jain & M. C. Kharkwal, Eds.*Plant breeding: Mendelina to molecular approaches.* New Delhi: Narosa Publishing House, pp. 601.

Khush, G. S. (1999). Green revolution: Preparing for the 21st century. *Genome, 42*, pp. 646-655. DOI: 10.1139/gen-42-4-646.

Lusser, M., Parisi, C., Plan D., & Rodriguez-Cerezo, E. (2012). Deployment of new biotechnologies in plant breeding. *Nature Biotechnology*, 30, pp. 231-239.

Mackenzie, D. (1994). Transgenic tobacco is European first. *New Scientist, 8.*

Martino-Catt , S. J., & Sachs, E. S. (2008). Editor's choice series: The next generation of biotech crops. *Plant Physiology,* 147, pp. 3-5. DOI: 10.1104/pp.104.900256.

Morris, M., Dreher, K., Ribaut, J. M. & Khairallah, M. (2003). Money matters (ii) Costs of maize inbred line conversion schemes at cimmyt using conventional and marker-assisted selection. *Molecular Breeding,* 11, pp. 235-247.

Nemana, V. (2012). In india, GM crops come at a high price. *New York Times.* [online]. Available at: *http://india.blogs.nytimes.com/2012/10/16/in-india-gm-crops-come-at-a-high-price/?_r=0*

Newar, N. (2012). Nepali farmers blame crop failure on climate change. *Inter Press Service.*

Pawar, Y. (2012). Bt failure to hit cotton yield by 40%: Govt, *DNA.* [online]. Available at: *http://www.dnaindia.com/mumbai/report-bt-failure-to-hit-cotton-yield-by-40-govt-1769428*.

Qiu, J. (2008). Agriculture: Is china ready for gm rice? *Nature,* 455, pp. 850-852. DOI: 10.1038/455850a.

Redding, R.W. (1988). A general explanation of subsistence change: from hunting and gathering to food-production. *Journal of Anthropological Archaeology, 7*, pp. 56-97. DOI: 10.1016/0278-4165(88)90007-4.

Singh, B. K. (2012, November 6).Bt cotton: No seed of doubt left. *Hindustan Times.*

Stolte, D. (2012). Trouble on the horizon for gm crops?. *University of Arizona News.* [online]. Available at: *http://uanews.org/story/trouble-horizon-gm-crops.*

Varshney, R. K., Graner, A. & Sorrells, M. E. (2005). Genomics-assisted breeding for crop improvement. *Trends in Plant Science,*10,621-630. DOI: 10.1016/j.tplants.2005.10.004.

Witcombe, J. R., Gyawali, S., Subedi. M., Virk, D. S., & Joshi, K. D. (2013). Plant breeding can be made more efficient by having fewer better crosses. *BMC Plant Biology,* 13, pp. 22.

5

# Prospects of Developing Commercial Production of Tree Fruits in Nepal with Focus on Citrus Production

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## Abstract
This article outlines the steps required to achieve commercialisation of Nepalese tree fruit production, with special focus on citrus production. The national macro-settings that underpin the development of the tree crops industry are explored, and existing marketing and production practices are documented. A market-orientated system depends on local entrepreneurs that face the end market and reward growers that meet relevant market requirements, such as time of production and quality standards. This effort requires public and private investment into key infrastructure of cool storage, packing and sorting facilities, transportation and electricity infrastructure after profitable markets are defined. A mixed enterprise approach of combining fruit production with agro-tourism is recommended to preserve village communities. Specific suggestions for the mandarin orange industry include broadening the period of supply to the domestic market, supply to domestic supermarkets, and exploration of market potential (price/volume requirements) of near markets such as Tibet and India, and development of contract farming systems. Contract farming systems should support growers with technical production and post-harvest and marketing expertise. Given an appropriate market and price for the fruit, a price reward is created that will drive change to improve production quality and quantity. Areas requiring improvement include production and post-harvest practice, including the use of appropriate rootstocks, use of varieties to extend the production window, micro-irrigation, improved insect pest and disease management, record keeping of on-farm practices, care in fruit handling during harvest and transport to increase shelf life, and use of packaging and logos to create brand awareness.

## 1. Introduction
Despite an enormous potential for commercial fruit production in Nepal, this sector is not developing well because of different institutional and technical constraints. Production practices and marketing systems are not well developed so that the farmers are not harnessing the benefits from this sector. The objective of this chapter is to discuss ways towards market-oriented production system

and commercialisation of Nepalese tree fruit production, with special focus on citrus production. The chapter is written based on the experiences of the authors supported by the relevant published literature in this sector. The key areas requiring improvement of this sector are discussed and include production and post-harvest practices and linking citrus fruit production with domestic, regional, and international markets through value chain system.

## 2. Tree fruit industry in Nepal: Where are we at now?

Given the wide range of climates associated with altitude, stretching from sub-tropical in the southern plains to cool temperate in the northern high hills, a range of tree fruit crops can be grown in Nepal. The fertile flat lowland areas in the south (Terai) support cereal/grain crops and vegetable production, with areas of tropical tree fruits, including mango, banana, guava, papaya, litchi, areca nut and coconut. Subtropical tree fruits such as citrus and guava are grown in mid-hills, preferentially on north facing slopes (Figure 1). Temperate fruits like pome and stone fruits are grown in higher altitude regions. The terraced hilly terrain utilises slopes of 10 to 30 degrees, in which the erosion rate is high, thus requiring minimal disturbance of the soil system. This land is therefore, unsuitable for growing staple crops such as cereals, which are based on intensive tillage practices. The steep terrain is also difficult to manage because of access difficulties and ultimately an increased cost of production. The Ministry of Agriculture Development maintains a useful online summary of national fruit production statistics for Nepal (Figure 2).

**Figure 1:** Fruit tree cultivation on steep hill slopes of Nepal with a bench terracing system.

The past two decades has seen an increase in fruit production, particularly citrus (Figure 2). Productivity per unit area has increased only for citrus. The category 'citrus' includes mandarin (*Citrus reticulate* Blanco.), orange (*Citrus sinensis* (L.) Osb.), limes (*Citrus aurantifolia* L.), lemon (*Citrus limon* (L.) Burm.f.) and pomelo (*Citrus maxima* (Burm.f.) Merr.). Of these, mandarin is recognised as a high value cash crop by the national Agriculture Perspective Plan (APP) and the newly formulated Agriculture Development Strategy (ADS). However, despite having a huge production potential and being a national priority crop, the production practices are largely at a subsistence level with only 71 metric tonnes of mandarin fruit exported in 2009/2010 (CBSN, 2010).

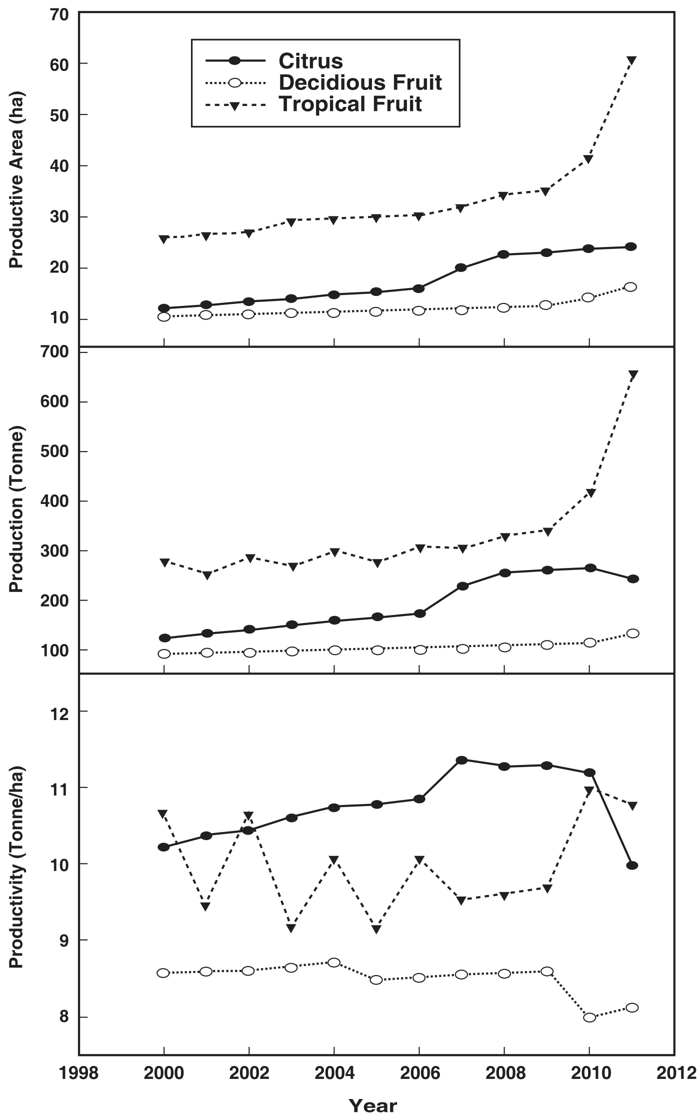


**Figure 2.** Tree fruit productive area, production and productivity per hectare over eleven years. (Source: MOAD, 2012)

What path should the mandarin orange industry take in Nepal? This question is part of a very large discussion for the people of Nepal about the vision for their nation. Can an '*agrarian utopia*' of prosperous villages on mountain slopes, with people enjoying the benefits of modern technology and services, be sustained by income from fruit tree crops sold to local domestic markets, supplemented by remittance income from abroad. Will those returning from abroad bring innovation and entrepreneurship to agricultural practices? Another vision might foresee massive changes within a few decades, with depopulation of rural areas, massive urbanisation, loss of subsistence production practices and conversion to farming systems that are internationally competitive. In practice, reality may lay somewhere between these visions.

## 2.1 Driving change

In this chapter we aim to picture the future of the tree fruit industry in Nepal, shaped by the 'environment' of demographics, investment trends, government policies, national infrastructure issues such as road and electrical networks and research, development and extension capacity to support tree fruit crop development. This challenge involves understanding market potential, and production requirements needed to produce fruit for such markets. This involves understanding the 'supply chain' and the factors required to produce a 'value chain'. In this context, a 'supply chain' is the network of people involved in getting fruit to a consumer, from nurseryman and agricultural product supplier to the retailer. If these actors pull together, they can create a 'value chain', in which each player adds value to the product.

The consumer is the major determinant of success or failure of a value chain. The value chain is defined as the whole series of activities that create and build value at every step. The consumers' preference determines quality and a value chain must work to address these quality issues. Thus, the focus of any value chain must be the market. The market requirements and its willingness to pay for the product must be determined. Then a production system can be developed to address this market. Unfortunately, far too often the reverse happens—resources are poured into supporting production, and then some thought is given later to determine whether a market exists.

## 2.2 Demographics

Agriculture remains the mainstay activity for two-thirds of Nepal's population of 33 million people (MOAD, 2013), albeit dominated by subsistence production systems. With an increasing population the per capita land availability has decreased from 0.6 ha in 1954 to 0.1 ha in 2005 (MoA, 2008). The trend of urbanisation is yet in its infancy, but it is likely to gather speed over the next decades. For example, Kathmandu currently has a population of about 2-3 million, but this is set to dramatically increase in the coming decades.

This demographic shift will result in abandonment of agricultural areas, offering opportunities for land parcel consolidation. Increasing urbanisation and purchasing capacity of the population also creates a market for fresh fruit consumption, although this trend acts at the expense of the rural labour force. Moreover, there is also a decreasing interest of the younger generations towards agribusiness. Anecdotally, this is reflected in comments from Nepalese agricultural advisors who deal with a steady stream of enquiries from people returning from work overseas. These returnees are unwilling to return to the subsistence lifestyle of their rural parents, but are set to inherit parental land. Thus they are now looking for advice on different, lower labour demanding horticultural opportunities.

## 2.3 Investment environment

Recent history has witnessed over a billion people move out of poverty in China, India and parts of South East Asia, buoyed by the development of a market economy. Thus the most effective aid is that spent supporting trade development. The limiting business environment factors in Nepal for tree fruit crops include:

(a) Lack of significant private investment in agriculture production and related business;
(b) Poor experiences of farmers in cooperatives; and
(c) Inadequate knowledge of marketing and market conditions of fresh produces.

The development of value chains around fruit marketing in Nepal is yet in its infancy, with no players of significant scale. Such issues are symptomatic of a fragmented marketing chain. The Nepalese private sector has invested far more in the manufacturing sector than in agriculture. Nevertheless, there are a number of enterprises focused on processing of horticultural products, but they are based on the use of raw materials from abroad (e.g. Rijal Tashi Industries Pvt. Ltd, in brand name Druk). This reluctance to invest in horticultural production reflects the lack of adequate and reliable supply and the risks of dealing with perishable produce when both physical (e.g. storage and road networks) and social ‘infrastructure’ are uncertain.

### *2.3.1 Policy and implementation issues*

Policy and attendant regulations set the environment for the type of enterprise growth. Of course, trade liberalisation opens both opportunities and threats for commercialisation of the horticulture sector in Nepal, enabling both export and import of produce. For example, DoA (2008) reported an increased export of Nepalese agricultural commodities to India following an easing of India's Prevention of Food Adulteration Act.

Nepal became a provisional member of World Trade Organization (WTO) in 2004 and will be a full member by 2014. The WTO members are required to work towards free trade with other members. Nepal, as a developing economy, is allowed to maintain a level of subsidy/import protection on agricultural products. However, despite financial support by the Asian Development Bank and World Bank to increase the competitiveness of the agricultural sector, Nepal has become an importer of tree fruit. This lack of competitiveness is a function of the underdevelopment of the Nepalese value chains. The Nepalese businesses are unable to maintain or document product specifications, and at an institutional level has low capacity to document phytosanitary and quality standards required for the export market.

Nepal is currently running under the Agriculture Perspective Plan (APP, 1995-2014), a 20-year vision. This was an ambitious plan, which achieved some progress in certain areas such as shallow tube-well and small irrigation schemes. However, few outcomes were achieved in terms of increasing production, productivity or establishment of value chains around tree fruits (Figure 2), although some success has been occurred in the dairy and poultry sectors. The Nepalese Government is now drafting a 20-year policy document for agriculture, the Agriculture Development Strategy (ADS). This policy has greater focus on creating policy environment favourable to private investment (ADB, 2011; IFAD, 2013). The plan aims to intensify production of subtropical fruit in the mid-hills and temperate fruit in the high hills supported by investment in road, electricity and service delivery systems. The plan includes the laudable aims of land consolidation and combined public-private investment in infrastructure and logistic support. Land consolidation is proposed around management units, building on co-operatives. Infrastructure such as cool and cold stores and transport hubs are sought. Protection of domestic production systems through increased tax on imports is being considered.

These actions should foster a positive business environment around tree fruit crop production, except for the notion on increased tax on imports. Such action, if taken, should be selective and phased out over a set time period, and made within a larger range of actions designed to establish a particular industry. Prolonged support will only delay industry evolution to an internationally competitive standard, and disadvantage consumers.

### *2.3.2 Transport, electricity and storage*

Refrigerated storage and transport, and efficient markets are key elements to modern horticultural trade. A clear example is provided within China, where a massive investment for the establishment of market and transport facilities has been made to support horticultural trade. For example, a second fresh fruit and vegetable market opened near Shanghai in August 2013 and is expected to trade more than US$ 1 billion in its first year of operation (DoA, 2013).

Another example is provided by the Indian requirement of large foreign retailer entrants to invest into cool chain facilities. Foreign investment into a retail entity is capped at 51% ownership, with the foreign partner required to invest US$ 50 M upon entry into the market in ‘back-end infrastructure’ (Jones, 2013).

A commercialisation of agriculture requires efficient transportation. The road distance between the two major population centres of Kathmandu and Pokhara is approximately 200 km, but the driving time is about 8 hours, a major impediment to trade. However, transport linkages to and within, Nepal is improving. China has completed a rail link to Lhasa, Tibet, and a high quality bitumen road to the Nepal border only 180 km from Kathmandu. This infrastructure greatly increases access to Nepal for Chinese product (e.g. apples, Figure 3), but also opens opportunities for export of Nepalese product. Similarly, road links to India have steadily improved. In terms of domestic infrastructure, Nepal has developed a network of green agricultural roads in most rural areas, with the goal of improving transport of products to markets.


Figure 3. Chinese apple penetrating to regional wholesale markets in Nepal

The electrical grid has also been greatly expanded in Nepal in recent years; however, load shedding occurs on an almost daily basis. This severely hampers the installation of cold storage facilities. Currently, the cold storage facilities are primarily in the Terai areas for the storage of seed potato. Fruit growers are obliged to sell their products immediately after harvest, generally in the over-supplied market conditions. In contrast, the Chinese and Indian products enjoy reliable cold storage and scheduling facilities, and hence are likely to dominate the Nepalese wholesale markets.

There is some potential for passive cooling or development of centralised cold stores in Nepal if the supply of constant power is ensured. Public investment into developing stable base load power supply systems, and private investment into regional cold storage facilities, should be encouraged.

Establishment of a profitable fruit industry requires a holistic approach. Action in one area alone can have devastating consequences. For example, an improved road and cool store network facilities will allow improved penetration of imported horticultural produce into rural areas if there is no competitive local produce. This was seen in 2012 when well-presented apples from northern China were sold in rural Nepal for Rs.160/kg, compared to Rs. 200/kg for local apples (Figure 3).

**2.4 What research and extension underpins development?**

Ideally, governments invest in research, development and extension in support of areas of national priority that have ‘market failures’ that are not mature. Nepal government recognises the need to support the development of agriculture, in particular certain tree fruit crops, and maintains a number of organisations as follows:

(i) The National Planning Commission sets national priorities.

(ii) The Nepal Agriculture Research Council (NARC) is mandated to undertake agricultural research for the country. There are specific commodity research programs for maize, rice, wheat, legumes, citrus, ginger and cardamom.

(iii) The Department of Agriculture is responsible for technology transfer. The system of extension service is largely focussed to work with subsistence farmers, rather than to commercial growers, however, the Project for Commercialisation and Trade (www.pact.gov.np) and the Commercial Agriculture Development Project (www.cadp.gov.np), target commercial agriculture. The Directorate of Agribusiness Development and Marketing Development (www.agribiz.gov.np) is responsible for developing agriculture as a business through services and market linkages.

(iv) The Ministry of Cooperatives and Poverty Alleviation is a newly formed ministry for the promotion of cooperatives for poverty alleviation.

(v) The Ministry of Industry, Department of Small Business and Industry (www.moi.gov.np, www.doind.gov.np).

(vi) The Federation of Nepalese Chamber of Commerce and Industry maintains an Agro enterprise Centre (www.aec-fncci.org).

(vii) Tribhuvan University, Institute of Agriculture and Animal Science (www.iaas.edu.np) and Agriculture and Forestry University (www.afu.edu.np) provide horticultural science training and research, while the Council for Technical Education and Vocational Training (CTEVT; www.ctevt.org.np) provides skills in horticultural practices.

As in all systems, there is room for evolution and improvement. Lack of coordination in public-sector support systems results in activities that are launched either in isolation or overlap/duplicate within and between ministries. A quarterly sharing system exists between NARC and DOA to exchange knowledge of current field problems and research outputs, but there is need to further focus activity to address production bottleneck issues, with follow up analysis of outcomes at regular intervals. There is also an observation that investment into research, development and extension (RD&E) related to market analysis and postharvest issues are inadequate relative to the investment made into production issues.

Substantial development aid investment occurs in non-government led research and development on specific issues, with the risk that this work is not institutionalised into ongoing programs. Additionally, commercial growers tend to rely on ‘learning by doing’ or on technical support provided by the agro-chemical retailers for implementation of novel technologies. An example of a technology that has received scant attention in the formal research system but has seen grower uptake is the use of drip irrigation. These ‘private’ RD&E systems should be encouraged. Nepal boasts a well-established mobile phone and radio communication system, reaching most of the people. There is an adage that data is not information, information is not knowledge, and knowledge is not wisdom. Wisdom and knowledge require industry experts and investment in human capacity. However, the extension system, be that public or corporate, could immediately make better use of the explosion in communication capacity to transfer information, and perhaps some knowledge to service providers and farmers. Information on production technologies, pests and diseases forecasting and diagnostics services, weather forecasting, and price information are ready targets. For example, a mobile phone text messaging service could be established to send a daily report on fruit prices and volumes in key markets to subscribers. There are also more than 500 local FM radio stations with good coverage in rural areas, but very few of them have agricultural programs of 15 minutes per week. Newspaper articles and technical bulletins should continue for dissemination of targeted information.

## 3. Where are the markets?

Nepalese tree fruit production systems are currently small in scale and scattered, with unorganised marketing to scattered domestic markets. There are still some remnants of barter systems among subsistence fruit producers within local communities. On the other hand, new urban centres are emerging requiring a more organised trading system. In general terms, two markets exist in the large urban centres, that serving the general populace and also serving the developing supermarket chains and high end hotels, with their tighter specifications. Domestic fruit production tends to be very seasonal, and this glut causes an oversupply of the market and a reduction of prices, such that a market niche exists from the supply of fruit in shoulder periods.

Successful entry to an export market requires clarification and ideally reduction of tariff and non-tariff barriers, a system designed to meet phytosanitary requirements, and good market intelligence on the size and value of the prospective markets. Seasonal advantage, consistency in volume of supply and quality (post-harvest self-life) of fruit and packaging/transport methods will be key factors in maintaining a presence in such export markets. To date, the ability of Nepalese value chains to deliver in these areas has been limited. The markets of the developed world demand a high level of quality control, e.g. in quality assurance documentation, in phytosanitary procedures, traceability and certification (e.g. Global Gap or organic status), making these markets difficult to enter. Rather, the geography and transport infrastructure of Nepal suggest potential export markets in India and China (Tibet). Certainly it is remarkable that larger quantities of fruit from India and China are entering into the Nepalese market with apparently no regulation (e.g. no labeling of cartons illustrated in Figure 3), while trade in the reverse direction is quite tightly regulated.

Nepalese fruit exporters should be able to access the Indian market easily, as at a federal level India imposes neither tariff nor non-tariff (e.g. phytosanitary) barriers. However, anecdotal evidence from Nepalese mandarin growers/traders indicates the existence of effective entry barriers on an Indian state basis. An informal ('grey') trade exists, involving Indian traders from bordering towns who purchase fruit in 'assembly markets' in Nepal. However, the size of this flow is currently very small, sporadic, and not well documented.

Bangladesh seems to be a potential market for citrus (orange and mandarin), as it imports in the order of 3,500 metric tons every year, currently sourced from Bhutan, India and Australia. However, exports to Bangladesh face high tariffs, taxes and non-tariff barriers vis-à-vis exports from Bhutan.

The Department of Agriculture (DoA, 2008) predicted that Nepal would not achieve significantly increased levels of exports to markets other than India and Bangladesh in the short and medium term. However, China is keen to be a good neighbour to Nepal and has, for example, granted access for Nepalese mandarins to Tibet on relatively simple phytosanitary conditions (e.g. involving exclusion of six insect pests: *Aleurocanthus wolgumi, Bactrocera correcta, B. cucurbitae, B. dorsalis, B. tsuneonis,* and *B. zonata*) and three diseases (*citrus greening disease, Colleotrichum acutatum,*and *citrus canker, Xanthomonas campestris*). However, formal assessment of the value and size of the Tibetan market is yet to occur. However, a group of citrus traders from Western hills of Nepal visited Lhasa markets in December 2013 and reported that Nepali mandarins could be marketed at a wholesale level for 10-12 Yuan per kg (1 Yuan = 17 Rs.) (B. Thapa, Nepal Citrus Development Programme, pers. comm.).

Nepal has a strong trekking-tourist economy. There is a potential for a greatly expanded agro/cultural tourism involving short to medium stays, giving tourists the opportunity to observe an agrarian lifestyle. The mandarin production area is currently based in very scenic areas within Nepal, where near subsistence agriculture is still practiced involving cultivation of an array of animal and plants by individual families.

## 4. Market requirements

Successful entry to an export market requires clarification and ideally reduction of tariff or non-tariff barriers, a system designed to meet phytosanitary requirements, and good market intelligence on the size and value of the prospective markets. Seasonal advantage, consistency and volume of supply and quality (post-harvest self-life) of fruit and packaging/transport methods will be key factors in maintaining a presence in such export markets. To date, the ability of Nepalese value chains to deliver in these areas has been limited. The markets of the developed world demand a high level of quality control, e.g. quality assurance documentation, phytosanitary procedures, traceability and certification (e.g. Global Gap or organic status). These procedures are essential to be competitive, but can create problems for new comers in the global market. The geography and transport infrastructure of Nepal shows potential export markets in India and China (Tibet), but this is yet to be developed. In contrary, large quantities of fruit from India and China are entering the Nepalese market with apparently little or no regulation (e.g. no labeling of cartons illustrated in Figure 3), while trade in the reverse direction is quite tightly regulated.

Fresh fruit export markets require attention to the postharvest shelf life of the produce. Practices such as washing and waxing of fruit and use of cardboard cartons are the norm for export, but are not practiced within the Nepalese industry to date. The plastic crates used in domestic trade are provided as a government subsidised service and are very robust. However, they cannot be used for one-way flow to export markets. For product targeting ‘premium’ markets, attention is needed to presentation and packaging style (Figure 4). Obviously, such practices add to cost of production, so extra value must be present in the export market to support such practices.

**Figure 4.** Packaging of Indian mandarin fruit arriving in Nepal (left), an example of cartons in use for domestic market in Australia (middle), and in international trade (right).

These marketing groups (value chains) should develop their own labels, but consideration should also be given to a national label that aims for Global Gap certification. For example, Australian fruit traders use an umbrella label and fund co-joint international marketing exercises. Such a label could play on Nepal's position 'in the shadow of the Himalayas'.

## 5. Current trading system

The current trading system caters for a low value market (< Rs.100/kg), a price that has not changed much over a decade. New value chains are required to achieve higher returns for the product and to ensure equitable sharing of profit to those adding value to the chain. It is important to understand how the current system operates and which elements might be perturbed and resist change. The fruit trading systems currently in operation have been documented by Department of Agriculture in 2013.

1. Farmer – Collection Centre – Commission Agent – Wholesaler – Retailer – Consumer
2. Farmer – Cooperatives – Commission Agent – Wholesaler –Retailer – Consumer
3. Farmer Trader – Commission Agent – Wholesaler – Retailer – Consumer
4. Farmer Trader – Wholesaler – Retailer – Consumer
5. Farmer – Middlemen– Retailer – Consumer
6. Farmer – Middlemen – Wholesaler – Commission Agent -Retailer – Consumer

Collection centres are generally established at major roadsides covering several production pockets, and servicing 50 or so small growers. From the collection centres, fruit are brought to larger centres and sold locally and/or taken to district *Haat bazaars*. These market centres are developed and sustained by local communities and held once or twice a week. Bigger wholesale markets are operated in larger city centres, operated by a committee composed of concerned stakeholders (Figure 5). In these centres, small micro-retailers will buy from the market and sell from small retail shops or from trolleys or bicycles along roadsides, clustered by bus stops. Fruit from some markets (e.g. Dharan, Birtamod, Gaighat and Biratanagar in Eastern Nepal; Birgunj, Narayanghad, Butwal and Bhairahawa in Central and Western Nepal) are exported to Indian border towns. These markets also serve in distribution of imported produce (e.g. apples from China).

**Figure 5.** Fruit and vegetable wholesale market at Kalimati (Kathmandu) (left) and Pokhara right.

Each of the players in the supply chain is a small business owned and operated by a family. Some information on market pricing is kept, in terms of raw data on prices and arrivals of fruit in selected markets only, but dissemination of this information is very poor. The first steps in the consolidation of retailing are seen in the emergence of a supermarket format. The Bhat Bhateni, a supermarket retail chain with stores in Pokhara and Kathmandu, is the most well developed example of this type. However, due to lack of consistency in quality and uncertainty on chemical residues, this chain does not generally buy domestically produced fruit.

In summary, the current supply chains deliver low cost with low quality fruit of poor shelf life.  An improved value chain should target markets that reward activity for improving product quality and shelf life, such as orchard hygiene, care of fruit during harvest, washing and waxing of fruit after harvest and proper labelling and packaging.

# 6. Production constraints?

### 6.1 Scale of operation

Nepalese fruit producers are largely engaged in a subsistence level of production, often farming in less than a quarter hectare of land, with integration of cereals, fruit, livestock and agro-forestry. Only a few commercial farmers are growing tree fruit crops on a semi-commercial to commercial scale. The tree fruit production systems receive little attention and are not part of the dietary system, but represent a source of cash income. Increase in fruit production generally occurs at the expense of cereal and livestock production, and thus requires sufficient cash income on fruit sale to replace lost production.

However, current demographic shifts are seeing areas of previously farmed land left unattended. Appropriate policy settings may promote leasing or sale of such parcels to increase the size of production units, increasing scale of economy. There is also potential for a level of corporatisation of farming, with similar management and overall cultural practice through developing the cluster as a unit and raising crops in a cooperative approach. This can significantly increase the production, productivity and quality, while strengthening the bargaining power of the producer group and giving a scale and quality of production that allows the trader to target new markets.

The contract farming example of the Swift Group in Thailand and Laos is worthy of study in this context (Swift, 2010). In this model, the company contracts growers to produce certain high value crops, e.g. asparagus. Training and resources are provided with crop graded at a company pack-house to set specifications. The farmers are paid a pre-agreed price. The company manages documentation to satisfy Global Gap Certification and targets high value markets, e.g. the Middle East and Europe.

### 6.2 Improved agronomic practices

Correct selection of varieties to match the production area and market need is critical. For example, a primary constraint to current mandarin production is the use of seedling grown trees. While cheap to establish, the seedling trees take longer period (5-7 years) to bear fruit, become thorny, tall and upright, making it difficult to harvest relative to grafted trees. Clear guidelines on recommended varieties by production region and commodity are required, with attention to the needs of the intended market.

Management of nutrient, irrigation, training/pruning and other stress including disease and pests are keys for maintaining the fruit quality and yield. Higher yields and quality set the foundation for improved value in marketing. However there can be a 'chicken and egg' situation where change to crop management practice cannot be afforded on current market prices and new markets cannot be established on current scale of production and product quality.

Farm records are typically not kept in any consistent way. Such records are critical to guide management, showing the efficacy of the various variants of a farming system. All farm details (e.g. area, no. of plants, date of planting, date of flowering, fertilisation or irrigation events, use of chemicals, presence of pests and disease, date of harvest, and yield) should be on an individual production block basis. Such records allow for transition to organic production system provided international inspection by organic certifying bodies, or to satisfy a more discerning retailer or export requirements.

The current crop management limitations for mandarin and oranges are:

(i) Lack of irrigation during the dry season in most of the hills of Nepal. It is estimated that use of dry season irrigation would allow for a 25% increase in crop yield;

(ii) Lack of consistent crop nutrition-especially micronutrient deficiencies are commonly observed throughout citrus growing belts;

(iii) Lack of pest and disease management e.g. consistent fruit fly baiting programs;

(iv) Poor practice for canopy management such as light pruning should be undertaken during harvest, and completed after harvest;

(v) Under canopy cropping (e.g. for citrus, maize, or millet, ginger, turmeric, pulses or vegetables may be grown under the tree canopy) involves ploughing and digging which damages the roots of the trees, but farmers see this practice as good for tree health through increasing soil aeration, infiltration and weed control;

(vi) Very low use of grafted planting stock (grafted stock produces fruit in 3 to 4 years compared to 5 to 7 for seedling trees, produces trees true to type, and produces more manageable trees);

(vii) Use of inappropriate rootstocks: There is a very low level of using appropriate rootstocks. For example, Troyer or Carozzo rootstock should be used for mandarin;

(viii) No use of picking aids to minimise fruit damage during harvest;

(ix) Narrow production time widows (Nepali mandarin production is based on essentially one variety, and occurs with late November through January – earlier and later bearing varieties are required).

### 6.3 Post-harvest issues

As alluded to earlier, current production and harvest practices are not appropriate and affect the postharvest life of the fruit. Large gains in quality can be achieved by relatively simple changes in harvest and postharvest practices. For example, postharvest shelf-life and quality of mandarin can be significantly improved by cutting the peduncle rather than tearing the fruit off the peduncle, using picking bags during harvest and washing and waxing of fruit. Increased shelf life may allow a profitable export market to be reached.

## 7. Mandarin production – a case study

Mandarin orange is recognised as a potentially profitable crop for the mid hills region of Nepal (MoA, 2008).  However, moving from a low value subsistence level to a commercial production system requires the development and servicing of appropriate markets. The current system has poor vertical integration of producers, with forward selling arrangement and an absence of functional value chains. The lack of larger fruit production and marketing groups is a consequence of a negative history of corruption and in effectiveness and the lack of entrepreneurial culture. Because of this lack of scale, access to production inputs and capital for small-scale producers is limited. In this section, the insights of the Full Bright (2008), MoA (2008) and Full Bright (2013) on limitations to the development of the mandarin industry are synthesised.

### 7.1 Cost of production and market price

A rough estimate of how the cost of produce increases as it passes through the chain is presented in Table 1:

**Table1.** Costs involved in the mandarin supply chain at the Dharan market centre of Eastern Nepal.

| Item | Cost (Rs/kg) | % of total | Cost borne by |
|---|---|---|---|
| 1. Cost of production | 4 | 13.3 | farmer |
| 2. Price received by the grower | 10 | 33 | contractor |
| 3. Harvesting cost | 0.5 | 1.6 | contractor |
| 3. Transportation to road side by porters | 2 | 6.6 | contractor |
| 4. Assembling and packaging cost* | 0.5 | 1.6 | contractor |
| 5. Local taxes* | 0.25 | 0.8 | contractor |
| 6. Truck transportation* | 3.5 | 11.6 | contractor |
| 7. Loading, unloading | 0.25 | 0.8 | contractor |
| 8. Wholesaler commission* | 1.5 | 5 | trader/retailer |
| 9. Management cost | 1 | 3.3 | trader/retailer |
| 10. Transportation, storage fruit losses | 1.5 | 5 | trader/retailer |
| 11. Repacking and loading cost* | 0.15 | 0.5 | trader/retailer |
| 12. Market facility cost | 0.10 | 0.3 | trader/retailer |
| 13. Contractor profit | 4 | 13.3 | contractor |
| 14. Traders, retailer profit | 4 | 13.3 | trader/retailer |
| 15. Total (Micro-retail sale price) | 30 | **100** | **consumer** |
| Supermarket sale price (imported produce) 2012 | **391** | | |

(Source: Full Bright, 2008)

* Item 4 is calculated as storage charge at the assembling point Rs. 500 for one truck load (about 6 metric tonnes) and packaging charge per truck load of Rs. 500 (paddy straws and leaves).

* Item 5 represents 'taxes' or 'general payments' in a generic sense needed to gain entry to the wholesale market or District Development Centre, which differs from district to district, e.g. in case of Dhankuta district it is Rs. 7 and for Panchthar Rs. 12 per *doko* load (50-60 kg).

* Item 6 will depend on distance.

* Item 8, e.g. the commission charged by the wholesaler or commission agent at Dharan is 6-8 % of total sale price.

* Item 11 represents a repacking cost to plastic crates or cardboard boxes and loading charge of Rs. 0.15 -0.20 per kg.

Within Nepal, the highest wholesale and retail prices are achieved in Pokhara and Kathmandu. The consumer price in 2013 in Kathmandu was approximately Rs. 80 (US$ 0.80) per kg of fruit in the main season, and around Rs. 60 in the shoulder periods, during which fruit quality is notably poor owing to lack of early and late bearing varieties, and storage facilities. The main season price is very low by international standards and provides little reward for actors in this chain. In contrast, citrus fruit in the Bhat Bhateni supermarkets retailed in 2012 for around five times as high, sufficient to fund improvements in practices and quality throughout the chain. The value achievable in export markets such as Tibet, Bangladesh and India remains to be established.

Having established the market price for fruit, it is essential to estimate cost of production under various scenarios. Such estimates should be revised at intervals and checked by local groups. If the cost of production is well under market value of the produce, there is a clear signal for investment. The most recent gross margin analysis for mandarin production available was prepared by the DoA in 2006 (Table 2). Note, the very low estimate of input costs, e.g. planting material at Rs. 4800 (US$ 48) per ha, plant protection at Rs. 100 (US$ 1) per ha per annum, the assumption of intercropping (with consequent damage to citrus roots and production) and the relatively generous estimate of income from intercropping (accounting for 195% of land area!). Unfortunately, this low rate of return is the reality for current mandarin production in Nepal. Such a low profit prohibits the use of grafted material on appropriate rootstocks, the use of micro-irrigation or programmed fertilisation, improved pruning and harvesting techniques, etc. Thus there is need to create new gross margin analyses that assume higher levels of inputs, delivering higher quantities and quality of fruit, in order to calculate the base price required for such products in new markets or supply windows.

**Table 2.** Analysis of the gross margin (per hectare) for the production of mandarin oranges in Nepal. This analysis assumes cropping at 300 trees/ha, with intercropping for the first two years of establishment of an orchard (A), and for 25 years of production (B), assuming a yield of X t/ha from year 9 at a value of Rs. per kg.

| Items/ Inputs | First Year | | | | Second year | |
|---|---|---|---|---|---|---|
| | Unit | Cost | Quantity | Value | Quantity | Value |
| Land Clearance/Fencing/ Preparation, Labour | days | 100 | 50 | 5000 | 20 | 2000 |
| Digging/Pit making, Fencing, Labour | days | 100 | 200 | 20000 | 60 | 6000 |
| Manuring, Transport, Labour | days | 100 | 60 | 6000 | 30 | 3000 |
| Manure | kg | 0.4 | 7500 | 3000 | 500 | 200 |
| Micronutrients | Rs. | 400 | 1 | 400 | 4 | 1600 |
| Sapling/Replacement | No | 15 | 320 | 4800 | 32 | 480 |
| Weeding/Training/Pruning Labour | Days | 100 | 10 | 1000 | 15 | 1500 |
| Irrigation Costs | Rs. | 100 | | 0 | | 0 |
| Plant Protection measures | Rs. | 100 | | 100 | | 600 |
| **Fixed Inputs** | | | | | | |
| Land revenues** | Rs. | 65 | | 65 | | 65 |
| Other Costs | Rs. | | | 635 | | 1000 |
| Interest costs, previous year | | | | | | 4100 |
| Total Cost toward Mandarin, Output, mandarin, 90 % saleable, Alternative crops/ composition | | | | 41000 | | 20545 |
| Net profit, Vegetables/spice crops, 30% area covered | | | | 13500 | | 16875 |
| Net profit, Maize, 100 % area covered | | | | 1803.6 | | 2254.5 |
| Net profit, Millet, 50 % area covered | | | | 900 | | 1125 |
| Net profit, Mustard/ Others, 15 % covered | | | | 390 | | 487.5 |
| Value of Mandarin | | | | 0 | | 0 |
| Total value of all products | | | | 16593.6 | | 20742 |

## (B)

| Year | Mandarin | | | Alternative crop mix | Net Cash Flow |
|---|---|---|---|---|---|
| | Cost | Value of output | Net Profit | Net Profit | Current value |
| 1 | 41000 | 0 | -41000 | 16594 | -24406 |
| 2 | 20545 | 0 | -20545 | 20742 | 197 |
| 3 | 20545 | 0 | -20545 | 16594 | -3951 |
| 4 | 20545 | 19200 | -1345 | 6914 | 5569 |
| 5 | 20545 | 40000 | 19455 | 6223 | 25678 |
| 6 | 20545 | 80000 | 59455 | 5600 | 65055 |
| 7 | 20545 | 120000 | 99455 | 5040 | 104495 |
| 8 | 20545 | 200000 | 179455 | 4536 | 183991 |
| 9 | 20545 | 240000 | 179455 | 4083 | 183538 |
| 10 | 20545 | 240000 | 219455 | 3674 | 223129 |

(Source: DOA-Nepal, 2006)

### 7.2 The trading system

The pre-harvest contract system is the most common marketing practice followed by the mandarin producers (Bastakoti, 2001), despite the low farm gate price achieved. A more detailed description of one typical scenario, observed in the Banksharka, Parbat district, is described as follows:

Fruit growers are at a very small scale (less than 100 trees), with fruit production as a side activity of the subsistence farming. A trader (also termed a petty collector, ‘doke’ or contractor), will pass door to door offering a price for fruit ‘on the tree’. The amount is negotiated on the basis of the average number of fruit per tree, generally regardless of the fruit size and other quality factors, with an average farm gate price of less than one third of local market (at around Rs.10 per kg in 2013). The trader now owns the crop on the tree. Often this will occur just before a religious festival when the growers are need of cash. These middlemen visit the producer villages in September or October and negotiate the total value of whole orchard. The outside buyers are very familiar to the producers; indeed, they may be a larger local grower. The producers receive partial payment of the negotiated price in advance, with the difference paid in installments after the harvest and sale of the fruit. The grower bears no further risk, e.g. to a hailstorm.

The trader organises harvest of the fruit, with no care given to trees (e.g. breakage of branches) and fruit is transported to a local roadside or market where the fruit might be sold for local consumption or sold to a trader who consolidates fruit for shipment to a larger urban centre. The fruit may pass several hands before arrival in the largest market, Kathmandu. In this system, growers have little or no knowledge of the final market of their fruit and fruit quality (in terms of shelf life) is generally very poor. Fruit growers believe the buyers have the upper hands in fixing the price of the crop, but the contractors believe their service of offering a fixed price ahead of harvest, and organisation of harvest, transport and marketing should have higher value. Therefore, some leader farmers are selling product directly to the wholesale market (Shrestha et al., 1998).

### 7.3 Limitations in the transport chain

After harvest, fruit are carried off the hill slopes in *'doko'* (bamboo baskets with about 20 -25 kg of fruit). Plastic crates (carrying approximately 20 kg) are used in transport of fruit to more distant domestic markets. The *'doko'* is emptied over the head of the carrier, with fruit dropping to the ground, prior to placement into crates. The physical damage done to the fruit in carrying in and unloading from 'doko' will become evident within days as bruising and infection. Some rudimentary sorting on fruit size may be done in loading the crates. A large trader will operate two trucks on a contract in the peak of the harvest season. While one truck returns from Kathmandu with empty crates, the other truck is loaded with fruit crates at the collection centre. There is no postharvest care (washing, waxing, sorting) of fruit. The trucks do not have any cooling system for the fruit consignment. Rather fruit is exposed to the environmental conditions (rain, dust, heat). In some cases, fruit may be transported in utility trays (Figure 6A) to local markets, where it is sorted into plastic crates for on-trading. Local retailers will buy from these markets, selling fruit from roadside stalls or small stores (Figure 6B).

A B

**Figure 6.** Nepalese *suntala* (mandarin) arriving to Pokhara market: (A) being graded into plastic crates and (B) sold by roadside retailers.

### 7.4 Risks in production

Availability of Nepalese mandarin is highly seasonal (November to January). Indian fruit floods the market from the end of January. Consequently, there is a need for varietal selection to extend the production window, particularly for early season fruit. Poor cultivation techniques and postharvest handling cause low product quality, resulting in short shelf life. For example, harvest crews handle the fruit roughly while harvesting, causing physical damage. Bruising will appear on such fruit within a day of harvest. Emphasis is placed on trading the fruit quickly, before the problem becomes apparent, rather than solving the problem at harvest.

Further, the quality and coverage of the extension system is very weak. There is a need to augment the government advisory system with value chain led systems. For example, at present the sellers of production supplies do not have enough knowledge to effectively advise mandarin growers and thus they will attempt push product that will not have high quality in the market.

Different projects have attempted to support the commercialisation of citrus production in Nepal. Farmers in designated priority districts in mid hill districts have been provided with technical and economic support with the goal of expanding production area and increasing productivity as given below:

- 50%  subsidy on the cost of fruit saplings
- 50% subsidy on the cost of equipment such as secateurs, pruning saws, grafting knives, etc.
- 25% subsidy on the cost of sprayers
- 100% subsidy for on-farm nursery establishment with provision of sprayers, secateurs, pruning saws, grafting and budding knives, plastic bags, pesticides, water cans, polythene pipe, etc.
- 25% subsidy up to Rs. 10,000.00 for the construction of cellar stores
- 100% subsidy on zinc sheets for the construction of collection canters
- 25% subsidy on the cost of plastic crates for transportation of fruit
- Rs. 2,000.00 per ha for maintenance of poor bearing orchards

However, without development of markets and a value chain to serve these markets, these efforts have resulted in limited benefits. Indeed, Full Bright (2008) reported that some farmers were earning a net income of Rs. 50,000 to 60,000 (US$ 1 = Rs.100) per ha per annum. When asked why they did not increase production, the responses included:

- The farmers' first priority is food security, so effort is invested into a range of other crops
- farmers prefer to maintain production near their houses for security and ease of access
- trees can be cultivated only under certain favourable soil and water conditions
- irrigation water is not available
- farmers do not have easy access to, knowledge of, or confidence in the implementation of improved technologies
- management of pests and diseases can be difficult, requiring a high level of specialisation/expertise
- all fruit are marketed within a narrow window, leading to market saturation and decreased prices
- lack of storage facilities
- long orchard establishment period of 6-7 years and related cash flow issues
- problems of post-harvest handling such as packaging, grading, transportation etc., resulting in loss of quality of fruit in the market, such that returns were not consistent

## 8. Conclusion—shaping the future

The tree fruit industry might continue in an 'augmented subsistence' farming mode. However, it seems likely that the current production system cannot persist as such, faced with the onslaught of imported produce and the loss of rural labour.

The key to commercialisation is identification of appropriate markets that offer a better 'value proposition', followed by focus on growing product to meet the needs of those markets. With increased profit available, there is incentive for:

- consolidation of land parcels
- adoption of grower co-operative or contract growing arrangements
- irrigation
- adoption of new crop management and postharvest practices
- adoption new varieties and crops (once appropriate markets are identified)

Other than citrus, promising alternative tree fruit crops include avocado and macadamia, but market research is needed.

Value chains must form, focussed on developing and exploiting market niches. These value chains represent a vertical integration of effort and they should develop capacity in terms of providing finance and advice to actors within the chain. A contract farming arrangement could be trialled as a means of involving existing producers. District level producers' committees could evolve in this direction if the co-operative structure allows an entrepreneurial lead.

The government services should:

- provide market information, both domestic and export (prices and volume by month in key export markets)
- ensure timely support of export activities (e.g. phytosanitary inspections, market assessments)
- ensure that proven varieties are readily available for area expansion
- provide extension material and training to emergent value chains
- encourage extension self-sufficiency of established value chains
- provide assessments of new commodities and production areas (e.g. Table 1)
- encourage external investment into integrated agro-tourism operations

Marketing groups should make use of the altitude gradients available over relatively short distances in Nepal to arrange production of a given tree fruit crop over an extended window, augmented by cold storage. A national marketing activity should develop a 'brand' for Nepalese fruit in key export markets, as well in the developing Nepalese supermarkets.

## References

ADB. (2009). *An evaluation study on 'agriculture and natural resources sector in Nepal'.* Kathmandu: Asian Development Bank (ADB).

ADB. (2011). *Assessment report "technical assistance for the preparation of the Agricultural Development Strategy."* Kathmandu: Asian Development Bank (ADB).

ADB. (2011). *Vision report: Technical assistance for the preparation of the Agricultural Development Strategy. Kathmandu:* Asian Development Bank (ADB).

Bastakoti, R. C. (2001). *Production and marketing efficiency of mandarin oranges in western hills of Nepal.* M. Sc. Thesis, Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal.

Chirwa, E. W., & Mattita, M. (2012). From Subsistence to smallholder commercial farming in Malawi: A Case of NASFAM commercialization initiatives. Working Paper 037. *Future Agricultures.* [online]. Available at: *http://www.future-agricultures.org.*

FAO. (2010). *Agricultural extension services delivery system in Nepal.* Lalitpur, Nepal: Food and Agricultural Organization of the United Nations.

FAO. (2014). Horticultural chain management for countries of Asia and the pacific region: A training package. [online]. Available at: *ftp://ftp.fao.org/docrep/fao/012/i0782e/i0782e00.pdf.*

Full Bright Consultancy (Pvt.) Ltd., (2008). *Product chain study: Mandarin orange.* Biratnagar, Nepal: Commercial Agriculture Development Project, Ministry of Agriculture and Co-operatives, Department of Agricultureand Kathmandu: Full Bright Consultancy.

IFAD. (2013). *Accountability and learning for better rural livelihoods*. Rome: International Fund for Agricultural Development (IFAD). [online]. Available at: *www.ruralpovertyportal.org*

Jones, M. (2013). *AsiaFruit,* [online]. Available at: *www.fruitnet.com*

Kanel, D., and Baan, E. (2011). *From saplings to satisfaction: Increasing market access for small apple farmers by brokering the relation with national agribusinesses.* Kathmandu: SNV. [online]. Available at: *http//:www.snvworld.org/en/sectors/agriculture.*

MoAD. (2008). *Final report on product chain study: Mandarin orange. Kathmandu:* Commercial Agriculture Development Project. Ministry of Agriculture and Cooperatives.

MoAD. (2012). Government of Nepal, Ministry of Agricultural Development (MoAD), Agribusiness Promotion and Statistics Division, Agri. Statistics section. [online]. Available at: *http://www.moad.gov.np/downloadfile/yearbook2012_1363677455.pdf).*

Pokhrel, C. N. (2011). *Analysis of market chain of mandarin in Nepal: A case of Lamjung district.* A Master's Thesis for Agricultural Production Chain Management. Van Hall Larenstein University of Applied Sciences, The Netherlands.

Samriddhi. (2011). *Agriculture commercialization in Nepal: A discussion paper*. Kathmandu, Samriddhi Foundation.

Shrestha, B., Subedi, P.P. & Thapa, J. J. (1998). Socio-economic factors affecting adoption of cellar store as a post-harvest technology for mandarin orange in the western hills of Nepal. *LARC Working Paper No. 98/34.* Lumle. Kaski, Nepal: Agriculture Research Centre.

Shrestha, G. P., & Gautam, K. R. (2011). Fruit and Vegetable Production and Marketing in Nepal.In special paper presented on December 14 in: *Consultation meeting on public support on production and marketing system of agriculture of SAARC countries.*

Sindi, J. K. (2008). *Kenya's domestic horticulture subsector: What drives commercialization decisions by rural households?* A Master's Thesis submitted to Department of Food, Agriculture and Resource Economics. Michigan State University, USA.

Uathavikul, P. (2004). Poverty reduction through contract farming, lessons from Srakaew province, Thailand. In presentation on August 9-12 in:ADB-UNESCAP *workshop on contract farming and poverty reduction.*

UNDP. (2012). *Promoting ICT based agricultural knowledge management to increase production and productivity of smallholder farmers in Ethiopia. Rome: United Nations Development Program (UNDP).*

6

# Use and Misuse of Agro-Chemicals in Nepal: Challenges for Sustainable Agriculture and the Environment

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## Abstract

Agro-chemicals refer to the chemical compounds or substances that are used for the augmentation of plant nutrients and control of pests to enhance agricultural production. Several chemicals mainly fertilisers, pesticides and growth regulators/hormones have been increasingly used in Nepal in recent years. Agro-chemicals are primarily used for boosting crop production, but if used improperly they can trigger serious long-term human health and environmental hazards. Nepal uses relatively small amount of agro-chemicals as compared to other developed countries; however, the level of their misuse is very high and the fate associated with them in the environment and public health are enormous. This paper reviews the current practices of using different agro-chemical in Nepal and how they pose challenges for the sustainable agriculture, environment, and human health. The adverse health and environmental effects, especially due to the misuse of pesticides include growing number of acute poisoning and long-term illness such as cancers, reproductive defects and contamination of air, soil and water sources. Poor or inadequate regulatory and compliance systems for registration, import, distribution, marketing and disposal of agro-chemicals have aggravated the scale of misuse. The key factors contributing to health and environmental hazards through agro-chemicals are over use, injudicious and inappropriate uses (e.g. date-expired, banned, off-label and counterfeit products), lack of proper knowledge of storage, handling, application and disposal practices; improper occupational health and safety measures; and low level of awareness among general public about the pesticide residues in food commodities and their harmful effects on human health and environment. There is also a lack of stringent measures to restrict import and use of older and extremely harmful pesticides. Because of the non-existence of a systematic monitoring, analysis and warning systems for the pesticide residues, foods produced locally or imported from outside are significant source of pesticides contamination. Nepal is, therefore, heading towards irrevocable health risks and environmental hazards induced by the misuse of agro-chemicals. These will have huge environmental and economic burden to the country. Strong regulatory compliance system on registration, import, marketing, storage and use, extensive

training, education and public awareness programs on safer pesticides use, and promotion of practical non-chemical or safer alternatives such as bio-pesticides and reduced-risk pest control products, integrated pest management (IPM) practices are the suggested measures to prevent or reduce the unwanted havoc of agro-chemicals use in Nepal.

# 1. Introduction

This chapter is prepared based on the review of published literatures and web based information relevant to the theme of this chapter. The objective of this chapter is to present the current practices of using different agro-chemicals in Nepal and discuss the scenarios pertaining to how the misuse of agro-chemicals has caused adverse effects to human health and the environment, and poses a challenge to sustainable agriculture.

Agro-chemicals are the chemical substances that are used in agricultural production, household and industrial uses for the control of pests, and as a source of plant nutrition for the enhancement of their growth. In recent years, fertilisers, pesticides and growth hormones or growth regulators have been used increasingly and indiscriminately in Nepal. Use of pesticides and fertilisers has increased sharply with the green revolution technologies and expansion of commercial crops production such as fruits and vegetables. Agro-chemicals are used for boosting agricultural production, but if misused, they can trigger serious long-term human health and environmental hazards. Inappropriate use of these chemicals can have several adverse effects on crops, bring harm to humans and animals, cause contamination of food and feed, and have adverse effects on the environment through degradation on the qualities of water, soil, air and impact on biodiversity.
Agro-chemicals can be broadly categorised in three major groups: pesticides, chemical fertilisers and hormones and plant growth regulators. Among these, pesticides have a significant impact on human and animal health and environment; therefore, they are discussed in greater details than the other two groups.

## 1.1 Pesticides

The word pesticide was originated from a combination of English word ‘pest’, meaning unwanted organism, and the Latin word ‘cide’, meaning killer agent. Food and Agriculture Organization (FAO, 1989) defines a pesticide as any substance, mixture of substances, or micro-organisms (including viruses) intended to repel, destroy or control any pests, including vectors of human or animal disease, nuisance pests, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products or animal feeding stuffs, or which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. Based on the specific target pest, these chemicals are further classified into different groups each intended to control a specific type of pest as listed in Table 1.

**Table 1:** Pesticides classification based on their target pests.

| Pests | Pesticides |
|---|---|
| Algae | Algaecides |
| Bacteria | Bactericides (antibiotics) |
| Birds | Avicide |
| Fungi | Fungicides |
| Insects | Insecticides |
| Mites/ ticks | Miticide/Acaricide |
| Snails/slug | Molluscicides |
| Nematodes | Nematicides |
| Rodents/mice/rats | Rodenticides |
| Weeds | Weedicides/herbicides |

In addition to those listed above, many of the household chemicals such as mosquito repellents, household disinfectants, swimming pool chemicals (disinfectants and sanitisers), food preservatives, and chemicals used in lawns and gardens are all considered as pesticides.

Among the agro-chemicals, pesticides are the largest in number, most widely used and most hazardous for human health and environment. Currently, there are over 900 active ingredients in pesticides registered worldwide, which are formulated into thousands of pesticide products available in the marketplace. About 350 pesticides are used on the foods we eat and to protect our homes and pets (DPR, no date). In Nepal, pesticides were first introduced in 1956 for mosquito control with the aim of eradicating malaria a vector-borne disease. Since then, it has expanded its scope and the agriculture sector shares a large use of pesticide. Agriculture intensification via monoculture cropping and increased prevalence of inputs such as fertilisers, irrigation and new plant varieties continues to intensify pest problems (Schaefers, 1996). Consequently, pesticides are being used heavily, especially in areas accessible to roads and markets and in the commercialised agriculture production pockets in Terai region, Kathmandu valley and surrounding areas (Jha & Regmi 2009; Giri et al., 2012; Sharma et al., 2012). High value crops such as fruits and vegetables, as well as crops that are grown on commercial scale (tea and cotton), have attracted higher rates of pesticide application.

## 2. Why pesticides are needed?

Different categories of pests as listed above cause harm to crops, livestock, forestry and public health. Loss of crops in the field as well as in post-harvest storage has been reported to be as high as 35% in Nepal (PPD, 2012), due to various types of insects, pests, diseases, weeds, birds and rats/rodents. Unless natural control of such pests exists, pesticides are an important management tool to control or suppress pests. Pesticides are often considered as a quick, easy and inexpensive solution for controlling pests because they act rapidly and can work against a specific target pest or broad range of pests. Other advantages of pesticides are that small amount of pesticides can be effective in covering a large pest population or crop area. When used properly, safely and responsibly, they have many beneficial uses.

Pesticides have been promoted as a means to increase agricultural production. If there were no pesticides discovered or not being used, there would have been a serious food scarcity and public health threat in the world. Pesticides in many cases protected various crops from insect pests and disease epidemics. Historical pest epidemics such as mosquitoes (causing malaria), locust swarms, potato famine caused by late blight (*Phytopthora infestant*) in Ireland and coffee rust (*Hemileia vastatrix*) in Sri Lanka are some of the worst examples of pest epidemics which would not have been eradicated or controlled without the use of pesticides. If pesticides were not being used, there would have been a serious food scarcity and public health threat in the world. Similarly, the achievements of Green Revolution would not have been fully realised if pesticides were not available or used.

The use of pesticides has also shown significant impacts in controlling pests of human health as well as agricultural importance around the globe. They have proved to be critical in suppressing insect vectors of diseases such as malaria, dengue, West Nile Virus. They are also very useful in suppressing pests of livestock such as ticks and flies.

**2.1 Pesticide use in Nepal**

Nepal does not use as much pesticide as many other countries in South Asia. The average pesticide consumption on agriculture in Nepal is only 0.14 kg/ha (Bista et al., 2004), whereas in most of the South East Asian countries the average use is 3.6 kg/ha (Manandhar, 2006). In terms of crop commodities in Nepal, the most pesticide was applied in cotton (2.56 kg/ha) followed by tea (2.1 kg/ha) and vegetables production (1.45 kg/ha), with a national average of only 0.14 kg/ha (Bista et al., 2004). However, in recent years, the area under cotton production has drastically reduced and the use of pesticides has been increased sharply in vegetables and potato production. It is generally argued that the actual quantities of pesticides used in Nepal could be much higher than as reported by the formal sources. It is likely that large amounts of pesticides illegally enter Nepal thorough the porous border with India and no statistics of such imports can be available. Jha and Regmi (2009) also reported that the average pesticide use in the survey area was higher than previously estimated.

Total pesticide import and consumption is steadily increasing in Nepal (Figure 1). However, there is a lack of a systematic data recording system for the procurement and consumption of pesticides. It is ironic that the government statistics in Nepal only refer to the data provided by government agencies, such as Agricultural Input Corporation Limited (AICL), when the reality is that most of the procurement and distribution of these chemicals is done through private sectors.

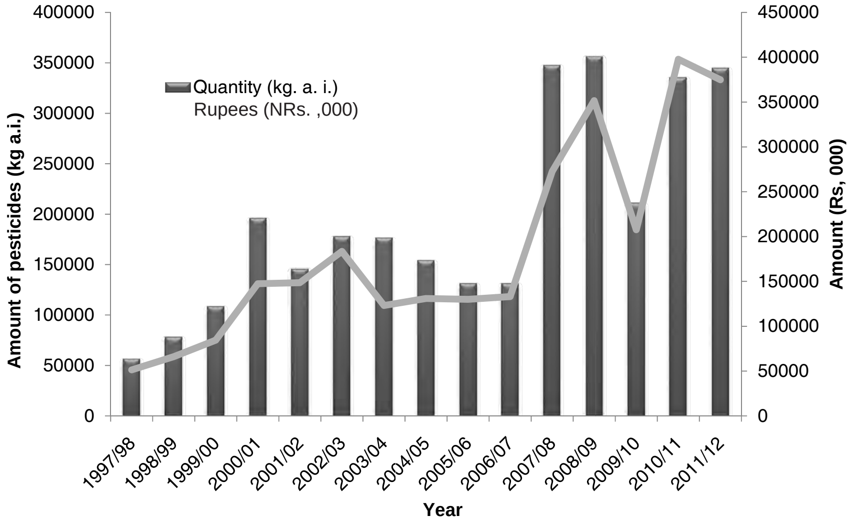


Figure 1: Trend of pesticides active ingredients (a.i.) import in Nepal and their monetary value (Nepalese Rupees) from 1997/98 to 2011/12 (Source: PMRD, 2011).

With the implementation of national Integrated Pest Management (IPM) Program in 1997, gross pesticide import and consumption in Nepal appeared to have stabilised until 2006, but increased sharply after 2007 (PRMD, 2011). In the past, insecticides (60%) dominated the pesticides import followed by fungicides (30%) and other pesticides (10%) (Manandhar, 2006). However, the trend has changed in the recent years; fungicides (61%) have become most common pesticide followed by insecticides (29%), herbicides (7%) and others (Sharma et al., 2012). Currently organophosphates and synthetic pyrethroids are more commonly used pesticides in agriculture and public health (PRMD, 2011).

There are reports that pesticides, classified as being extremely or highly hazardous to health by FAO and WHO, are still commonly used in Nepal for some time (Paudel, 2011). The porous Nepal-India border makes it difficult to regulate cross-border movement of unauthorised pesticides that includes chemicals such as dichloro-diphenyl-trichloroethane (DDT) and Benzene hexachloride (BHC), supposedly banned in both countries.

**2.2 What is pesticides misuse?**

Pesticide misuse is the practice of handling, applying, storing and disposing pesticides illegally or without following proper safety measures as prescribed on the label; this leads to immediate or long-term injury to persons or non-target organisms, contamination of feed or food and unwanted effects to the environment. Most pesticide related incidents occur because of its improper use leading to adverse effects on unintended or non-target areas or uses. Since all pesticides are hazardous chemicals, their misuse can lead to deadly accidents or long lasting human and animal health and environmental effects. Therefore, pesticide misuse is becoming a serious concern in Nepal (Sharma et al., 2012).

Pesticides are unique chemicals as they are intrinsically toxic to several biological targets, are deliberately spread into the environment, and their toxicity has a limited species selectivity (Maroni et al., 2006). The most important threats from the pesticides are health hazards due to their indiscriminate and improper use. Acute pesticide poisoning is a major public health problem in many developing countries including Nepal. Every year, hundreds of thousands of people get sick and/or die around the world due to misuse of pesticides and Nepal is no exception. In most cases, only acute and obvious cases are reported (Forget, 1991) and others go unnoticed which may include pesticide related deaths.

Nepalese farmers and urban consumers are the primary victims of pesticide exposure with potentially devastating impacts. Despite the growing concern about the toxic effects of pesticides to human health and the environment of Nepal, preventive measures are insufficient. The most commonly observed impacts of pesticide misuses may be categorised as:

i. Occupational exposure—due to unsafe application, storage, disposal and handling practices;

ii. Consumers—through unacceptable levels of pesticide residues in food and drinking water;

iii. Self-poisoning or intentional misuse of pesticides;

iv. Accidental or incidental use of pesticides;

v. Effects on bystanders—people living on farms or near agricultural areas, where pesticides are frequently and heavily used; and

vi. Environmental—contamination of water, soil and air due to unsafe application, storage and disposal practices.

### 2.3 Causes of pesticides misuse in Nepal

Although the use of pesticides in Nepal is far less when compared to the industrialised countries, the extent of misuse in Nepal is huge. Several factors are responsible for this misuse as outlined below:

**i. Poor access to information:** The lack of adequate information and/or poor awareness among farmers and the general public about the harmful effects of pesticides is the most important factor for many pesticide related hazards in Nepal. When pesticides were first introduced in Nepal, the government agencies promoted pesticides as '*aushadhi*', meaning medicine, and heavily subsidised it, at times even providing it for free. It did not provide adequate precautionary measures for its handling, application, storage and disposal.

In Nepal, all pesticides are imported either from India or other countries and bear labels in foreign language. Although required by law, pesticides sold in Nepal do not have labels printed in Nepali or other languages commonly spoken by the local farming community. Furthermore, the majority of the Nepalese farmers are illiterate and cannot read the label even if they are written in their own language. Most farmers, therefore, depend on their fellow farmers (who are similarly not well-informed) or on the pesticide retailers (who are not well trained) for information on pesticide use.

ii. **Lack of technical knowledge:** The majority of farmers in Nepal are unaware of the extent of the hazards associated with pesticides, either because they do not read the label instructions as ignorance, or they do not have adequate knowledge and understanding of the safe use of pesticides and about their adverse effects (Paneru et al., 2004; Giri, 2010; Sharma et al., 2012). Most farmers do not follow the label instructions while handling, mixing, applying, storing and disposing of pesticides. For example, Giri et al. (2009) reported that only about 50% of the farmers read pesticide labels before using.

They also do not have adequate knowledge of treatment measures in the event of pesticides poisoning. Due to lack of knowledge of the economic threshold level of pests, farmers use pesticides once pests appear in the crop without considering whether the application is warranted. Farmers also apply pesticides without proper diagnosis which often leads to incorrect use of pesticides, such as spraying fungicides against insect pests and vice versa. Due to poor understanding, farmers may underestimate the toxic effects of pesticides and continue using them without safety precautions (Atreya, 2008). Consequently, harmful effects of pesticides on human health and environment continue.

iii. **Pest diagnostics and threshold:** Pest diagnosis is major a problem in Nepal. Laboratories in the country are largely inaccessible to most farmers. Extension agents or extension supports are not easily accessible. Pesticide retailers (the most common source of pest management information) make pesticide recommendations based on the descriptive symptomology of crop damage provided by farmers. The practice of suggesting a 'cocktail' of fungicide and insecticides or systemic and contact poisons is not uncommon. There is also a lack of knowledge of the economic threshold level of pests, and farmers are advised to use pesticides upon the first appearance of pests on crops without consideration of the true need for pesticide application.

iv. **Inappropriate application practices:** A lack of well-trained manpower and pesticide use education continues to be one of the major factors of pesticides misuse in developing countries (Schaefers, 1996; Mancini et al., 2005). The majority of Nepalese farmers are not properly trained and do not have adequate knowledge of occupational safety procedures for handling pesticides. For example, they do not wear protective clothing, gloves, and boots, and in extreme cases, some farmers apply pesticides with their bare hands. Use of faulty and unsafe equipment, adulterated products, poor handling practices and availability of unsafe, more toxic and restricted pesticides are the other causes of pesticides misuse in Nepal. The technology available to small farmers for pesticide application is often inappropriate: faulty sprayers, lack of protective equipment adapted to tropical conditions and nonexistent first-aid provisions (Forget, 1991). Giri et al., (2009) also reported that out of 471 pesticide practitioners surveyed in Nepal, none of the respondents followed the recommended safety measures perfectly. Therefore, occupational exposure to pesticides has been a major cause of pesticide misuse in Nepal.

v. **Improper storage and disposal:** A high proportion of pesticide intoxications are due to lack of knowledge, unsafe attitudes and dangerous practices (Forget, 1991). In addition to the poor knowledge of farmers, there is a lack of facilities for safe storage and disposal, which causes frequent accidental poisonings. Unsafe storage, disposal and transportation procedures, reuse of pesticide containers, continuous use or storage of obsolete pesticides and storing pesticide containers in unsafe places are also major cause of pesticides poising and environmental contamination. Misuse of empty pesticide containers to store foodstuffs is a common practice among some farmers. Giri (2010) found in a survey that out of 30 farmers interviewed, 50% stored pesticides in an unlocked room. The recent (2013) death of 23 school children in Bihar was reported to be after they ate food contaminated with an insecticide. The cooking oil was reportedly stored in an old container of monocrotophos. This is just one example; there could be many more unreported incidences. Another hazardous practice is storing or selling pesticides and veterinary drugs in the same location, such as at Agro-Vets. It is also not uncommon for pesticides and food to be sold in the same store.

vi. **Poor regulatory and compliance system:** Although there are laws and regulations available for pesticide use in Nepal, there is no effective or functional monitoring and compliance system. As a result, there is a widespread use of unregistered, obsolete, banned, off-label, expired and counterfeit pesticides. Pesticides classified as extremely or highly hazardous by FAO and WHO, many of which are banned by other countries, are still used in developing countries (Kesavachandran et al., 2009). Indian dealers are able to illegally sell pesticides in Terai region and major towns of Nepal due to the porous border (Palikhe, 2002). Consequently, possession and sale of unregistered pesticides by the pesticide retailers and continuous use of banned, ineffective, adulterated and expired products, including the persistent organic pesticides (POP), are reported in Nepal (Bista et al., 2004; Thapalaya, 2011; Paudel, 2011; Giri et al., 2012).

vii. **Under-or-over use of pesticides:** Generally, farmers apply pesticides once they notice some insects or diseases on their crops without proper identification of pests and/or judging whether pesticide application is really needed. Similarly, applying either an over-dose or under-dose is common, and farmers often do either fail to apply the correct pesticide for the infestation being treated or miss the crucial period for application for pest population control. Farmers also deliberately apply an overdose of pesticides because they are uncertain of the effectiveness of the dose and use higher rates to avert the risk of bigger pest problems (Jha & Regmi, 2009). Such practices lead to poor efficacy on target pests and may harm non-target organisms; additionally, this may cause crop damage as well as waste a farmer's time, money and pesticide supply.

viii. **Not following adequate waiting period:** There is a failure to wait the proper period of time for re-entry into treated areas or pre-harvest interval (PHI) by the farmers, leading to higher pesticide residues in raw agricultural produce or exposure to the farm workers. The PHI is the minimum amount of time that must pass between the last pesticide application and the harvesting of the crop, or the grazing or cutting of the crop for livestock feed/forage. If the treated crop is harvested before the PHI has elapsed, there may be pesticide residues in excess of the maximum residue limits (MRL), which is defined as the maximum concentration of a pesticide that is allowed in certain foods without posing a risk to human or animal health. These standards are set by the national or international agencies. Palikhe (2002) reported that over 60% of farmers who had used pesticides for over five years waited less than two weeks after spraying pesticides before harvesting crop. Similarly, Giri (2010) in a survey around the Kathmandu Valley reported that more than 30% of farmers waited less than one week after pesticide application for harvest, although the PHI for such pesticides was not indicated.

ix. **Cosmetic use of pesticides:** Sometimes pesticides are used inappropriately, such as dipping or drenching vegetables and fruits for colour enhancement or to keep them fresh (Palikhe, 2002; Giri, 2010). Treating stored grains against the pests such as grain moth, weevils and beetles directly with pesticides is common; such grains are often consumed in rural Nepal. This is not only a serious violation of labelled use pattern, but also poses an ethical issue.

x. **Non-targeted uses:** Pesticides are also misused in applications such as fishing and poaching, and even to treat lice infestations for humans (Paneru et al., 2004); some baiting and recreational uses is also common in Nepal. Similarly, using pesticides without proper identification of pest or not matching the mode of action to the pest or critical timing are also common misuses. Such misuse of pesticides has also believed to be responsible for killing non-target and beneficial animals or creatures. The disappearance of endangered species such as certain birds (e.g. vultures), and mammals (jackals) is believed to be a consequence of non-target use of pesticides.

### 2.4 Adverse effects of pesticides

Despite some economic benefits of pesticides to protect crops and livestock, increase production of food and fibre and control of vector-borne diseases such as malaria, dengue fever, West Nile Virus, and pests of livestock such as ticks and flies, these chemicals pose several adverse effects on human health, environment and biodiversity. Pesticides are poisonous and formulated to kill or suppress target pests. Use of these toxic chemicals without following proper safety measures can led to several unintended and hazardous consequences; crops may be damaged (phytotoxicity), pests may not be controlled, beneficial natural enemies of pests may be destroyed, human and livestock health may be impaired, birds, wildlife and aquatic animals may be killed, and soil, air and water may be contaminated.

Although Nepal uses relatively small quantity of pesticides as compared to the developed and mechanised counties, the level of pesticide misuses is high and the environmental and health hazards are considered greater than in the developed countries. Many pesticides commonly sold in Asia are extremely hazardous (Category I and II chemicals), which are either banned or severely restricted for use in the developed world even when used with high levels of protection (Pingali & Roger, 1995). The most common harmful effects of pesticides on human health and environment are described as follows:

### *2.4.1 Human health hazards*

Developing countries use only 20% of the world's agrochemicals, yet suffer 99% of deaths from pesticide poisoning (Kesavachandran et al., 2009). Nepal belongs under this category but there is a lack of easily available information on pesticide related illness and death. Like most other developing countries, the awareness about the health hazards of pesticides and information on health risks of pesticides misuse are rare in Nepal. Only recently, few studies have estimated health risks of pesticides misuse in Nepal such as Aterya (2008) who estimated that the average cost of illness resulting from pesticide exposure was NPR 114 per person which is nearly one-third of a person's total expenditure on health care. Despite the fact that pesticides misuse can have serious consequences, the adverse effects of pesticide on human health are not considered serious because the majority of the public remains unaware of the harmful effects of pesticides and their long-term impacts on human health.

The degree of health hazards due to pesticide exposure depends on the: inherent toxicity of the compound, mode of exposure to the toxicity, duration of exposure, dose of toxic substance and sensitivity of an individual to that toxin. The health effects of a pesticide product may be a consequence of either the active ingredient or the other ingredients in the formulation or both (Alavanja et al., 2004). Generally, as the amount of exposure increases, the risk of toxic effect also increases; the longer or more often a person is exposed to a given amount of a pesticide, and greater the strength of toxicity of the chemical, the greater the extent of harm.

### *2.4.2 Pathways of human exposure to pesticides*

Pesticides can enter to the human body through 'direct' and 'indirect' pathways. The 'direct exposure' occurs when individuals come in direct contact to pesticides through dermal or eye exposure, inhalation and ingestion. The dermal absorption route is considered as the principal source of exposure. Persons such as mixers, loaders, applicators and production workers who come into direct contact of pesticides are likely to have the highest levels of direct exposure. Nepalese farmers who apply pesticides without taking adequate precautions and without personal protection equipment are most likely to suffer from direct exposure to pesticides.

The 'indirect exposures' occur through drinking water, breathing air, dust, and residues in foods which represent routes of long-term, generally low-level exposures (Alavanja et al., 2004). The major source of indirect exposure to pesticides is thought to be from residues in treated crops. A food containing pesticide residue that exceeds the established MRL is not considered safe for consumption. However, there is a widespread ignorance of the chronic pesticide poisoning in Nepal (Palikhe, 2002). In addition, contaminated water resources and contaminated air (application drift, pesticide leak from pesticide formulation plants, storage etc.) are other avenues of indirect exposure. Pesticides are also exposed to others such as bystanders—those who come in contact with the sprayed areas along roadsides, playgrounds where pesticides are used and water sources or areas that receive pesticide drifts.

### *2.4.3 Types of pesticide poisonings*

The types of pesticide exposure to humans are classified as either acute poisoning (a short term, sudden and severe exposure) or chronic poisoning (prolonged or repeated exposures over long time).

**Acute effects:** The acute poisoning usually occurs when a person inhales or ingests an unacceptable level of pesticides in an accidental event or short time period. The immediate or acute symptoms of over-exposure to pesticides include burning, irritating, stinging, or itchiness of eyes, nose, throat and skin, nausea, dizziness, numbness, vomiting, diarrhoea, coughing, headache, seizures, difficulties in breathing, loss of consciousness, and even death. All types of pesticides but the organophosphate and carbonate groups are considered as more serious for acute poisoning.

The other major type of acute effect is self-poisoning. Pesticide self-poisoning is one of the most commonly used means of suicide worldwide (Gunnell et al., 2007) and magnitude of the problem and global distribution is not clear. Konradsen et al. (2003) reported about 3 million cases of pesticide self-poising world-wide annually, accounting 30% of all suicides. Bertolote et al. (2006) also estimated that self-poisoning with pesticides accounts for about a third of all suicides worldwide. This is also one of the major causes of deaths in developing countries including Nepal. Konradsen et al. (2003) reported that in South East Asia, about 20% officially recorded suicides were pesticide self-poisonings. However, in Nepal, the figure is estimated to be even higher: 31% of all suicidal deaths between 1999-2000 were due to pesticide poisoning (CBS, 2001). Deadly chemicals such as Zinc Phosphide (rodenticide) have been frequently used for self-poisoning.

**Chronic effects:** Chronic poisoning occurs through consumption of foods such as fruits, vegetables, meat, fish and dairy products, drinking of contaminated water and exposure to contaminated air for a long time. The effects of chronic poisoning include organ damage such as liver and kidney failure, reproductive disorders (birth defects) carcinogenic (cancer), neurotoxicity (neurological disorders), mutagenicity (gene mutations), metabolism (toxicokinetics), respiratory problems, memory disorders and death.

Chronic exposure too many organophosphate insecticides can cause disruption to the nervous system including brain. Chlorpyrifos (Dursban), a common pesticide used to control indoor pests such as termites, fleas and cockroaches has been reported to cause birth defects on human (Sherman, 1996). In the past, more harmful classes of pesticides such as organophosphates (e.g. methyl parathion, Malathion, chlorpyrifos) and organchlorines (e.g. DDT, BHC, Chlordane, Heptachlor, and Lindane) have been extensively used in Nepal. Pesticides such as DDT have been shown to be transferred from mother unknowingly to infants through breast milk thereby affecting development of the baby.

Among the other possible health impacts of chronic pesticide exposures, cancer has been considered as the major concern. Epidemiological studies of cancer and neurological diseases suggest that human health effects occur at current exposure levels in occupational and environmental settings (Alavanja et al., 2004). Several laboratory animal experiments have shown carcinogenic effects from pesticides. Jaga and Dharmani (2005) observed that pesticide exposure is an important risk factor associated with cancer development making agricultural and industrial workers high risk-groups. Bassil et al. (2007) reported positive associations between pesticide exposure and solid tumour development. They also reported that higher rates of stomach cancer were found in areas with high levels of atrazine contamination in the water. The most consistent associations were found for brain and prostate cancer. An association was also found between kidney cancer in children and their parents' exposure to pesticides at work. Continued ingestion of toxic chemicals such as BHC, DDT and cyclodine compounds show carcinogenic effect on human even at low doses (Bista et al., 2004). The United State Environment Protection Agency (US-EPA) has evaluated several pesticides and classified them for 'carcinogenic potential' based on the evidences from laboratory animal testing, metabolism studies and epidemiological experiments. Several pesticides currently in use including butachlor, diuron, mancozeb, mataldehyde, permethrin, primicarb, thiodicarb and 2, 4-D have been classified as 'probable human carcinogens'.

### *2.4.4 Environmental hazards*

Environmental pollution includes contamination of water, soil, air and destruction of biodiversity. Pesticides are considered as one of the top six environmental polluters (Blacksmith Institute, 2013). Even if pesticides are applied precisely following appropriate methods and labelled directions, they have unintended effects and reach destinations other than the target pests. For example, applied pesticides are deposited on soils, water sources, surrounding plants and air. The degree of pesticide contamination in untargeted places depends on the pesticides' chemical properties, its stability and weather conditions such as temperature, wind speed and direction. The commonly observed environmental hazards from pesticides are as follows:

### *2.4.5 Persistence in nature*

Some of the pesticides breakdown once exposed to environmental factors such as heat, light, water and microorganism, while others remain highly stable for years before breaking down into inert materials. Such compounds are called persistent organic pesticides (POP). This group of pollutants includes nine of the older organochlorines namely Aldrin, BHC, Chlordane, DDT, Diendrin, Endrin, Heptachlor, Mirex, and Toxaphene, and three other chemicals namely polychlorinated biphenyls (PCBs), Dioxins and Furans. These 12 chemicals are also called the 'Dirty Dozen'. Most of these have been banned for use in majority of countries, including Nepal.

The key features of a POP are that they persist in the environment for a longer time, they travel long distances or far from their sources and they are capable of accumulating in the body fat of living organisms, which is known as 'bioaccumulation'. Pesticides such as DDT are fat soluble and are therefore found in fatty foods such as meat and dairy products. The DDT Factsheet (PAN-UK, 1998) reports that analysis of 203 human fat samples in the UK showed 99% of the samples contained detectable residues of DDT. Even in North America and countries across Northern Europe, where use of DDT has been banned for several years, its residues are still often found in foods as a result of environmental persistence, illegal use or importation of contaminated foods from regions where DDT is still being used. Therefore, the POPs are global pollutants and because of their toxicity and persistence in nature, they pose serious adverse effects on human health, wildlife and aquatic lives across the globe.

Not only do pesticides persist and are dangerous in their original form, they can also break down into other forms such as metabolites and become even more dangerous chemicals than their parent chemicals. Upon exposure to the environment, many pesticides can evaporate or volatilise, often forming volatile organic compounds (VOCs), which can cause several adverse effects to human beings and animals. The VOCs also play a role in the formation of ground-level ozone, a major factor in air pollution and a significant health hazard.

### *2.4.6 Contamination of soil, water and air*

Pesticides have contaminated almost every part of our environment. Pesticide residues are commonly found in soil, water (surface and ground water) and air, creating a widespread problem globally. Pesticides can reach surface water through runoff and contaminate ground water through leaching. Pesticide drift is a major environmental problem. Drift of volatile compounds cause air pollution. Based on the persistence and mobility nature of pesticides, they have the potential to contaminate water sources through runoff, leaching and spray drift. Although this is an ongoing concern, fortunately, soil, water and air contamination with pesticides are not yet considered serious in Nepal.

### *2.4.7 Effect on biodiversity*

Pesticides are dangerous chemicals with the capability of killing any non-target species including human beings. Pesticides either from their direct contact or drift from their original point of application can harm beneficial insects such as honey bees, other pollinators, natural enemies of pest such as predators and parasite insects, scavengers and spiders that can lead to ecological imbalance. Insecticides are also toxic to avian species, wildlife, fish, amphibians and several other aquatic organisms. Therefore, pesticide contamination poses significant risk to the non-target organisms ranging from beneficial soil microorganisms to mammals. The impacts of pesticides on biodiversity are huge in Nepal, although they are not properly studied.

All of the above-discussed environmental effects have direct or indirect impacts on human health and well-being.

### *2.4.8 Development of resistant pests*

Insecticide Resistance Action Committee (IRAC, online) defines resistance as "a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species." Repeated applications and higher than required rates of a single synthetic pesticides can result in resistance amongst the target populations. This phenomenon occurs when a pesticide kills the majority of the target pest population, but some resistant individuals survive. The offspring of these survivors will carry the ability to tolerate the exposure to the same type of pesticides. Their population will increase in greater proportion with each succeeding generation and pesticides from the same mode of action will not kill them because offspring of resistant individuals will dominate the population. Development of resistance to pests is commonly observed in both insects and weeds.

Currently, several species of insects, weeds and mites have developed resistance to certain groups of pesticides. For example, over 574 species of insect pests have been reported to develop resistance to 338 compounds globally (APRD, online). Some examples include mosquito resistance to DDT, dieldrin and Malathion in India and Nepal, fruit fly resistance to malathion in USA and Colorado beetle resistance to 52 different compounds belonging to major insecticide classes. Similarly, according to the International Survey of Herbicide Resistant Weeds (HRAC, online), 449 biotypes from 210 weed species (143 dicots and 102 monocots) have been confirmed to be resistant to 156 different herbicides.

Although, farmers in Nepal occasionally complain about the ineffectiveness of pesticides in controlling targeted pests, only *Helicoverpa armigera* from cotton growing areas of Nepalgunj and fresh vegetable (tomato) growing area of Dhanubase, Syangja have been confirmed to have developed resistance to several pesticides (Armes & Pandey, 1996). Indiscriminate and repeated use of pesticides with a similar mode of action is liable to develop resistance in many other pests, especially in fresh vegetable growing areas of the country.

### *2.4.9 Secondary pests resurgence*

Indiscriminate and unnecessary use of certain broad-spectrum pesticides kill not only the target pests, but also other natural control agents such as predators and parasites. Pest resurgence occurs when a pesticide treatment destroys a target pest population; it also kills, repels, irritates or otherwise deters the natural enemies of the pest. After the expiry of residual activity of the pesticide, the pest population can increase more rapidly and to a higher abundance when natural enemies are absent or are in low abundance (Dutcher, 2007). A secondary population will rapidly increase in number because no natural enemies remain to prevent the population explosion. In some instances, secondary pests cause greater damage than the pests that were initially the problem. An outbreak of brown plant hopper following insecticide application to suppress rice bug in Chitwan in 1996 was a case of secondary pest resurgence. Farmers from Kaski and Tanahu districts have reported similar outbreaks of brown plant hopper in rice and scale insects in citrus.

#### *2.4.10 Economic burden*

Pesticide misuse has a huge economic burden in any country as it impacts human health, production costs, international trade implications and environment degradation. As a member of the World Trade Organization (WTO), Nepal has to fulfil the international trade agreements such as Sanitary and Phytosanitary (SPS) and Codex MRL requirements. With the increasing globalisation of trade, Nepal has a huge potential of exporting products such as tea, coffee, spices, ginger, honey, fruits and vegetables to international markets. However, as such, they cannot be exported if they do not meet the international and regional standards. For any nation, impacts of pesticides on human health and the environment will have huge economic consequences.

### 2.5 Extent of pesticides misuse in Nepal

The misuse of pesticides in Nepal is quite alarming as evidenced from a recent (2014) survey of the vegetables being supplied to the market in Kathmandu. More than 90% of the vegetables sold in the Kathmandu Valley have been found with unacceptable levels of pesticide residue. This is just a one example; the big picture of pesticide misuse could be beyond the expectations of everyone.

The use of pesticides in Nepal appears to be increasing (Figure 1) and so is the extent of misuses. Acute pesticide poisoning due to improper application and handling practices, intentional misuse such as self-poisoning and chronic effects due to long-term exposure to pesticide residues in food and water are the major concerns of pesticide misuse in Nepal. Rottenberg (2004) concluded that Nepalese are most susceptible to exposure of POP pesticides through contaminated foods, mostly milk, meat and fish. Breast milk contamination is another concern due to the ability of POPs to bioaccumulation. Paneru et al. (2004) reported that farmers were still using banned POPs such as DDT and BHC for different purposes and nationally banned pesticides were easily available in the market through illegal routes. Residues of large number of POPs, which has been banned for use in agriculture and public health since 2001, have also been reported in food commodities (Koirala et al., 2009).

Despite these problems, limited data are available on the contamination of food with pesticides and related health issues. The Department of Food Technology and Quality Control (DFTQC) conducted a survey across the country from 1995-2007 and analysed 1,034 food samples from different food commodities in Nepal (Koirala et al., 2007). Of the total samples analysed, 12% were detected with residues of

Malathion (3.9%), BHC (3.1%), methyl parathion (2.8%) and DDT (1.8%). The highest level of contamination was detected in root vegetables (11.9%) followed by leafy vegetables (10.9%).

Giri (2010) collected and analysed samples of vegetables (16), fruit (5) and soils (19) from nearby Kathmandu Valley and 11 tea samples from different tea estates in eastern Nepal. The tea samples were found to be contaminated with banned pesticides such as Ethion. Almost all soil samples except those from Kathmandu were found to be contaminated with pesticides. Some of the fresh fruits and vegetables were also contaminated with banned pesticides such as Ethion, Chloropyrus and Carbendazim. These results are alarming as it is assumed that the farmers from neighbourhoods in the Kathmandu valley are relatively aware and follow the guidelines for pesticide use accurately. This indicates the pesticide contamination in further remote or interior areas could be even worse.

In a survey of commercial vegetable growers in Bhaktapur district, Jha and Regmi (2009) found that farmers deliberately apply an overdose of pesticides because they are uncertain of effectiveness of the recommended dose. They also observed that although all farmers used higher than recommended doses of pesticides, the farmers trained on IPM used relatively lower amounts than those without the training. For example, farmers without the IPM training used 4.4 times the optimal dose as compared to 2.7 times by the trained farmers. They also concluded that the reduction in pesticide use from current level would not decrease yield significantly.

Generally, consumers and the general public are not aware of pesticide misuse or illness due to pesticide poisonings; illness or incidences with pesticides misuse are often not reported. Recently, a few media stories have reported that Nepali food markets are flooded with banned, fake and obsolete pesticides (Thapaliya, 2011; Paudel, 2011). Banned pesticides such as DDT, Dieldrin, Aldrin, Heptachlor, Texaphene, BHC, Linden, methyl parathion and monocrotophus, among others, were available in the Nepali market (Thapaliya, 2011). Dealers were found tampering with expiry dates and selling them in the market. These practices are common even today and banned pesticides are being sold under the trademark of renowned Indian pharmaceutical companies. Because of the porous border and poor regulatory system of the country, several types of fake pesticides are imported illegally from India. Stamping new expiry dates on the outdated pesticides by dealers is not an uncommon practice.

The contamination of soil, water and air with pesticides is not commonly considered as a major concern in Nepal. In a recent study, Giri et al. (2012) analysed soil samples from four districts around Kathmandu valley and found that some soil samples were contaminated with different pesticides including parathion-methyl, a highly carcinogenic organophosphorus insecticide, which has been banned for use in Nepal.

Residues of banned pesticides, such as organophosphate insecticides, are still found in grains, fresh vegetables, fruits and water that we consume daily. The checking of cross-border entry of foods that are indiscriminately and illegally treated with pesticides is a big challenge for Nepal. Despite the existence of quarantine offices in main check points along the Indo-Nepal border, there is no systematic sampling and analysis of foods entering Nepal especially fresh vegetables and fruits. Safe disposal of banned, date expired and other obsolete chemicals are another major concern in Nepal. Over 74 tons of obsolete pesticides were reported to be still stockpiled in warehouses at different locations and were being used on farm and for other agricultural purposes (Sah, 2002; Rottenberg, 2004). The risks of contamination of such pesticides in the environment are very high through the spills, leaks and improper dumping/disposal practices.

Due to a low level of awareness among the general public, pesticide misuse is a growing concern in Nepal. The impacts of current pesticides misuse will become apparent only in the next 10-20 years. Considering the current scenario, there will be havoc on human health and environmental issues from pesticide misuse in Nepal. The burden will be huge and hard to handle. Therefore, every sector involved needs to act promptly and diligently to avoid this situation.

## 3. Chemical fertilisers

Chemical fertilisers are the artificially manufactured compounds that supply certain plant nutrients. Among the agro-chemicals, chemical fertilisers constitute the largest volume in terms of use. The importance of chemical fertilisers in the modern agriculture is significant and it may not be possible to meet the growing demands of agricultural production (food, feed, fibre) without the use of fertilisers. Fertilisers when used judiciously and in combination with other sources of plant nutrients are beneficial. In the global perspective, Nepal is one of the least fertiliser consuming countries.

Systematic importation and distribution of fertilisers started in Nepal with the establishment a public sector enterprise—Agriculture Input Corporation (AIC)—in 1966 (Shrestha, 2010). No fertilisers are manufactured in Nepal. Therefore, the supplying adequate fertilisers in the country have always been a challenge for the government. During the period from 1973 to 1997 the government provided some price and transport subsidy and all of the fertilisers import, distribution and sale was under the monopoly of AIC. In 1997/98, the government introduced a fertiliser deregulation policy and gave equal opportunities to the private companies. Withdrawal of subsidy led to the decline in fertiliser consumption (Figure 2), and the supply situation could not be improved even after the deregulation (Shrestha, 2010). Both AICL and private traders were unable to supply adequate fertilisers after 1999 because of large price fluctuations in the international market and subsidy issues in Nepal. The provision of government subsidy has directly impacted fertiliser consumption pattern in Nepal. Therefore, the formal statistics show a substantial decline in the total fertiliser use in Nepal (Figure 2B). However, it is very difficult to estimate the exact amount of fertilisers imported and used in Nepal because the informally or illegally traded fertilisers, especially from India, constitute a major portion of fertilisers being used in Nepal (Shrestha, 2010).

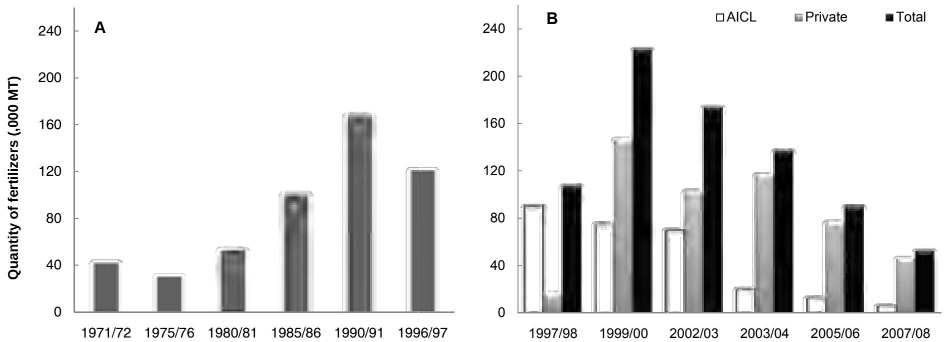


Figure 2. Trend of chemical fertilisers use (,000 MT) in Nepal: (A) before the deregulation (1971-1997) and (B) after the deregulation (1997-2009) (Source: MOAD, 2012).

Nitrogen (N) is the most common yield limiting nutrients for crop production in Nepal. Although the total amount of fertilises used in Nepal is small, many farmers in Nepal use excessive amount of nitrogenous fertilisers such as urea in certain cereals and most of the commercial crops such as vegetable and potato production. This practice has affected the soil reaction and nutrient balance leading to decline in crop productivity. Excessive and non-judicious use of chemical fertilisers has huge negative impacts on environment, human health and the cost of production. Crops cannot absorb all of the nutrients applied through fertilisers, nor can soil retain residual nutrients for a long time. The unused or residual nutrients in soil are prone to loss into the air and water. This loss not only affects farmers' profit (as they have to invest more on fertiliser), but this also has environmental consequences. The most common adverse effects of fertilisers misuse can be as follows:

**i. Effect on soil quality:** Chemical fertilisers contain high concentrations of mineral salts and inert materials. They do not add any organic matter to the soil. Therefore, chemical fertilisers are not beneficial to soil organisms and also do not contribute to improving soil structure. In the context of Nepal where the recycling of organic residues is limited, if chemical fertilisers alone are used continuously without organic amendments, soil organic matter (SOM) will decline, microbial activities in the soil will diminish and soil will become compact and hard to work; overall, soil fertility deteriorates. Similarly, continuous use of chemical fertilisers alone results in soil acidification as a result of lowering of soil pH by mobilising or increasing acidic compounds in the soil and depletion of other nutrients that are not supplied by a particular fertiliser. The problem may be caused by over application of acidifying fertilisers such as ammonium sulphate.

**ii. Effect on water quality:** After fertiliser is applied, part of it is washed away with surface runoff and part of it is leached to ground water, ending up in drinking water sources. Therefore, excessive rates and inappropriate methods of application, especially when using nitrogenous fertilisers, can have adverse effects on ground water quality through leaching as soil nitrate ($NO_3$-). Leached or washed $NO_3$ ends up in the ground water as well in water bodies such as lakes, wells, rivers and streams. Excess concentrations of phosphorus (P) and N in surface runoff are the major contributors to the impairment of water bodies, which can cause algal blooms, eutrophication, and subsequent dead zones. This aspect, however, is not seriously considered in Nepal.

**iii. Greenhouse gas emission:** When N is added to the soil through the use of synthetic fertilisers, nitrous oxide ($N_2O$), which is one of the major greenhouse gases, is emitted. Therefore, agricultural soil management is considered as the largest source of $N_2O$ emissions contributing to greenhouse gases and air pollution.

In addition to these environmental effects after their application, fertilisers use huge amounts of energy if they have to be manufactured. Moreover, for a country like Nepal, where there is no fertiliser manufacturing, it becomes an expensive input and requires large amounts of financing for their import. Similarly, use of chemical fertilisers alone increases the dependency of farmers on them. If, for some reason, there is a shortage of a specific or commonly used fertiliser, famers in Nepal would face a shortage, decreasing the overall yield of their crops; this is a common issue. The dependence on chemical fertilisers is not a sustainable means for crop production.

## 4. Hormones and plant growth regulators

Plant hormones are the substances that are produced naturally within plants and are essential for regulating their growth and development. Plant growth regulators (PGR) also known as plant exogenous hormones that occur naturally in plants and function similarly to naturally available plant hormones. They are not nutrients but are used for the purpose of altering or modifying plant growth processes. They act by controlling or modifying plant growth processes, such as enhanced germination, initiation of roots, growth of leaves and flowers, elongation of stems, fruit set and drop, development and ripening of fruit (Lyng, 2007; Yau, 2011; Fishel, 2012). Plant growth regulators are therefore a group of chemicals for controlling, enhancing or modifying the natural plant growth processes. There are five major classes of PGR commonly used in plants as follows:

**(i)** **Auxins:** Endogenous auxins and synthetic compounds such as indolebutyric acid (IAA) and naphthylacetic acid (NAA) are used for the initiation and acceleration of the rooting of cuttings and shoot elongation. They are used for delaying leaf senescence, ripening of fruits and also to prevent the dropping of fruit.

**(ii)** **Cytokinins:** Promote cell division and stimulate shoot proliferation. They are used to stimulate shoot initiation and bud formation in tissue culture, to hasten maturity, enhance fruit color, and to prolong storage life of flowers and vegetables.

**(iii)** **Gibberellins:** Arederivatives of gibberellic acid and they promote flowering, stem elongation and the dormancy break of seeds. They are also used to increase stalk length, flower and fruit size and to produce seedless fruits.

(iv) **Abscisic acid:** A plant growth inhibitor or growth retardant; it acts as an antagonist of gibberellins.

(v) **Ethylene:** It induces dormancy, prevents seeds from germination and causes abscission of leaves, fruits, and flowers. Ethylene is a gas which induces ripening of many types of fruit, including banana and mango.

Although PGRs are not as widely and excessively used as fertilisers and pesticides, their use is not properly regulated in Nepal. Some of the PGRs in Nepal are used for ripening agents, swelling and sweetening agents in plants. The misuse of PGRs may not be as significant as pesticides, but there are concerns of residues on crops especially while used in ripening and growth hastening.

Generally, PGRs are not considered hazardous to human health if they are used in accordance with good agricultural practice. However, if they are misused, crops will experience an enhanced ripening process, resulting in ripening on the fruit surface with the core remaining raw, which may adversely affect the palatability and quality of the fruit as often seen in banana and mango. Farmers in Nepal use several types of PGRs without knowing their functions and effects. Incidences such as continuous growing/swelling of fruits such as cucumber and pumpkins after harvest are the results of overuse of PGRs applied just prior to harvest.

Several types of hormones and antibiotics are also reported to be used in animal such as in poultry, dairy and aquaculture for the purpose of hastened growth and producing more yields. The uncontrolled use of antibiotics can lead to the emergence of antibiotic resistant bacteria. This can be a serious public health concern in some countries but there are no reports of this problem occurring in Nepal.

# 5. Regulation of agro-chemicals in Nepal

Every year, new pesticides, fertilisers and PGRs are introduced in Nepal, but not all of the chemicals imported are legally registered for sale and use. As a universally accepted rule, before a new product is imported, distributed, sold, and used, it must be rigorously assessed against human health, environment and safety standards and registered through appropriate government agencies. It must ensure that the human health and environmental risks associated with its proposed use are acceptable. In order to safeguard human health and the environment, all agro-chemicals must be effectively regulated.

## 5.1 Regulation of pesticides

Currently, there are several acts and regulations available for the regulation of pesticides. The Nepal Pesticide Act 1991 was promulgated to have a provision with regard to import, export, production, marketing and use of pesticides. Similarly, Pesticide Regulations (1994) and Environmental Protection Act (1996) are available for the regulation of pesticides.

The Pesticide Act has the provision of a Pesticide Registration Office, which is responsible for registration of appropriate pesticides and preparation of necessary guidelines for effective, logical and proper use of pesticides. The Pesticide

Registration Office regulates the import, manufacture, sale, transport, distribution, marketing and use of pesticides in Nepal. It has a provision of a Registrar and Pesticide Board to develop regulations and guidelines for registration of imported pesticides, licensing of pesticides dealers or wholesalers/retailers and commercial applicators. The Pesticide Regulation deals about the procedures related to various aspects of pesticides registration and use in Nepal including: registration of pesticides, cancellation or suspension of registration, approval of container and label, restriction for sale and distribution, and granting and revoking licences to pesticide retailers, formulators and spraying entrepreneur.

Currently, there are more than 70 registered pesticide importers and five pesticide formulators in Nepal. More than 1,098 Trade names and 108 common names of various pesticides have been registered in Nepal (Table 2).

**Table 2:** Summary of registered pesticides in Nepal as of 2011.

| S.N. | Pesticides | Trade name | Common name |
|---|---|---|---|
| 1 | Insecticide | 613 | 44 |
| 2 | Fungicide | 304 | 31 |
| 3 | Herbicide | 120 | 18 |
| 4 | Biopesticide | 23 | 6 |
| 5 | Rodenticide | 18 | 2 |
| 6 | Acaricide | 12 | 4 |
| 7 | Bactericide | 7 | 2 |
| 8 | Molluscicide | 1 | 1 |
| | **Total** | **1,098** | **108** |

(Source: Pesticide Registration and Management Division (PMRD), 2011)

Despite the provision of regulatory Acts and regulation in Nepal, the regulatory and compliance system is weak. As a result, banned, expired and counterfeit pesticides are imported and sold in Nepal illegally. The porous Nepal-India border makes it difficult to control cross-border smuggling of unauthorised pesticides. Therefore, it is expected that the actual quantities of pesticides used or imported in Nepal could be much higher due to this undocumented imports.

There is also a lack of a recording system for potentially hazardous chemicals in terms of their storage, sale and use in the country. It is possible to trace the import records through customs offices that are legally imported but this will not provide the complete inventory of the stocks. Although, PPD has started lately documenting this it is far from being complete. In the absence of such records not much can be said in terms of total demand and is matching supply and whether farmers in Nepal are benefitting from the recent advances in this area of science. Another aspect is the lack of regulatory oversight and the high levels of pesticide residues on food commodities in the market. Because of the inappropriate pesticides use practices and lack of an adequate monitoring system, excessive pesticide residues have been found in fresh fruits and vegetables grown locally and imported from elsewhere. Such products are sold indiscriminately without proper checking of MRLs for pesticides. The Central Food Research Laboratory is responsible for the analysis of food residues. However, its technical and human resources capacities are not adequate for monitoring and analysing the food samples for pesticide residues. There is an urgent need to improve the food monitoring system supported by analytical facilities which can collect samples and analyse foods, especially fresh vegetables, fruits, and dairy and poultry products for the residue of pesticides.

Rigorous assessment of pesticide should be mandatory in order to make sure that there is no harm to human health and environmental from the use or exposure to the product under the proposed use pattern. The pesticide label, which is a legal document, provides directions for using properly that gives effective product performance while minimising risk to human health and the environment. Using any pesticide in any other way or on any other crop or pest than specified on the label is illegal. Unfortunately, the users in Nepal rarely follow pesticide labels and the law enforcement is almost absent (Giri et al., 2009). There is also a lack of systematic approval/registration procedure. Post-registration monitoring and the enforcement of these regulations are almost absent. Similarly, there is no control over illegal importation, distribution, sale, storage and disposal practices. Consequently, non-recommended or non-registered pesticides are being sold and used. A critical evaluation of legislation regarding pesticide imports, registration and use should be urgently implemented.

Nepal should establish a robust and functional pesticide regulatory system similar to other developed countries such as USA, Canada, United Kingdom, Australia and most European Union countries, which have well established pesticide registration and compliance systems. For example, in the United States, all pesticides are registered and regulated by the Environmental Protection Agency (EPA). Similarly, the Pest Management Regulatory Agency (PMRA) is responsible for the regulation of pesticides in Canada. Such agencies approve the registration of pesticide following evaluation of scientific data whether the pesticide is safe for human health and the environment. They also re-evaluate registered pesticides periodically to determine whether they meet the current health and environmental protection standards. If any problems arise from any type of pesticide, they take action to recall those products from shelves and cessation of registration.

Further, if new information indicates that a pesticide could pose unacceptable risks to human health, environment, the pesticide in question should be re-evaluated, and regulatory decision should be made based on its risk assessment.

Nepal being a signatory of some of the important international conventions such as Stockholm Convention (treaty to protect human health and the environment from POPs), Rotterdam Convention (convention for the control of certain hazardous chemicals in international trade) and being a member of the WTO, it is obliged to be responsible for international cooperation and regulation of such chemicals in regard to human health and the environment. Being a member of WTO, it must comply with SPS requirements, which impact on the international trade of agricultural commodities in Nepal.

### 5.2 Regulation of fertilisers

Prior to 1997, fertiliser trade and quality control in Nepal was not the sole responsibility of the government. However, after the deregulation, as private sector fertiliser suppliers became involved, the quality control of chemical fertilisers became the responsibility of the government. The fertilisers are now considered as ‘essential commodities’. The government of Nepal promulgated the Fertiliser Control Order 1997 and developed the Fertilizer Guideline 1999. The order and guidelines provide specific codes of conduct for manufacturers, importers and dealers to ensure the quality of fertilisers (Manandhar & Khanal, 2004). As a quality control mechanism, there is a provision for a ‘Fertiliser Inspector’ in each district. The Fertiliser Inspectors are responsible for the monitoring of supply, distribution, stock of fertilisers, quality checks and filing legal cases against the defaulters. There are also seven accredited fertiliser test facilities in the country.

Despite some regulatory provisions, there is a lack of functional regulatory mechanisms for the control of illegal imports and quality of fertilisers in Nepal. The uncontrolled inflow of adulterated and substandard fertilisers from India is what poses the biggest challenge of regulating the fertiliser sector (Shrestha, 2010). As a result, farmers have been facing the problems of fake and sub-standard fertilisers and an unavailability of the right types of fertilisers at the required time. For the adequate availability of quality fertilisers, all concerned stakeholders (government agencies, dealers, distributors, quality control laboratories and farmers) should take their responsibilities.

Nepal is one of the least fertiliser-consuming countries but the excessive use of fertilisers is also a serious problem in certain parts of Nepal. There is a lack of soil testing facilities and recommendation if any are too vague for the diverse soil types and cropping systems. Farmers also normally do not follow the recommendations. As a result, there is an imbalanced use of nutrients, pre-dominantly nitrogenous fertilisers, resulting in soil fertility concerns.

There are also increasing concerns of newer fertilisers such as micronutrients, bio-fertilisers and organic fertilisers, which are available in the market without proper labelling but with attractive packaging and advertisements (Manandahar & Khanal, 2004). Strict regulation and quality control of all types of fertilisers is crucial.

### 5.3 Regulation of hormones and PGRs

In Nepal, the uses of PGRs are neither regulated nor properly documented. Such products are imported as non-pesticide products and used indiscriminately in Nepal. Excessive or improper use of PGRs can have adverse human health and environmental consequences. From a regulatory perspective, all PGRs should be classified under ‘pesticides’. They have to be registered with the competent authority before use. Before registration, their safety and efficacy should be assessed. Therefore, all import distribution and use of PGRs and hormones in

Nepal must be brought under a regulatory framework and their quality control is crucial. Although the use of antibiotics in agriculture especially in poultry, fish and livestock is ever growing, there are no regulations and systematic monitoring of such uses. Their impacts on public health could be huge if they are not properly regulated.

## 6. Conclusion and recommendations

Given the current scenario of excessive misuse of agro-chemicals, especially pesticides in Nepal, irreversible health and environmental problems are imminent if this continues. Prevention of health risks caused by pesticides is technically feasible and economically rewarding for the individuals and the whole community (Maroni et al., 2006). Currently, there are indistinguishable roles and weak regulatory systems in Nepal. Different stakeholders should understand their roles and responsibilities and work responsibly. Therefore, protecting our health and the environment should be our main concern. The safe and sustainable use of agro-chemicals and reducing their impacts is everyone’s responsibility. The role and responsibilities of different stakeholders in safe use of agro-chemicals should be as summarised in Table 3.

**Table 3.** Role and responsibilities of different stakeholders in safe use of agro-chemicals.

| Regulator | Dealers/Retailers | Extension Workers | Farmers | Vendors/ Consumers |
|---|---|---|---|---|
| • Provide sound regulatory measures on registration, import, distribution, sale and recall of pesticides.<br>• Strictly regulate non-compliance of agro-chemicals use such as off-label, date-expired, counterfeit and banned products, and follow stern prosecution to the defaulters/culprits.<br>• Strictly prohibit the entry of phased-out or banned products and eliminate the formulations that exist in the warehouses and with dealers.<br>• Conduct routine inspections/ surveillance to ensure only registered and legitimate agro-chemicals are being sold and label requirements are being met.<br>• Provide health and safety information to the public through public media.<br>• Re-evaluate pesticides that are already in the market to ensure they meet the current standards.<br>• Monitor pesticide residues in raw agricultural produce before they are sold in the market. | • Must comply with national and international pesticide Acts and Regulations that govern pesticides registration, import, sale and distribution.<br>• Sale only registered products with label intact with full product information.<br>• Provide guidance to farmers whether a pesticide or PGR is really needed and whether the intended use matches the pest or problem in question.<br>• Provide technical guidance to the farmers about the safe use of pesticides and PRG such as right timing, rate and methods of application; waiting period and re-entry intervals so as to minimising the risks to human health and environment. | • Train and increase the number of skilled technicians and extension workers<br>• Train/educate/aware farmers about the proper use, handling, storage and disposal of agro-chemicals<br>• Train farmers to identify pests and their threshold level to determine help identify pest problems and help them to determine whether application of pesticide is really needed?<br>• Conduct public awareness programs or campaigns through public media and formal (schools) and informal forums so as to make aware farmers, consumers, general public about the health and environmental hazards associated with pesticides misuse.<br>• Farmers, pesticide applicators and their families need to be informed and educated on how to recognise and prevent pesticide poisonings incidents. | • Identify pests correctly and check the crop damage threshold level before applying pesticides and their level of injury correctly, and determine whether a pesticide is really needed?<br>• Try using IPM approaches for pest control and minimise/avoid the chemical methods.<br>• Follow integrated plant nutrients management (IPNM) practices for the balanced use of organic and inorganic sources plant nutrients<br>• Buy agro-chemicals only from reliable and licensed dealer or suppliers.<br>• Read labels and apply only required rate of pesticides/PGRs following label directions and/or as recommended by the technician.<br>• Follow safe pesticides handling measures such as using protective clothes, gloves, washing hands after pesticides use, not entering to the treated area until the prescribed re-entry period and not eating or drinking while pesticides applying.<br>• Allow sufficient waiting time or pre-harvest interval (PHI) after pesticides PGR use.<br>• Store pesticides only in their original containers and in safe places, out of the reach of children and pets.<br>• Dispose empty pesticide containers in safe places and never use them for household uses. | • Be aware of the harmful effects of pesticides and their contaminations in food products in the market.<br>• Purchase foods only from reliable sources/growers.<br>• Discourage the use or consumption of improperly produced raw agricultural produces.<br>• Report any incidences of pesticides misuse to the concerned agencies/ authorities.<br>• Develop a habit of washing fresh or raw fruits and vegetables before cooking or eating. |

In addition to the roles and responsibilities of the different stakeholders involved in agro-chemicals use as outlined above, the following regulatory measures and policies should be implemented by the responsible agencies.

- In order to reduce the unwanted havoc of pesticides misuse in Nepal, a high priority should be placed on developing stronger IPM programs as a viable alternative. Studies have shown that the adoption of IPM practices helped to reduce the use of pesticides and the incidence of acute pesticide poisoning (Mancini et al., 2009; Jha and Regmi, 2009). The successful implementation IPM program including the phase-out of most hazardous pesticides will reduce the number of intentional and unintentional cases of pesticide incidences (Konradsen et al., 2003). This will include the production of bio-rational alternatives compounds such as botanicals and indigenous plant materials and microbial based bio-pesticides, which have already been initiated by PPD since 2011.

- The IPM research program should receive a high priority and should identify both short-term and long-term goals and target pests to resolve the problems faced by farmers in commercialised, high value crop production pockets (such as fresh vegetables, fruits, tea, coffee etc.). More research is also necessary to develop and popularise bio-rational and environmentally safe alternatives for pest management, exploration of natural biodiversity in relation to the pest and their natural enemies, and develop methods to promote the conservation of such beneficial agents.

- It is very important to provide general awareness of the harmful effects of pesticides to every citizen whether they are farming or not. As Mancini et al. (2009) have observed that the reduction of adverse health effects was attained through a reduction in exposure to toxic pesticides and behavioural changes. For this, both formal and informal education and public media should be used. Efficient and well trained agricultural research, training, and extension services especially geared towards the needs of small and marginal farmers is needed. In addition to the informal education and extension services, a course on safe use of pesticides should be incorporated in schools and college curriculum.

- Regulatory policy is an essential component in pesticides management (Schaefers, 1996). The current regulatory system for agro-chemicals in Nepal is very weak if not non-functional. Therefore, pesticides and other agro-chemicals must be treated as hazardous materials. They should be accessible only to the people who are capable of handling them safely. Agrochemicals should only be registered after their adequate field evaluation under local environments. Similarly, all the previously registered pesticides must periodically re-evaluated for their efficacy and environmental safety and those found unsafe must be restricted, banned or phased-out in Nepal.

- Each registered formulation/packaging of pesticides should bear a unique Nepal registration number. It should be the responsibility of traders/dealer/retailer to provide written label information that describes use, safety, application method, doses and target pests, waiting periods etc. related to the pesticides that is approved by registering agency. It should be the responsibility of the registering agency to develop such label information and the government agency should thoroughly review the information its completeness, authenticity and accuracy.

- Restricting access to the most hazardous pesticides would be of paramount importance to reduce the number of acute poisoning and fatalities (Konradsen et al., 2003). Therefore, the government should work immediately towards restricting access and use of highly toxic compounds and substitute them with less toxic or reduced-risk alternatives. Illegal entry of unregistered or banned products must be effectively controlled and those stockpiled in the country should be safely disposed.

- There is an urgent need of a strong food inspection and monitoring system. Pesticide residues should be monitored in all food commodities and any adulterated food or foods containing pesticide residues that exceed the established MRL should be prohibited for sale. This should be supported with analytical capacity (laboratory and infrastructure) in the country. The existing pesticide testing facilities in Nepal are inadequate. Pesticide residue monitoring is very expensive and almost impossible to implement under current individualised small farming system. The human resources and laboratory facilities should be upgraded to facilitate the analysis of food and water samples on a regular basis.

- Private-sector agencies particularly Agro-vets are the major players in the trade of agro-chemicals and seeds in Nepal. The majority of the vendors do not have agricultural science background, hence the content and quality of information. It is, therefore, necessary to provide proper training of pesticide use for vendors and provision of this training should be one of the criteria for renewing licenses.

- Many of the deaths due to accidental or intentional poisoning can be prevented if quality of care for poisoning is provided. Primary health care services should be closely aligned to the agricultural extension services and includes occupational health care especially the prevention, recognition and treatment of pesticide poisoning. Poison control centers should be updated with information on dealing with accidental and self-inflicted poisoning.

- The pest quarantine program (external) is quite weak and internal plant quarantine is non-existent. Bacterial wilt of potato, potato tuber moth, citrus greening disease and club root disease of cole crops are devastating pests that have spread to many areas within the country which could have been restricted had there been effective internal quarantine. Therefore, a strong quarantine program must be developed and implemented.

- For the sustainable use of fertilisers, an IPNM approach of nutrients management should be adopted in a national scale. Details about the IPNM are discussed in the companion paper.

- Quality control of imported fertilisers, micronutrient formulations, PGRs, and hormones should be strictly regulated. Similarly, training and extension activities should be focussed toward balanced and need-based use of chemical fertilisers.

## References

Alavanja, M. CHoppin, R. 1., Jane A., & Kamel, F. (2004). Health effects of chronic pesticide ecposure: Cancer and Neurotoxicity. *Annual Review of Public Health,* pp.155–97.

APRD (n.d.). *Online Arthropod Pesticide Resistance Database.* IRAC-Michigan State University. [online] Retrieved from http://www.pesticideresistance.org.

Armes, N. J. & Pandey, R. R. (1995). Pyrethroid resistance in *Helicoverpa armigera in Nepal. Resistant Pest Management, 7,* pp. 11-12.

Aterya, K. (2008). Health Costs from short-term exposure of pesticides in Nepal. *Social Science and Medicine, 67,* pp. 511-519.

Bassil, K. L., Vakil C., Sanborn M., Cole, D. C., Kaur J. S., & Kerr K. J. (2007). Cancer health effects of pesticides: systematic review. *Canadian Family Physician, 53*, pp. 1704-1711.

Bertolote, J. M., Fleischmann, M., Eddleston, M., & Gunnell, F. (2006). Deaths from pesticide poisoning: a global response. *The British Journal of Psychiatry,189*, pp. 201-203.

Bista, S., Aryal, S., & Maharjan, R. (2004). Pesticide stock inventory and possible contamination in Nepal. In D. B., Thapa, D. N., Manandhar, J. R., Adhikari, & S. Bista. Eds., In proceedings on January 14-15: *Inception workshop, Enabling POPs activities in Nepal.* Kathmandu: MOEP and UNIDO, pp72-84.

Blacksmith Institute. (2009). *The top six environmental polluters.* New Delhi: Blacksmith Institute. [online]. Available at: http//:www.worstpolluted.org (Accessed at March 12, 2013).

CBS. (2001). *Statistical Year Book of Nepal 2001.* Kathmandu: Central Bureau of Statistics (CBS).

CBS. (2008). *Environmental Statistics of Nepal 2008.* Kathmandu: Central Bureau of Statistics (CBS).

DPR (n.d.). *Assessing the health risk of pesticides.* California Department of Pesticide Regulation. [online]. Available at: http://www.cdpr.ca.gov/docs/dept/factshts/artic12.pdf.

Dutcher, J. D. (2007). A review of resurgence and replacement causing pest outbreaks in IPM.. In: A. Ciancio & K. G. Mukerji. Eds., *General concepts in integrated pest and disease management. New York: Springer,* pp. 27–43.

FAO. (1989). *International Code of Conduct on the Distribution and Use of Pesticides.* Rome: Food and Agriculture organization.

Fishel, F. M. (2012). *Plant growth regulators. Publication No. Pl-102,* Gainesville: University of Florida, IFSA Extension. [online]. Available at: http://edis.ifas.edu/pi139.

Forget, G. (1991). Pesticides and the third world. *Journal of Toxicology and Environmental Health: Current Issues, 32,* pp. 11-31.

Giri, N. (2010). *Pesticides Use and Food Safety in Kathmandu Valley/Nepal.* Master Thesis. Submitted to the Institute of Soil Research, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria.

Giri, N., Blum, W. E. H., Sieghardt, M., Lesueur, C., & Mentler, A. (2012). A preliminary study of the content and distribution of pesticide residues in soil samples from the Kathmandu valley, Nepal. *Spanish Journal of Soil Science,* 2,pp. 20-31.

Giri, Y. P., Maharjan, R., Sporleder, & Krischel, J. (2009). Pesticide use practices and awareness among potato growers in Nepal. In: *15th Triennial ISTRC Symposium, International Society for Tropical Root Crops (ISTRC).* pp. 27–43

Gunnell, D., Eddleston, M., Phillips, M. R., & Konradsen, F. *(2007)*. The global distribution of fatal pesticide self-poisoning: systematic review. *BMC Public Health,7,* pp. 357.

IRAC. (n.d.). Resistance: Resistance management for sustainable agriculture and improved public health. Insecticide Resistance Action Committee (IRAC). [online]. Available at: *http://www.irac-online.org/about/resistance/*

ISHRW. (2015). *International Survey of Herbicide Resistant Weeds, 2015*. [online]. Available at: *http://weedscience.org.*

Jaga, K., & Dharmani, C. (2005). The epidemiology of pesticide exposure and cancer: A review. *Review of Environmental Health,20*, pp. 15-38.

Jha, R. K., and Regmi, A. P. (2009). *Productivity of pesticides in vegetable farming in Nepal.SANDEE Working Paper No. 43-09.* Kathmandu: South Asian Network for Development and Environmental Economics (SANDEE).

Kesavachandran, C. N., Fareed, M., Pathak, M. K., Bihari, V., Mathur, N., & Srivastava, A. K. (2009). Adverse health effects of pesticides in agrarian population #s in developing countries. Review of Environmental *Contamination and Toxicology, 200,* pp. 33-52.

Koirala, P., Dhakal. S., &Tamrakar, A. S. (2009). Pesticide application and food safety issue in Nepal. *The Journal of Agriculture and Environment, 10*, pp. 111-114.

Koirala, P., Khadka, D. B., and Mishra, A. (2007). Pesticide residue as environmental contaminants in foods in Nepal. *The Journal of Agriculture and Environment,8,* pp. 96-100.

Konradsen, F., Hoek, W. Van der, Cole, D. C., Hutchinson, G., Daisley, H., Singh, S., & Eddleston, M. (2003). Reducing acute poisoning in developing countries-options for restricting the availability of pesticides. *Toxicology,*192, pp. 249-261.

Lyng, R.E. (2007). Plant growth regulators. [online]. Available at: *http://www.healthguidance.org/entry/8188/1/Plant-Growth-Regulators.html.*

Manandhar, R. & Khanal, M. P. (2004). Commercial fertilizers and their quality control in Nepal. In: J.K. Tuladhar, K. B. Karki & P. Anderson, Eds., *Micronutrients in South and South East Asia.* Nepal: ICIMOD, pp. 66-73.

Mancini, F., Jiggins, J. L, & O'Malley, M. (2009). Reducing the incidence of acute pesticide poisoning by educating farmers on the integrated pest management in South India. *International Journal of Occupational and Environmental Health, 15,* pp. 143-151.

Mancini, F., Van Bruggen, A. H., Jiggins, J. L., Ambatipudi, A. C., & Murphy, H. (2005). Acute pesticide poisoning among female and male cotton growers in India. *International Journal of Occupational and Environmental Health,11,* pp.221-232.

Maroni, M., Fanetti, A. C., Metruccio, F. (2006). Risk assessment and management of occupational exposure to pesticides. *Med Lav,* 97, pp. 430-437.

MoAD. (2012). *Statistical Information on Nepalese Agriculture 2011/2012.* Kathmandu: Government of Nepal, Ministry of Agricultural Development (MoAD). [online]. Available at: *http://www.moad.gov.np/downloadfile/yearbook2012_1363677455.pdf*

Palikhe, R. R. (2002). Challenges and options of pesticides use: in the context of Nepal. *Landschaftsokologie und Umweltforschung,38,* pp. 130-141.

Paneru, R. B., Giri, Y. R., & Mainali, B. P. (2004). Status of POPs in Nepal: Preliminary inventory of production, import, distribution and use. In D. B. Thapa, D. N., Manandhar, J. R. Adhikari, J.R., & Bista, S., Eds., *Proceedings of inception workshop January 14-15:* Enabling POPs activities in Nepal. Kathmandu: MOEP and UNIDO. pp. 56-63.

PAN-UK. (1998). DDT Fact Sheet. *Pesticides News No.40.* UK: Pesticide Action Network. Pp 18-20. [online]. Available at: *http://www.pan-uk.org/pestnews/Actives/ddt.htm.*

Paudel, A. (2011, May 19). Dangerous pesticide residue found in foods across Nepal. *The Republica.*

Pingali, P.L. (1995). Impact of pesticides on farmer health and the rice environment: an overview of results from a multidisciplinary study in the Philippines. In P. L. Pingali & P. A. Roger, Eds., *Impact of pesticides on farmer health and the rice environment. IRRI, Phillipines.* pp. 56-63.

PPD. (2012). *Annual Report.* Plant Protection Directorate (PPD), Department of Agriculture, Government of Nepal, pp. 112.

PMRD. (2011). *Annual Report.* Pesticide Registration and Management Division, Plant Protection Directorate, Department of Agriculture, Kathmandu, Nepal. pp 45.

Rottenberg, B. (2004). Health effects of POP pesticides in Nepal. In D. B., Thapa, D. N., Manandhar, J. R., Adhikari, & S. Bista, Eds., *Proceedings of inception workshop held January 14-15: Enabling POPs activities in nepal*(pp. 42-48). Kathmandu: MOEP and UNIDO. pp. 42-48.

Sah, R. C. (2002). *Obsolete pesticides stockpiles in Nepal and its environmental impact.* Kathmandu: Forum for Protection of Public Interest (Pro-Public).

Schaefers, G. A. (1996). Status of pesticide policy and regulations in developing countries. *Journal of Agricultural Entomology,13,* pp. 213-222.

Sharma, D. R., Thapa, R. B., Manandahr, H. K., Shresthe, S. M., & Pradhan, S. B. (2012). Use of pesticides in Nepal and impacts on human health and environment. *Journal of Agriculture and Environment,13,* pp. 67-74.

Sherman, J. D. (1996). Chlorpyrifos (Dursban)-associated birth defects: report of four cases. *Archives of Environmental Health, 51(1)*, pp. 5-8.

Shrestha, R. K. (2010). Fertilizer policy development in Nepal. *The Journal of Agriculture and Environment, 10,* pp. 126-137.

Thapaliya, Y. (2011, February 2). Banned pesticides in Nepali market: Food safety. *Arthik Abhiyan.*

Yau, J. (2011). What are plant growth regulators? *Food Safety Focus. (60)*. [online]. Available at: *http://www.cfs.gov.hk/english/multimedia/multimedia_pub/multimedia_pub_fsf 60_02.html.*

7

# Sustainable Ruminant Production in Nepal

Drona P. Rasali

## Abstract

The aim of this paper is to explore some important aspects of ruminant production, including some technological practices deemed as sustainable in various agro-ecological regions of Nepal. The scientific findings published elsewhere, especially as peer-reviewed journal articles were reviewed to synthesise the evidence. The evidence shows that ruminant population of Nepal dominates the livestock production, and the vast majority of them are still indigenous breeds. Yet they are not fully characterised for understanding their potential for sustainable production. Nonetheless, ruminants (both large and small) play a dominant role in the rural livelihoods in their respective ecological zones, where they have been raised from time immemorial. However, the ruminant production across all ecological zones are hampered by the increasing deficit in biomass production to feed them, the competing pressure of ever increasing human population on limited land, the reduced soil fertility in the land areas, and ever rising cost of inputs. Adoption of systematic breeding practices with control in the population and productivity of the stock, selected but scientifically tested technologies of feeds and feeding practices, and veterinary care are necessary, in the form of enterprise, for sustainability of ruminant production in Nepal.

## 1. Introduction

Nepal's livestock sector is largely dominated by domesticated ruminant species, especially comprised of buffalo, cattle, goats, sheep and Yak (male)/Nak (female). Buffaloes are economically the most important livestock, producing milk, meat, manure and draft power. Cattle command the largest population and are raised for the purpose of producing milk, work and manure. Goats have a special place in the country's livestock production system as their meat is most preferred and highly priced in the consumers' market, and manure production is also valued. Sheep are raised for meat, wool and manure. Yak/Nak (hereafter simply yak) production is an important specialty of farming in the Himalayan ranges, specifically along the northern side of the country. Hides and furs from all of these ruminants are also valuable products.

This chapter aims to describe some of the important aspects of ruminant production including some technological practices deemed as sustainable in various agro-ecological regions of the country, where they have been raised and produced from time immemorial. The methodology used to synthesise the evidence was to review the scientific findings published elsewhere, especially in peer-reviewed journal articles.

## 2. Sustainability in ruminant production systems

Devendra (2010) citing the Millennium Ecosystems Assessment's definition described the concept of sustainability as, "a characteristic or state whereby the needs of the present and the local population can be met without compromising the ability of future generations or population in other locations to meet their needs." Though the concept of sustainability in agriculture was initially focused on environmental aspects, more recently, it has become broader in scope due to the inclusion of socio-economic and political components. Specifically, the sustainability in ruminant production systems of Nepal is an important aspect of rural livelihoods in the country, where most of the people (over 60%) live largely on subsistence farming in rural Nepal.

Devendra (2010) illustrated a conceptual framework for sustainable ruminant production systems (see Figure 1). In his own words, the framework is described as:

*"Considering the agro-ecological zones, small farm systems, bio-physical and socio-economic environment, the major targets for development are efficiency in the management of the natural resources, income growth, poverty alleviation, food security, economic viability, minimum dependence on external non-renewal inputs, response to changing consumers' preferences, rural growth, and self-reliance. The key sustainability issues are environmental protection, knowledge of traditional systems, preservation of biodiversity, maintenance of soil fertility, increased access to markets, socially acceptable improvements, widespread adoption of improved technologies, farmer organisations and cooperatives and replicability of development initiatives."*

Clearly, there are several elements of sustainable ruminant production systems interacting with each other as illustrated above. However, the scope of sustainability in the context of this chapter is to outline only the major characteristics of ruminants, and highlight other natural and technological resources that are known to be readily adoptable and amenable to further improvement in sustainability of ruminant production systems in Nepal.

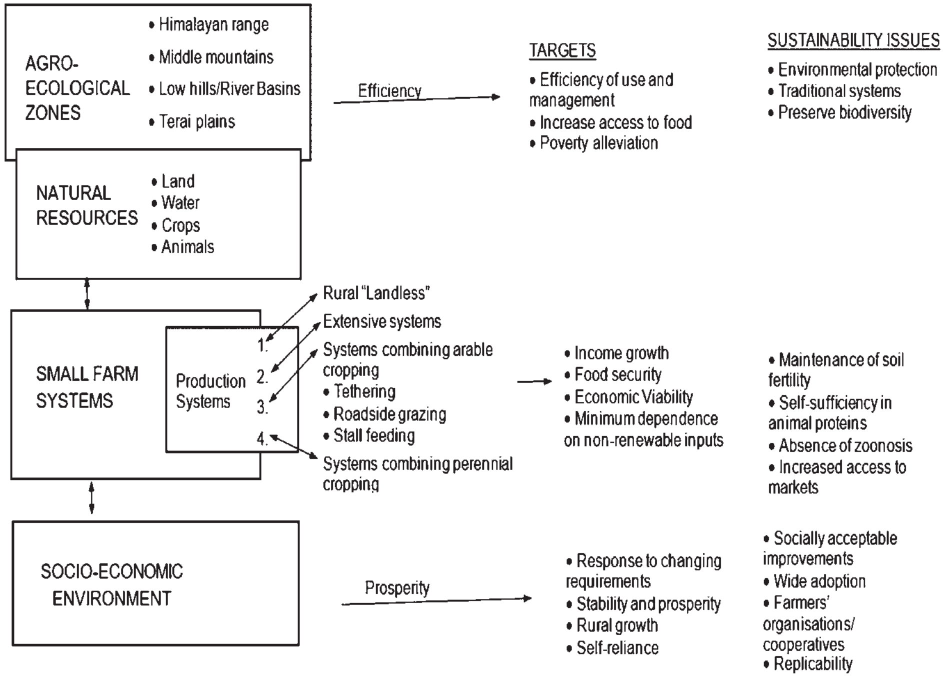


**Figure 1.** Sustainability model of ruminant production systems
(Adapted for Nepal from the source: C. Devendra, 2010)

## 3. Ruminant population and breeds

The livestock statistics of Nepal (CBS, 2010) show the estimated total number of cattle heads in the country has reached 7.2 million in the fiscal year 2009/10, a marginal increase of 0.34% from the preceding year. However, the number of milking cows is only 954,680 (13.3%) of the total cattle population. The number of buffaloes has increased by 3.34% totalling 4.8 million in 2009/10. The number of the milking buffaloes is estimated to be 1.25 million (25.9%) of the total population. The number of sheep slightly declined by 0.20% to 801,000 in the same period, whereas the number of goats increased by 4.38% to 8.84 million. The 2009/10 statistics showed that the total number of Yak in the country was 68,097, of which the largest number was found in Solukhumbu (12,097), followed by Humla (11,999) and Dolpa (10,168) districts. According to statistical records of last eight years data, the average annual growth of cattle population was 0.39%. Similarly, the average annual growth of buffaloes was 3.4% and goats 3.72%.

The vast majority of ruminant populations in Nepal are the indigenous stock comprising known breeds and non-descript types. The distribution of the indigenous breeds of ruminants across ecological zones of the country as described by Pradhan and Rasali (1995) are given in Table 1.

**Table 1.** The distribution of the indigenous breeds of ruminants across ecological zones.

| Ecological zones | Cattle | Buffalo | Sheep | Goats | Yak/Nak |
|---|---|---|---|---|---|
| Trans-Himalayan Range | Lulu, Kirko | - | Bhyanglung | Chyangra | Chauris, Yak/Nak |
| High Mountain Range | Kirko | Lime, Parkote | Baruwal, Dhorel | Sinhal | Chauris, Yak/Nak |
| Middle Mountains | Pahadi local (Zebu) | Lime, Parkote | Baruwal, Kage | Sinhal | - |
| Siwalik Hills | Pahadi local (Zebu) | Lime, Parkote | Kage | Khari | - |
| Terai | Terai local (Zebu) | Terai local | Lampuchhre | Terai local | - |

Source: Pradhan and Rasali (1995)

Small populations of crossbred ruminants with exotic breed blood have been created in scattered geographical areas across the country. The major exotic breeds used in crossbreeding indigenous ruminant breeds are: Jersey and Brown Swiss in Cattle, Murrah in buffaloes, Merino and Border Leicester in sheep, and Jamunapari and Sanen in goats.

## 4. Sustainable buffalo production

Economically buffaloes are known to be the most important livestock in Nepal, which contribute to 70% of the total milk and 64% of the total meat production (Vishwakarma & Rasali, 1996). Especially in the hills across the country, a buffalo serves as a living bank ensuring cash income of a typical household, where clarified butter (Ghee) is produced both for household consumption as well as cash income. A study conducted in three hill districts of Lumbini zone showed that each household produces an average of 34.4 kg ghee every year. The household income thereof was highest in the larger farmer category, but its production cost-benefit ratio was highest in the small farmer category (Vishwakarma & Rasali, 1996). This indicates that the small household production system in the hills of Nepal is sustainable. Despite these facts, the country imports 11,674 live buffaloes at a cost of NRs. 30.6 million annually from India to meet the consumers' demand (MOAC, 2008/09). There are ample market opportunities for the growth in buffalo production through increasing its population or improving its productivity, by way of using sustainable technologies for improving breeding, reproduction, feeding, production management and product marketing that are suited to various agro-ecological zones and the varied production systems in Nepal.

### 4.1 Buffalo breeding and reproduction

Importation of large number of productive buffaloes for the purpose of increasing their population for production growth is capital intensive and is not sustainable for a resource-poor country like Nepal. The only sustainable way to increase both population and productivity is through the genetic improvement and improved reproduction of the existing population. Cross-breeding of indigenous buffaloes with Indian Murrah breed has long been used as a sustainable method of breed improvement of buffalo herds by the Terai and low hill farmers. Government programs have implemented this method, learning for more than 40 years, which had a noticeable impact on the overall production systems across hill and mountain agro-ecozones. This method is applied system-wide in an increasing progression of production intensity. For example, in the Middle mountains, Siwalik hills and river valleys today, farmers are raising increasing number (>20) of buffaloes per farm under a commercial production setting from what was largely a household subsistence production of one or two buffaloes some 25 years ago.

Crossbreeding of two indigenous hill breeds: Lime (pronounced as Lee-may) and Parkote (pronounced as Par-ko-tay) (Box 1), with highly productive Indian Murrah has been recommended, especially after Rasali et al. (1998) established that both the hill buffaloes are similar to riverine type Murrah with their chromosome number of (2n=50), removing the past general suspicion that Lime belonged to swamp type that does not interbreed with riverine type to produce normal offspring. Artificial insemination (AI) technology is now well established in the country and is provided readily by the government livestock service networks in the feasible geographical pocket areas. Artificial insemination of indigenous or crossbred buffaloes with Murrah buffalo frozen semen has been proven technology for sustainable production in Terai, Siwalik hills, middle mountains, and river valleys and can be used to upgrade and maintain sustainably the Murrah blood level from 50 to 67.5%. This level of Murrah blood can be exceeded to upgrade the stock maintained in commercial herds especially in Terai and river valleys where the high quality feed resources are relatively abundant.

Infertility is a common occurrence in buffalo cows due to reproductive disorders such as anoestrus, repeat breeding, vaginal or uterine prolapse, dystocia, abortion and uterine torsion. This problem of infertility causes a colossal economic loss that has been a major risk factor for the sustainable buffalo production. Repeat breeding is often the condition of a buffalo cow that has clinically normal reproductive tract with normal or nearly normal oestrous cycles but is bred two or more times with normal bull or inseminated with fertile semen and has failed to conceive. The condition has been costing the farmers most treacherously, as they have to raise the buffalo with feeding and management at a level as if she is normally producing. Yet, little research has been conducted in the country and no specific guidelines have been set to remedy this problem due to lack of sufficient scientific information (Sah et. al., 2012). They reported that repeat breeding buffaloes responded quickly and excellently to the use of growth promoting hormone (GnRH) when supplemented with mineral-vitamin mixtures resulting in better conception rate when inseminated both artificially and naturally. This indicates that the nutritional deficiencies, especially in mineral and vitamins, are important causes of repeat breeding.

Box 1. Parkote (left) and Limé (right), two hill buffalo breeds of Nepal (Sources: Rasali, 1997; Rasali, 1998 a,b. as cited by Moioli and Borghese, 2007)

*Parkote*

(Photo by: D.P. Rasali)

The hill buffalo of Nepal, named Parkote buffaloes, are the typical buffalo of the mid-hills and river valleys. However, due to the traditional practice of crossbreeding with Limé buffalo as well as recent crossbreeding with Indian Murrah, their population in pure form is now declining. At present the pure bred population is estimated at only 25 percent of the indigenous population in the hills and mountains of Nepal.

Population size: 500,000

Description: The Parkote are dark in coat colour and of medium-built body size, with sword-shaped horns directed laterally or towards the back. Black skin, black muzzle, black eyebrows. Usually they have no markings on the legs.

Distribution: The breed is raised in the mountains, high hills and hill river valleys of Nepal. Height at withers of adult female is 114 cm, body weight is 410 kg.

*Limé*

(Photo by: D.P. Rasali)

The pure Limé breed is believed to have originated from the wild Arna and has been domesticated throughout the known history of Nepal. The Limé buffalo is estimated to constitute 35 percent of the total indigenous buffalo population in the hills and mountains of the country.

Population size: 700,000

Description: Light brown colour, small body size, characteristic chevrons of grey or white hair below the jaws and around the brisket, small sickle-shaped horns, curved towards the neck. Height at withers of adult female is 115 cm, body weight is 399 kg.

Distribution: The breed is found in the mountains, high hills and hill river valleys in Nepal. It is not found in the Terai plane.

| | |
|---|---|
| Husbandry: Mainly raised under migratory conditions or semi-stall systems. The breed is a voracious eater and is fed only low quality feedstuff such as rice, wheat and millet straw. Small farmers exchange breeding animals within and between villages. Among the migratory herds, male and females are grazed together and mated freely during the breeding season from June to November. Females are legally banned from slaughter; only culled animals are slaughtered for meat.<br><br>Dairy performance: Lactation duration 351 days Milk yield 875 kg Milk fat 7.0 percent Products: milk, ghee, meat, swiss-cheese, yoghurt, leather.<br><br>Source: Rasali as cited by Moioli and Borghese (2005). | Husbandry: Mainly raised under migratory conditions or semi-stall systems. The breed is a voracious eater and is fed only low quality feedstuff such as rice, wheat and millet straw. Small farmers exchange breeding animals within and between villages. Among the migratory herds, male and females are grazed together and mate freely during the breeding season from June to November. Females are legally banned from slaughter; only culled animals are slaughtered for meat.<br><br>Dairy performance: Lactation duration 351 days Milk yield 875 kg Milk fat 7.0 percent<br><br>Products: milk, ghee, meat, Swiss-cheese, yoghurt, leather.<br><br>Source: Rasali as cited by Moioli and Borghese (2005). |

### 4.2 Buffalo calf rearing

Buffalo calves are a valuable resource for replacement stock of the buffalo herds and means for increasing the buffalo population and productivity. Unfortunately, they are generally neglected especially in smallholder production systems that command the most of the buffalo population in Nepal. In some cases, especially the male calves are separated from their mothers at the time of their calving and sold or slaughtered for meat to save the milk from feeding the calves. This phenomenon is detrimental to the growth potential and sustainability of buffalo production system as a whole, not only because of less number of male calves being available for future production, but also because of the loss of genetic resource that would otherwise be available for breed improvement. Therefore, saving and salvaging buffalo calves for further rearing to the stages of weaning, growing and maturing to adult buffalo is very crucial in the production system as a whole.

#### *4.2.1 Feeding and caring of calves from birth to 6 months*

Feeding of buffalo calves initially for the first week is an important consideration in buffalo production. This author's experience is that many smallholder farmers across all ecological zones of Nepal do not see this as being critically important in the buffalo rearing practices and tend to grossly neglect this aspect. Scientific evidence suggests that calves that do not get colostrum immediately after birth and those that are not fed and cared for properly when young tend to be susceptible to diseases, and are of low productivity in their later life (Rasali, 1994). Some farmers even get rid of the calves soon after calving, especially the male calves, for the sole purpose of saving some milk yield from the dams. Unfortunately, this causes loss of valuable production resources and replacement breeding stock. It takes a significant amount of resources, time and effort on the part of the farmer to get a buffalo cow or heifer pregnant resulting in a successful outcome of calving. The practice of culling a buffalo calf at birth is counter-productive to buffalo husbandry and should be discouraged. Instead, the calves should be fed entirely on dam's milk by suckling at least for the first week, and then be transitioned gradually to milk replacer with grains in its contents until six months of age.

#### *4.2.2 Feeding and Caring of Buffalo Heifers from 6 months onwards*

Ideally, the buffalo calves are weaned from their dams at the age of six months (Box 2), after which, they do not need high plane of nutrition as in the early stages of their growth and can be gradually fed coarse fodder, incorporating gradually even a straw-based diet.

Nepalese farmers traditionally do not assess the growth performance of the calves on which to base their feeding and management schedules like in modern farms due to lack of knowledge between growth performance and reproductive efficiency. Rasali (2004) established genetic as well as environmental aspects of this positive relationship in beef cattle showing that better juvenile growth performance favours female reproductive efficiency, and a similar relationship can be anticipated in buffaloes. Especially, it is important to base the quality and quantity of feeds offered to growing buffaloes from six months to one year, depending upon the targets set as appropriate for growth performance for meat production or reproductive efficiency in breeding stock. In case of breeding stock, the farmers should plan their feeding and management program for achieving the target that the heifers can hit puberty soon after six months. Taking an illustration from Indian standards, an average daily growth rate of 450-550 g can be achieved with a ration containing 12% crude protein (CP) and 58-60% total digestible nutrients (TDN) (CIRB, 2014). A growth rate of 500-600 g/day between 100 and 300 Kg body weight is generally considered optimum growth rate for buffalo heifers by Indian standards (CIRB, 2014), which could be relatively less in Nepalese situation, especially in the small sized hill buffalo, even though due to lack of research no such guidelines are available. Underfeeding reduces growth rates during the rearing phase to 50% of the animal's potential and delays puberty significantly.

**Box 2. Feeding schedule of buffalo heifers from 6 months of age**

- For attaining 450- 500 g daily weight gain a concentrate mixture containing 20% CP and 63% TDN may be fed at the rate of 1.5, 2.0, 2.5 and 3.0 Kg per head per day, respectively, at 100, 150, 200 and 250 Kg body weight or above along with 10 Kg green fodder and ad libitum straw.
- The concentrate mixture can be prepared by mixing crushed cereal grain, wheat bran, rice bran, mustard cake, soybean cake or groundnut cake, mineral mixture and salt in the ratio of 35: 15:25:10:10: 2:1 or 30:20:17:15:15: 2:1.
- When green fodder is not available, additional 1 Kg concentrate mixture should be fed as replacement of 10 Kg green fodder. For a faster growth rate additional 1 Kg concentrate may be fed daily.

(Adapted from: Buffalopedia URL: http://www.buffalopedia.cirb.res.in)

### 4.3 Commercial buffalo dairy farming

A family run buffalo dairy farming can be sustainably operated in Terai, river valleys and low hill areas of Nepal, where fodder and feed-resources are relatively abundant. A farm herd of 10 buffalo cows can be profitably managed by a household family of four adults with grown up children. However, a herd of more than 10 buffalo cows becomes a serious commercial business involving significant financial investment that must be operationalised at higher occupational standards of dairy farming.

A lactation curve study in hill buffalo cows and their Murrah crossbred cows raised under farmers' management in the western hills of Nepal (Rasali & Harding, 1998) showed significantly different effects of breed genotypes (Figure 2), parity, management systems and length of lactation on the different phases of the lactation curve. The rising phase of the lactation curve is largely a function of breed genotype and lactation parity. However, in the declining phase of the curve, one of the main factors was the management system that was causing a sharp decline in daily milk yield especially after 10 weeks of the lactation length resulting in low lactation yield. Physiologically, in both hill buffalo and Murrah crossbred cows, there seems to be an ample opportunity to sustain the daily milk yield with a more gradual decline as the lactation period advances such that the total lactation yield is significantly increased. This can be achieved by improving nutritious feeding and management practices that are sustainable in the commercial dairy production systems across agro-ecological zones, especially so in river valleys and Terai plains.

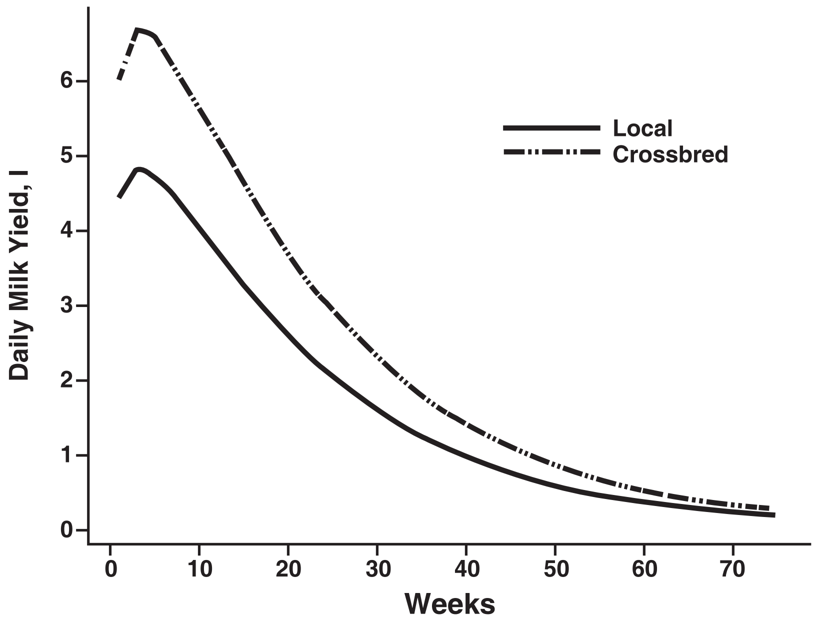


Figure 2. Different effects of breed genotypes in daily milk yield in buffaloes

## 4.4 Commercial buffalo fattening

Buffalo meat is a high demand commodity in the consumer markets throughout Nepal, especially in the middle mountains, Siwalik hills and river valleys. There is a need for a sustainable but extensive system of meat production that can be achieved through extensive research and development of the appropriate production technologies and their adoption in the hill production systems. A buffalo fattening operation of any magnitude should be managed as a commercial business meeting high farm management standards. The sustainability of buffalo fattening as a small family business is dubious, because of the lack of regular cash flow or in-kind revenue generated from the business. Small farms run by individual families face challenges of hauling the live animals as the finished product to distant market places. Buffalo fattening at the commercial scale is totally a new enterprise for most Nepalese farmers. Housing, feeding, watering and tending the animals are serious considerations as the labour intensive daily chores in this type of operation are significant.

## 5. Sustainable dairy cow production

The indigenous cattle in Nepal have been raised from time immemorial. Despite this fact, the vast majority of their population is raised with low inputs yielding low outputs under traditional cattle raising systems across the country. Such a set up can no longer be considered sustainable in the prevailing production systems, where they put tremendous pressure on resource utilisation without a sustainable level of productivity. The underlying problem lies with the traditional as well as legal ban on slaughter of cattle. As a result the stock can neither be bred systematically through selection based on scientific breeding principles for genetic improvement of the stock (e.g. for increasing meat or milk production) nor they can be culled when they become an unproductive resource burden to the farmers. The farmers are forced to raise such cows that are low in milk productivity, while they are not at all raised for producing meat. Draft animals are a valuable output from cattle, as oxen are the major source of power used for tilling the cropland across the country except in limited areas of Terai plains, where buffalo bulls are used instead. More recently tractors are taking over the tillage on farms. In addition, the cattle are the main source of manure for crop production particularly in the hills and mountains. Ironically, the cows, especially the indigenous cattle, are not the major source of milk or the main source of meat products produced in Nepal. However, since the introduction of crossbreeding of indigenous cattle with European dairy breeds, such as Jersey and Brown Swiss, there has been a population of crossbred dairy cattle located in some areas across the country. High grade dairy cows have been introduced for commercial production in some geographical pocket areas close to urban centres, where markets for milk exist. Crossbred dairy cow (Figure 3) production can be sustainable in these pocket areas, where feed resources and veterinary services can be made readily available.

Figure 3: Jersey crossbred heifers in a commercial dairy farm

## 6. Sustainable goat production

Goats are raised across all agro-ecological zones in Nepal primarily for the purpose of meat. Goat meat is the most preferred and expensive food of animal origin in Nepal. Milk, manure, hair and hides are other important by-products from goat production. Goats are very adaptive animals that can thrive well and reproduce in harsh environments. They are efficient converters of feed resources into human food under diverse production systems anywhere in high altitude mountain ranges, middle mountains, Siwalik hills, river valleys or Terai plains.

Devendra (2010), an internationally noted goat production expert, has described the prevailing goat production systems in the developing countries to fall under one of the four categories, namely: rural landless systems, extensive systems, crop-based systems and rangeland-based systems. Among these systems, the rural landless system comprising nomadic transhumance production practices is common in the Trans-Himalayan range and high mountain ranges in northern area. However, crop-based systems comprising large, mixed farming are most common in middle mountains, Siwalik hills, inner valleys and Terai plains. Economically, the goats are considered as the ‘living banking systems’ or ‘living bank’ of the resource poor farmers. They can be exchanged for cash at any time the farmers need.

Due to the indiscriminate browsing nature of their feeding habits, goats are occasionally blamed for forest degradation. This may be true when they are let free to graze anywhere in haphazard manner. However, if the goats are managed well, they are one of the most adaptive animals to raise across all production systems regardless of resourceful or resource poor settings. Goats are also found most advantageous for sustainable production in smallholdings due to their low unit cost and small size of production.

## 7. Sustainable sheep production

Sheep are raised across all agro-ecological zones in Nepal for the purposes of primarily wool and also meat and milk. Manure and hides are other products from sheep production.

The indigenous breeds of sheep found across various agro-ecological zones in Nepal are not very highly productive for both wool and meat productivity. However, they have evolved as sturdy local stock for rearing in traditional rural settings. The modern ways of people’s living with elevated living standards have raised the market demands both in quality and quantity of wool and meat, necessitating the genetic improvement of the local stock. However, there has not been any systematic effort to develop the pure indigenous breeds through selection. Some sporadic attempts have been used to introduce exotic breed into the local stock through crossbreeding, using European breeds, namely Merino at Jumla Sheep Farm and Border Leicester at Pokhara Lampatan Livestock Farm. Rasali et al. (2006) summarised the composite breeds of the sheep developed around the world and showed the benefits of mixing bloods from two or more traditional purebreds. This can be a goal for future plans regarding sheep development in Nepal.

# 8. Sustainable yak and nak production

Yak herding is an important and prestigious farming activity in the Trans-Himalayan and high-mountain ranges of Nepal. Yaks are reared for the purposes of milk, draft work, meat and fur production. The farming is carried out largely by traditional people living in the Himalayan ranges using traditional feeding and management practices in sustainable manner from time immemorial. However, Kharel (1995) has noted that some modern scientific practices are catching up especially among Sherpa people in the Eastern Himalayan ranges.

Yak are strong and hardy animals that can thrive well under extreme cold climatic conditions, while they are also exceptionally resistant to hypoxia and tolerant to the very low oxygen content in high mountain atmosphere. They are reared in these conditions of China, Mongolia, Russia, Bhutan, India, Nepal, Pakistan and Afghanistan, where they are found in this order of their population sizes (Paudyal, 1994).

The yaks and their hybrids with cattle are collectively called Yakow. All of them can live in cold, barren, difficult upland terrain, but can adapt to a lower altitude as well. In winter, they may descend to the lower lands as low as 1,600 metre above sea level (Paudyal, 1994). They are pastured in the highland grasses under the traditional transhumant system practiced in those areas, with no supplementation of feed or fodder provided except for sick animals. As they are reared in the traditional transhumant system in a sustainable manner, the breeding is the only component of present day human technological intervention introduced into their production systems through the practices of crossbreeding and hybridisation with cattle to meet the needs of the people.

The systems of Yak and cattle crossbreeding and hybridisation are very complex. A wide range of mating types is applied to produce crosses and hybrids bearing a wide variety of nomenclature (Joshi, 1982).

# 9. Major technologies for sustainable ruminant production

This section highlights the most important technologies that can support sustainable ruminant production in Nepal.

## 9.1 Sustainable feed resource technologies

Feeding is the most important component of ruminant production system across all agro-ecological zones of Nepal from Terai in the south to river valleys, hills and mountains in the north. The major livestock feeds available are varieties of grasses, tree fodders and grains (maize, rice bran, millets), and crop residues (rice, millets, wheat straws, maize stovers and legume vines), in addition to water and salt.

### *9.1.1 Tree Fodder Production*

The production of tree fodders is one of the most sustainable feed resource technologies that can support increasing ruminant production, especially the dairy buffaloes and cows. There are numerous fodder tree species known to have high nutritious value for animal fodder. Subba et. al. (1994) emphasised the usefulness of tree fodder contributing to a year-round green fodder supply for feeding ruminants daily in the Eastern hills of Nepal. They have documented seasonal variations of nutritional contents of the seven important tree fodders used in the region, namely: Tanki (*Bauhunia purpurea*), Koiralo (*Bauhinia veriegata*), Badahar (*Artocarpus lakoocha*), Kutmiro (*Litsea monopotela*), Gogun (*Saurania nepalensis*) Khari (*Celtis australis*) and Ghotli (*Grewla oppositifolia*).

From a rapid rural appraisal (called *Samuhik Bhraman* in Nepali), Paudel et al. (1996) have identified, in the Western hills, a total of 32 species of fodder trees that are lopped for animal fodder between the Fall starting from the month of September through Spring until April, while spring and pre-monsoon pose a critical period of feed scarcity that can be alleviated by preserving the tree fodder when they are produced relatively more in abundance. Commercial production of tree fodders in cultivable land area has not been a common practice among farmers, as the cultivable land is considered very important for agronomic crop and horticultural cultivation to spare for livestock fodder cultivation. Only the less fertile marginal land terraces have been used for producing the fodder trees. However, relatively larger dairy farms may need to consider producing tree fodders in the main farmland areas for sustainable dairy production. Silvipastoral cultivation of fodder trees and other crop cultivation under them as more sustainable way of optimisation of land use.

Taking one tree fodder for an example, Badahar is identified as one of the most important trees producing nutritious fodder leaves. An on-farm trial studying Badahar fodder biomass production and feeding (Paudel & Rasali, 1996) showed the significantly higher response of feeding Badahar leaves on milk yield, butter fat content and health condition in Murrah crossbred buffalo cows. During the Badahar feeding period, 4.09 litre milk was yielded per day compared to other experimental (control) periods (3.2-3.4 litre per day). The total butter fat production was higher due to significant increase in daily milk yield, but with no significant change in butter fat percentage in milk. The farmers have also reported that feeding Badahar leaves improved the overall health conditions of the milking animals. The feeding trial showed that approximately 70 to 85% of the fresh fodder is palatable to buffalo.

### *9.1.2 Green forage production*

Agronomic production of green forage in cultivable land area, especially in the winter, is one of the sustainable technologies available for supplying nutritious feed stuff for the feed-scarce period across all agro-ecological zones of Nepal. Similarly, growing forage grasses and legumes in the terrace risers, along the fences or marginal lands can increase the fodder supply sustainably.

### *9.1.3 Utilisation of agro-industrial by-products*

Various technologies are available for processing and utilising agricultural and agro-industrial by-products for feeding ruminants in a sustainable manner. Crop residues are biomasses with low nutritional values, but can be enriched in their feeding values by appropriate treatments without untoward hazardous effects on the health of the animals. Rice and wheat straws have been treated with 4% urea and even supplemented with mineral mixtures and or agro-industrial by-products, such as molasses, in many trials conducted across various agro-ecological zones over several years both on-farm and on-station conditions. These agricultural by-products have been shown to be enriched by the treatment with materials such as urea and molasses. From two on-farm experiments, Kadariya et al. (1997) reported that feeding urea treated rice straw increased straw dry matter intake (DMI) by 14.2% and the total DMI by 10.6% over the untreated rice straw, while these increases in treated wheat straw DMI and the total DMI were 20.2% and 17.4% respectively over untreated wheat straw. There were significant improvement in lactating buffaloes fed with treated rice and wheat straws. The farmers' responses to both these treated straws and their beneficial effect on milk yield were consistently positive. Kadariya et al. (1995) compared the use of cattle urine vs. 4% urea solution for treating rice straw and indicated that the cattle and buffalo urine can be used as cheap alternative to purchased urea for enriching the rice straws, though further studies are needed to develop this technology fully for its sustainable use without any detrimental effects on animals and their production.

### *9.1.4 Stall-feeding and shed improvement*

Small-holder farmers in the hills and mountains raise their non-migratory buffaloes under stall-feeding as well as semi stall-feeding (Rasali & Crow, 1999). Stall-feeding of ruminants in their shed has been a well-known practice in Nepal. It is commonly adopted by the farmers especially for the animals that are producing and/or are in reproductive stage such as in buffaloes and dairy cows. The practice has been recommended as a sustainable technology in all sedentary ruminants, small or large (Joshi, 1992; Ghimire, 1992). The practice facilitates conservation of resources with the following specific advantages: 1) it conserves the body energy of the animal avoiding unnecessary roaming in search of feeds; 2) it conserves feed resources avoiding their waste during feeding; 3) it conserves manure facilitating its collection at the shed; and, 4) it alleviates forest degradation by reducing livestock free range grazing. Also, the improvement of animal housing sheds can improve efficiency in feeding, management, protection and production of animals. High producing buffaloes and dairy cows have been kept sustainably in modest to more elaborate sheds in commercial and semi-commercial livestock farms across various parts of Nepal, especially in the urban areas, Terai and river valleys.

## 9.2 Preventative veterinary technologies

Prevalence of various infectious and parasitic diseases have been recognised as one of the major constraints resulting in the loss of production and productivity in large ruminants ever since the initiation of modern livestock development in Nepal in the 1960s. More recently, this has been exacerbated by wide-spread trans-border diseases for example the emergence of new diseases such as Peste des Petits Ruminants (PPR) in small ruminants, despite the fact that the most serious problem of a viral disease Rinderpest in cattle has now been eradicated by the concerted efforts of the government programs for more than three decades.

Vaccinations against the major infectious diseases, especially a viral disease, Food and Mouth Disease (FMD), two bacterial diseases: Hemorrhagic Septicemia

(HS) and Black Quarter (BQ), and strategic control of parasites have been proven as the preventive measures of sustainable technologies. A brief account of these control strategies of major diseases are provided below.

### *9.2.1 Foot and mouth disease (FMD) control*

Foot and Mouth Disease (FMD) is a highly contagious viral disease of all cloven-hoofed animals, both domestic and wild. The disease is considered economically disastrous livestock disease in Nepal as in many other developing countries. It is reportedly known to occur as endemic throughout the year with frequent outbreaks in all 75 districts of Nepal, resulting in colossal economic losses. The negative economic effect is mainly attributed to loss in milk and meat production, mortality of new-born animals, loss of draft animals due to lameness, reduction in breeding efficiency, and the cost required to control the outbreaks and restrictions on international trade (Chhetri et al., 2010; Thakuri, 2012). The annual economic loss from FMD alone through the reduction in milk yield and meat production is estimated to be 66 million USD (Gongal, 2002). An earlier analysis of the economic impact indicated that FMD alone in Nepal caused 26% of the overall economic losses in livestock production (Lohani & Rasali, 1995). The prevalence of FMD in Nepal has been a stumbling block for any international trade of livestock and its products. For example, in 2002, China banned Nepalese dairy products to enter in Tibet due to the fear of FMD transmission. Thakuri (2012) therefore warns that the Government and concerned agencies, both in national and regional levels, must be serious about bringing FMD under control.

Otherwise, the FMD particularly in cattle and buffaloes, will have severe negative impacts for their sustainable production. The mortality resulting from the disease may not be as high or as recognisable, but the morbidity of the animals in the face of outbreaks is high resulting in direct and significant economic losses to producers. The disease, which is caused by a Picorna virus, is not easy to control, as it spreads quickly to a large number of animals across village herds during an outbreak. Though the infected animals can be treated and be kept in isolation to contain the disease in a restricted area, the only effective control of the disease is through vaccination. However, the vaccine is specific to what are known as 'serotypes' of the virus, of which four ('O', 'A', 'C' and 'Asia 1') out of the total seven have been reported from Nepal. The vaccine is made from attenuated viruses; by the very nature of the vaccine, its immunity cannot last for a long period (Brown, 2011). The recommended practice is that the ruminants should be vaccinated against FMD every 7 months.

### *9.2.2 Peste des Petits Ruminants (PPR) vaccination*

Peste des Petits Ruminants (PPR) is a disease that was first noticed in Ivory Cost in West Africa; it is a disease affecting small ruminants and requires the most attention, particularly in endemic areas such as Sahara, Middle East and South Asia (Abubakar et al., 2010). Goats and sheep are the only natural hosts of the disease, but goats appear to be more susceptible to clinical form of the disease than sheep. PPR is caused by Morbilli virus within the paramixoviridae family, which shares an antigen with Rinderpest. It is a contagious disease characterised by the clinical signs of fever, erosive stomatitis, enteritis, pneumonia and death.

According to Thakuri (2012), Nepal's first PPR outbreak was recorded in 1995 in Dhanusha, Mahottari, Bara, Sarlahi, Rauthat and Gorkha districts, and the source of virus during the first outbreak was through trans-border movements of infected goats from India to Gadimai in Bara district of Nepal. From Bara the disease spread to other parts of the country resulting in the outbreaks reported in 52 districts by the end of 2001.

The PPR Control Project that was started in 2001 implemented a mass vaccination program against PPR. Goats comprised 95% of all infections during the outbreaks while the remaining 5% was in sheep between 2000 and 2011. The proportion of PPR vaccination coverage and the number of outbreaks during this period are shown in Figure 4 (Thakuri, 2012). As a result of the vaccination program, the number of outbreaks declined rapidly from 2002 onwards to very low levels indicating the effectiveness of the vaccination campaign. At the same time, the vaccination coverage was also reduced to about 12% between 2005 and 2007 as illustrated in the Figure 4 (Thakuri, 2012). Due to this reduction in coverage of vaccination across the country to the level that did not meet the scientific threshold level of vaccination for disease control, the disease flared up again with the number of PPR outbreaks increasing during 2006 and 2007.

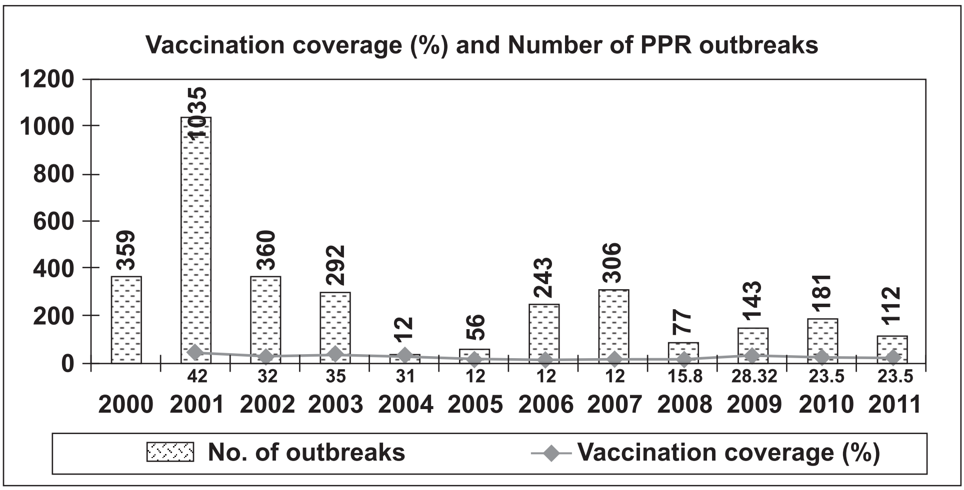


Figure 4. Vaccination coverage and number of PPR outbreaks, 2000-2011, Nepal
(Source: Thakuri, 2012)

### *9.2.3 Haemorrhagic Septicemia (HS) Vaccination*

Haemorrhagic Septicemia (HS) is a highly infectious acute disease of cattle and buffaloes. This disease is caused by the Gram Negative bacteria *Pasteurella multocida* and affects the entire body of the animal through blood infection and is characterised by the clinical signs of high fever, swelling of neck and sometimes of the whole head. The animal can die very quickly; sometimes, even before the clinical signs are apparent. The disease is highly prevalent across Terai and the mid hills of Nepal. Vaccination of all productive cattle and buffaloes prior to monsoon season is a standard and sustainable practice for controlling the disease. Especially, the

Alum precipitate adjuvant vaccine produced in the Nepal Government's laboratory which is recommended for vaccination prior to the hot and humid season when this disease tends to flare up across the village animal herds (Quesenberry, 1990).

### *9.2.4 Strategic control of internal parasites*

Infestations of internal parasites have been the cause of considerable loss of production in cattle, buffaloes, goats and sheep. A set of strategic approaches to control them in these animals have been developed through a series of studies in the western hills.

Fascioliasis (liver fluke infestation) is the most important parasitic disease of cattle and buffaloes, with the major risk period of the disease being between September and February (Joshi & Shrestha, 1998), causing heavy economic losses in Nepal (Lohani & Rasali, 1995). Studies conducted at the Lumle Agricultural Research Centre have demonstrated that drenching of cattle and buffaloes strategically using broad spectrum anthelmintics (e.g. Albendazole) against liver fluke infestations in the months of February and the following October/November was an effective method of parasites control. This control strategy resulted in reduced proportion of positive fecal samples from as high as 49% to as low as 4% with significant improvement in body condition scores of the treated animals (Gautam et al., 1997; Joshi & Shrestha, 1998). The use of strategic drenching schedule was found effective to reduce the overall infection rate in treated cows in the mid hills for the whole year. However, in the low hills, it was not equally effective in controlling the infection as in the mid hills (Joshi & Shrestha, 1998).

Gastrointestinal nematode (roundworm) parasites have been a major health problem in both migratory and sedentary sheep and goats in Nepal. Based on a series of field studies, Joshi (1996) developed a set of strategic control guidelines for sheep and goats in migratory as well as sedentary flocks raised in the middle mountains and high Himalayan ranges as follows:

- Strategic application of anthelmintic drugs to prevent the high level of infection in growing lambs and kids during wet summer months from June to August, using slow release boluses.

- A dose of broad spectrum anthelmintic at shearing time during late September might be beneficial to keep the sheep free from a nematode infection and reduce weight loss during winter.

- Frequent use of anthelmintic should be avoided from an economic stand point as well as for avoiding development of resistance to the anthelmintics.

- In case of sedentary sheep in particular, anthelmintic applications need to be given over the summer months in a feed-based or mineral block based formulation.

- In case of sedentary goats in particular, the ideal approach is to use a slow release intra-ruminal bolus in June and a follow-up treatment with broad spectrum anthelmintics in late September.

**9.3 Organic ruminant production: Opportunities or challenges**

According to Lu et al. (2010) global turnover for organic farming was reported to be US$ 40 billion in 2006. It has been growing steadily in the recent years at the rate of 10-30% per year, emerging as a new agricultural opportunity. It is generally viewed as being important to sustainability in agriculture, as it tends to address some of the concerns such as environmental conservation and rural economic vitality. However, Lu et al. (2010) warns that both the producers and consumers may not necessarily understand the challenges of organic farming from an economic, ecological, or animal welfare perspective.

Like any of the new emerging issues that flare up very quickly around in the present day globalised world, the fad and fancy of organic agriculture spreading from the western world has caught the attention of both producers and consumers in Nepal in recent years. It may not be surprising anymore to spot a rural farmer considering taking on an organic farming venture of some kind. This trend also applies to livestock organic farming, especially for small ruminants. There appears to be some opportunities for an alternative production system that creates rural income generation activities through specialised niche market farming production. However, with the characteristics of very small land holdings and small-scale livestock production in the resource poor rural setting of Nepal, the challenges of meeting the stringent standards for organic certifications are daunting. In order to better understand the opportunities and associated challenges for sustainable organic ruminant production, the major components that must be considered are: personnel, livestock (animal welfare and health), facility management, environment conservation, production quality and safety, and profitability (Lu et al., 2010). The summary of organic livestock production requirements based on US Department of Agriculture standards adapted from Lu et al. (2010) are illustrated in Box 3. Even based on the lowest expected standards for a developing country such as Nepal, the basic principle of organic production of animals is *more* than the production in the naturally-raised, free-range or grass fed environments; additionally those animals which must be treated with prohibited materials cannot be called ‘organic’, as emphasised by Lu et al. (2010).

**Box 3. Summary requirements for organic livestock production**

- Pastures must be certified organic and maintained without the use of pesticides, herbicides, chemical fertilizers, or restricted materials.
- Anything fed (green fodder, hay, grains, mixed feed or pellets, and milk replacer) to the animals must be organic certified.
- Organically grown feed cannot contain synthetic hormones, antibiotics, coccidiostats, urea, or other restricted materials.
- Even the bedding which can be easily consumed by the animals must be certified organic.
- Animals intended for slaughter cannot be treated with antibiotics, anthelmintics, growth implants, or prohibited materials.
- Breeding stock can be dewormed only with Ivermectin® on the basis of fecal egg counts, but not on a routine or preventive basis and not during the last gestation or during lactation.
- Vaccinations are acceptable.

Adapted from the USDA National Organic Program of the US Department of Agriculture (Source: Lu et al., 2010).

Considering the complexity of organic livestock production in relation to the prevailing production environments in Nepal, small ruminants – especially goats – rather than large ruminants may be manageable for organic production under an environment that can be under the control of the farmers. The organic production of goat meat and cheese making can be feasible enterprises to serve niche markets, provided the standards are met for organic certification. Lu et al. (2010) asserts that organic goat production can improve animal welfare, protect the environment, and sustain rewarding rural economic vitality through premium pricing of the products. However, it is feared that conversion of traditional to organic production may lead to decreased quantity of produce, which in turn may lead to insecurity due to decreases in food availability, access, stability and utilisation. Under the production conditions of Nepal, complete isolation of organically produced goats from the prevailing environment of external contamination with prohibited materials including chemical treatment or medication of animals may be largely unavoidable. In such situation, the alternative medicine using natural materials in place of prohibited materials would be promising.

Nevertheless, in the context of Nepal, Joshi and Khanal (2012) argue that traditional livestock production systems in general have been closer to sustainable organic farming with non-existent (or negligible) use of antibiotics and chemicals and other external inputs. It is only recently that Nepal has experienced advanced veterinary services, added inputs, increased commercialisation and intensified production systems. The authors see the potential to explore the organic livestock production enterprises in some rural pocket areas that have proximity to input resources as well as the niche markets of the organic livestock products. They have highlighted the required standards, procedure and approaches for organic livestock production and discussed its potential for increasing the livestock farmers' income. The requirements for organic livestock production are considered under the headings: feedstuffs, livestock health management, livestock management and environment management. The waiting periods for certification of organic production as proposed by Joshi and Khanal (2012) are: for meat production from cattle and buffaloes-12 months, calves for meat production- 6 months and milk production from cows and buffaloes-90 days. They suggest it should take 6 months for organic meat and milk production from sheep and goats.

## 10. Major constraints to sustainable production

The general notion among experts and farmers alike in Nepal is that rural farming systems are sustainable, because they have been time-tested practices through generations. Nevertheless, the rural situation and associated factors influencing the self-sustaining, largely subsistence and mixed farming systems are steadily changing at an unprecedented rate resulting in several constraints to sustainability in livestock production systems. Some of them are listed below for consideration:

1. Traditional farming systems in rural areas of Nepal have been largely based on crop-livestock-labour interaction within a family household. Crop cultivation was recognised as the primary enterprise, and livestock production has been considered secondary to the production. Considering the extent of inputs, outputs, labour and market forces, livestock production is no longer affordable to sustain as a secondary enterprise of a household. The ever increasing cost of production of a unit ruminant within a family household is now too high to be considered as a side-line business of the farm household.

2. The current tendency of all rural youth to flee out of the country or migrate to the urban centres leaves behind no labour force to sustain the livestock production system in the rural areas.

3. The arable land available is largely allocated to staple crop cultivation, and livestock production remains dependent on the marginal land or community pastures and forest resources. Unless the livestock are provided with adequate land for growing adequate biomass to feed them, the profitable commercial production of livestock in sustainable manner is no longer feasible.

4. External inputs, air quality, water quality, and general living conditions where livestock are raised are not hygienic and are contaminated with microbes and parasites. It is almost impossible to raise livestock without a plan to treat the animals with antibiotics, anthelmintics and other chemicals for profitable production from livestock.

## 11. Conclusion

The ruminant population of Nepal dominates the livestock production in the country, and the vast majority of them are still indigenous breeds, not fully characterised for understanding their potential for sustainable production. Nevertheless, what is known is that both large ruminants (buffalo, cattle and Yak/Nak) and small ruminants (goats and sheep) play a dominant role in the rural livelihoods in their respective ecological zones, where they have been raised from time immemorial, and still have substantial populations today. Some of the alarming constraints of the ruminant production across all ecological zones are the increasing deficit in biomass production to feed them, the competing pressure of ever-increasing human population on limited land, the reduced soil fertility in the land areas, and ever-rising cost of inputs for ruminant production. Therefore, the traditional farming practices used to support the age-old subsistence nature of production can no longer be viewed as sustainable. Adoption of systematic breeding practices with control in the population and productivity of the stock, selected but scientifically tested technologies of feeds and feeding practices management and veterinary care that can support the ruminant stock as an enterprise option for viable business should go a long way in the sustainability of ruminant production in the country.

## References

Abubakar, M., Khan, H.A., Ashed, M,.J., Hussain, M. & Ali, Q. (2011). Peste de petits ruminants (PPR): Disease appraisal with global and Pakistan perspective. *Small Ruminant Research, 96,* pp. 1-10.

Brown, C. (2011). Transboundary diseases of goats. *Small Ruminant Research, 98,* pp. 21-25.

CBS (2010). Nepal in Brief. In CBS, Ed., *Statistical pocket book Nepal 2010.* Kathmandu: Central Bureau of Statistics. [online]. Available at: http://cbs.gov.np/?page_id=1079

Chhetri, B.K., Perez, A.M. & Thurmond, M.C. (2010). Factors associated with special clustering of foot-and-mouth disease in Nepal. *Tropical Animal Health & Production, 42(7),* pp.1441–1449.

CIRB (2014). *Buffalopedia.* New Delhi: Government of India, Central Institute of Research on Buffalo. [online]. Available at: *http://www.buffalopedia.cirb.res.in*.

Devendra, C. (2010). Concluding synthesis and the future for sustainable goat production. *Small Ruminant Research, 89,* pp. 125-130.

Gautam, D.C., Ghimire, S.C., Kadariya, R.K. & Rasali, D.P. (1997). February drenching against fascioliasis and its effects on body condition of buffaloes in the western hills. *LARC Seminar Paper No. 97/19*. Kaski, Nepal: Lumle Agricultural Research Centre, pp. 8.

Gongol, G.N. (2002). *Foot and mouth disease in Nepal: Technical report.* Kathmandu: National FMD Laboratory.

Joshi, B.R. and Khanal, D.R. (2012). Organic livestock production: Standards, procedures and approaches for Nepalese farmers. *Proceedings on the 10th National Veterinary Conference of Nepali Veterinary Association (VETCON'12),* 28-30 March. Kathmandu: Nepal Veterinary Association, pp. 19-24.

Joshi, B.R. (1992). The role of large ruminants. In: J.B. Abington, Ed., *Sustainable livestock production in the mountain agro-ecosystem of Nepal Animal Health Production Paper. No. 105.* Rome: Food and Agriculture Organisation of the United Nations, pp. 47-76.

Joshi, D.D. (1982)*. Yak and chauri husbandry in Nepal.* Singha Durbar, Kathmandu, Nepal: H.M. Government Press.

Ghimire, S.C. (1992). The role of large ruminants. In: J.B. Abington, Ed., *Sustainable livestock production in the mountain agro-ecosystem of Nepal Animal Health Production Paper. No. 105.* Rome: Food and Agriculture Organisation of the United Nations, pp. 77-110.

Joshi, H.D. & Shrestha, H.K. (1998). Verification of strategic drenching against fascioliasis in cattle in western hills of Nepal.*Working Paper #: 98/15.* Kaski, Nepal: Lumle Regional Agricultural Research Centre.

Kadariya, R.K., English, P.R., Roden, J.A. & Rasali, D.P. (1995) Effect of cattle urine vs 4 % urea treated rice straw feeding on milk yield, straw intake and dung output in Jersey crossbred cows in the hills of Nepal. *Ann. Zootech., 44,* pp. 347-347.

Khanal, R.C., Gurung, D.B. and Kadariya, R.K. (1997) Effect of feeding urea treated rice and wheat straw on total and straw dry matter intake and milk yield of lactating buffaloes under farmers' conditions.*Working Paper No. 97-62*. Kaski, Nepal: Lumle Agricultural Research Centre. pp.6.

Kharel, M. (1995). Yak and chauri breeding and management practices in Eastern Himalayan region of Nepal. In: *Proceedings the 2nd National Animal Science Convention, April 7-10, Kathmandu, Nepal.* Kathmandu: Nepal Animal Science Association. pp. 73-77.

Lohani, M.N. & Rasali, D.P. (1995). Economic analysis of animal diseases in Nepal. *Bulletin of Veterinary Science and Animal Husbandry, 8*, pp. 21-23.

Lu, C.D., Gangyi, X. & Kawas, J.R. (2010). Organic goat production, processing and marketing: Opportunities, challenges and outlook. *Small Ruminant Research, 89,* pp. 102-109.

MOAC (2008). *Statistical information in Nepalese agriculture 2007/08.* Singh Durbar, Kathmandu, Nepal: Agri-business and Statistics Division. Ministry of Agriculture and Cooperatives, Government of Nepal,

Moioli, B. & Borghese, A. (2005). Buffalo breeds and management systems. In: A Borghese, Ed., *Buffalo production and research*. Rome: Food and Agriculture Organization of the United Nations, pp. 51-76.

Paudel, K.C., Aryal, I.K., Osti, N.P., Bari, R.P., Karki, T.B. & Rasali, D.P. (1996). Livestock feeds and feeding systems in the western hills of Nepal. *Seminar Paper No. 97-23.* Kaski, Nepal: Lumle Agricultural Research Centre. pp. 12.

Paudel, K.C. & Rasali, D.P. (1996). Fodder biomasss production from Badahar (Artocarpus lakoocha) and effects of its feeding on lactating buffaloes. Kaski, Nepal: Lumle Agricultural Research Centre, pp. 12.

Paudyal, R.M. (1994). The Yak: An indigenous animal of Asian highland. *Veterinary Review (Nepal), 9(2) & 10(1),* pp. 13-17.

Pradhan, S.L. & Rasali, D.P. (1995). Indigenous animal genetic resources of Nepal: Potential for their balance use across ecological zones. In: R.D. Crawford, E.E. Lister, & J.T. Buckley, Eds., Proceedings of the Third Global Conference on Conservation of Domestic Animal Genetic Resources, 1-4 August, 1994, Queen's University, Kingston, Ontario, Canada. Greece: Rare Breeds International, a, pp. 120-124.

Quesenberry, P. *(1990) Handbook of animal health (Pashu swasthya aate pustak).* Translated by D.P. Rasali and K. Sharma. Kathmandu: WC/CVM and Development Communication Productions.

Rasali, D.P. (1997). Present status of indigenous buffalo genetic resources in the western hills of Nepal. In: *Proceedings of the fourth global conference on conservation of domestic animal genetic resources. Greece:* Rare Breeds International, pp. 168-170.

Rasali, D.P. & Crow, Gary, G.H. (1999). Production of buffaloes (Bubalus bubalis) in the mountains and hills of Nepal: Constraints and opportunities. In: *FAO/ILRI/ICIMOD/CIP e-conference on livestock in mountain / highland production systems: Research and development challenges into the next millennium held in October 1999.*

Rasali, D.P. (2004). Genetic analysis of association among juvenile growth and female reproductive traits in Canadian Angus cattle. PhD. Thesis. University of Manitoba.

Rasali, D.P. and Harding, A.H. (1998). Factors affecting the lactation curves in the hill buffaloes and their Murrah crossbreds raised under farmers' management in the western hills of Nepal. Nepal Agricultural Research Journal, 2, pp. 1-7.

Rasali, D.P., Joshi, H.D., Shrestha, H. and Gautam, D.C. (1998a). Assessment of the infertility situation in cows and buffaloes in the western hills of Nepal. *Working Paper, 98/40. Kaski, Nepal: Lumle Agricultural Research Centre,* pp. 16.

Rasali, D.P., Joshi, H.D., Patel, R.K & Harding, A.H. (1998b). Phenotypic clusters and karyotypes of indigenous buffaloes in the western hills of Nepal.*Technical Paper, 98/2,* Kaski, Nepal: Lumle Agricultural Research Centre, pp. 24.

Sah, A.K., Sah, S.K., Yadav, J.L. & Kaphle, K. (2012). Conception rate in repeat breeding buffaloes using hormone GnRH and mineral-vitamin mixtures under farmers managed conditions in Chitwan, Nepal. In: P. Kushwaha, Ed., *Proceedings on 10th National Veterinary Conference (VetCon'12). Kathmandu: Nepal Veterinary Association,* pp. 51-56.

Subba, D.B., Tamang, P.M. & Tamang, B.B. (1994). Seasonal variation in the proximate principles of some common tree fodders in the Eastern Hills of Nepal. *Veterinary Review (Nepal), 9(2)&10(1),* pp. 23-26.

Thakuri, K.C. (2012). *Status of animal disease outbreak and identification of provisional disease free zone/Area.* Tripureshwor, Kathmandu, Nepal: Veterinary Epidemiology Centre Directorate of Animal Health.

Vishwakarma, O.P. and Rasali, D.P. (1996). A case-study of buffalo ghee pro*duction and its marketing in three hill districts of Lumbini zone of Nepal. In: Vol. 2: Free communication papers: Proceedings of the 8th AAAP Animal Science Congress (October 13-18). Tokyo: Japanese Society of Zootechnial Science, 980-981 pp.*

# Theme II:
## Natural Resources and Sustainable Livelihoods

8

# Community Forestry: In the Context of Changing Rural Dynamics in Nepal

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## Abstract

This paper provides a review of community forestry (CF) in Nepal in the context of changing rural landscapes. The results show that CF policies and programs are still supporting rural livelihoods and promoting grassroots democracy in Nepal. The relationship between its people and the forest has taken a new shape due to rapidly transforming rural economic and demographic situations. A host of factors including commercialisation, urbanisation, migration, and monetisation of the rural economy has affected changes in rural livelihood patterns. These changes have made it challenging to adapt the policy and regulatory structure of CF in Nepal quickly enough to keep pace. There is a need for reorientation of the conceptualised uses of forests and forestlands, and greater policy sensitivity towards poverty and hunger among the rural Nepalese. Further participatory action research that explores CF land production processes, institutional mechanisms and market arrangements may help increase relevance of CF for leveraging livelihood options for the rural people in Nepal.

Keywords: Community Forestry, Rural Livelihoods, Policy, Rural Landscape, Nepal.

## 1. Introduction

Community Forestry (CF) has been a flagship programme in Nepal for several decades and is globally recognised for its ability to conserve forests, support local livelihoods and institutionalise grassroots democracy (MoFSC, 2013; Thoms, 2008; Timsina, 2003). However, with the rapidly changing rural landscapes in Nepal, a debate on the scope and prospects of CF has intensified (Agrawal, et al., 2013; Basnett, 2013; MoFSC/FAO, 2008). Given this situation, the CF programme that was started in the early 1970s should be transformed to be a better fit with the changing rural economy, society and environment.

The paper aims to discuss some frequently raised questions on the new role of CF. These questions include: How is CF evolving in relation to changing forest-people interfaces? How is the rural landscape changing over time? How can CF be more relevant to changing rural dynamics? In order to answer these questions, this paper reviews published and grey literature to examine the evolution of CF in Nepal, the emerging elements transforming the rural landscape, and the gap observed between the potential and actual contributions offered by CF to rural livelihoods.

## 2. Evolving people-forest interfaces

Forest ecosystems are intricately related to agriculture, especially for rural agrarian economies where traditional integrated farming still dominates (Mahat, 1987; Malla, 2000; Paudel, 2005; Regmi, 2006). Apart from producing timber for construction and building materials, the forest supports agricultural production in a variety of ways, including supplying Non-timber Forest Products (NTFPs) such as wild fruits, vegetables, medicinal plants, fodder for livestock and providing a source of mulch and composting/bedding materials to maintain soil fertility (Figure 1). Forests play a critical role in supporting agriculture and thus food security in Nepal.

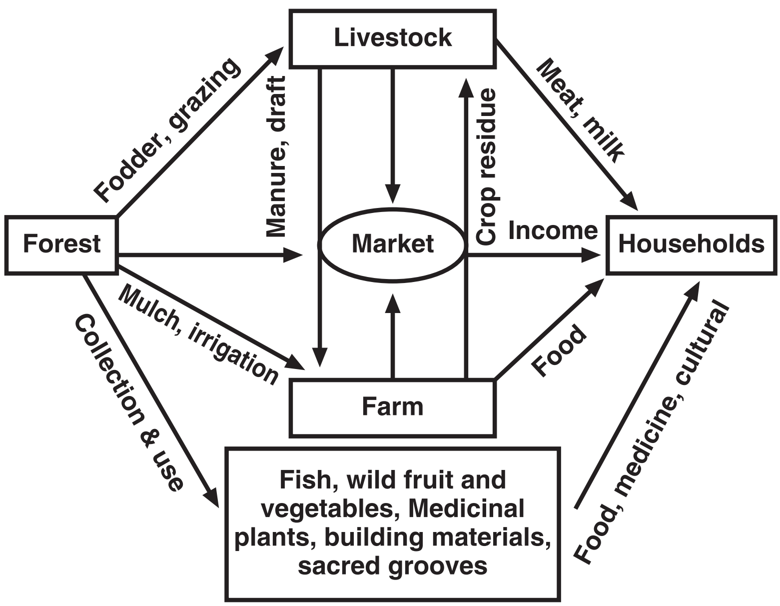


Figure 1: Relationships between the forest and agriculture under the traditional farming systems of Nepal (Source: Adapted from Paudel, 2005).

### 2.1 Evolution of community forestry

Participatory and community based forest management in Nepal began in the late 1970s; however, these initiatives were not formalised through relevant legislation until in the early 1990s. The Ninth Forestry Conference in 1974 created a unique environment to openly discuss the issue of increasing deforestation and its potential root causes. Subsequently, the National Forestry Plan (1976) was the first policy document for comprehensive forest management in Nepal. This plan supported the need to involve local people for forest management. According to this plan, the Forest Act 1961 was amended in 1977 to make arrangements facilitating the 'handing over' of forest management responsibilities to the local governments (called Village Panchayat[1]). In line with 1977 amendment to the Forest Act, Panchayat Forest and Panchayat Protected Forest Rules 1978 were established to further strengthen and enact CF in Nepal (Fox, 1993; Gautam, 2006; Joshi, 1993). The emergence of participatory discourses and increased international pressure for the devolution of state authority led to the enactment of the Decentralisation Act in 1982, which further empowered the Village Panchayats in managing forests (Regmi, 1984).

A decentralised approach that empowered a locally elected body such as the Village Panchayat did not work well as it could not provide a robust institutional framework for resource management and utilisation. The Panchayat system could neither provide a stable platform for resource use nor provide tenure security for the local people. Indeed, few use rights were transferred to the Panchayats and those transferred rights often proved to be a bundle of responsibilities rather than the opportunity itself. These experiences helped convince the early CF leaders to advocate for the transfer of tenure rights directly to local communities. In the meantime, several persons within the Nepalese government were looking for an innovative approach that could better protect the forests. The First National CF Workshop organised in 1987 provided an opportunity to reflect upon the ongoing process and experiences on CF practices. Piloting, experimentation, and sharing of early results encouraged further expansion of the concept and practice of CF (Kanel & Acharya, 2008; Ojha & Kanel, 2005). Following on this, the Nepalese government enacted the Master Plan for the Forestry Sector in 1988 (HMGN, 1989). The Master Plan articulated the situation and supported legitimising local people's subsistence use of forests, recognised user groups as key institutions in the management of forests, projected a clear plan for handover of all accessible forests to the communities, and redefined the role of forest authorities as facilitators.

A 1990's political change replaced the Panchayat system with a multi-party parliamentary system. The new Parliament passed a Forest Act in 1993 that legalised CF and recognised community forest user groups (CFUGs) as self-governing, autonomous, corporate institution, so that they could acquire, possess, transfer, or otherwise manage movable or immovable property (HMGN/MoLJ, 1993: Article 43). The CFUGs were entitled to receive all the benefits from the management of their forest. The Act stipulated that the District Forest Officer (DFO) could handover forests to identified CFUGs "who are willing and capable of managing any part of national forests" (HMG/MoLJ, 1993). The Act was later operationalised by the 1995 Forest Regulations, Operational Guidelines, and Directives. CF policies and practices in Nepal were also shaped by frequently organised National CF Workshops, Conferences (DoF, 2008; Kanel & Acharya, 2008; Ojha & Kanel, 2005), the government's five-year Development Plans (NPC, 1997, 2002, 2007), and donor agency strategies (Kanel & Acharya, 2008; Ojha, 2011).

[1] Panchayat was an archetypal party-less political system abolished after the popular political movement.

Today, over 17,685 CFUGs covering about 35% of the total population are managing almost 1.6 million ha of forest area across the country (DoF, 2011). It has been claimed that the CF programme has converted the heavily denuded Nepalese hills into green and healthy forested areas, which has increased the availability of daily forest products for rural inhabitants (Sharma, 2010; Shrestha & McManus, 2006). Local communities have also benefitted by utilising the revenue generated from CF in community infrastructure such as roads, schools, irrigation, drinking water supplies, and basic social services (MoFSC, 2013).

## 3. The changing rural landscape

Over the last two decades, rural dynamics have been changing in a manner that has significantly influenced people-forest relations. Some important changes include: commercialisation, urbanisation, monetisation, migration, deagrarisation, and feminisation. These changes have diverse implications on the future of CF in Nepal.

**3.1 Commercialisation:** Commercialisation of agricultural, livestock, and forest products has been growing mainly in Terai and along the roads in the hills. Encouraging policy provisions such as the adoption of a more liberal economic policy after 1990, had multiple effects. The Agricultural Perspective Plan (APP) that began in 1995 (APROSC & JMA, 1995) also had an influence by transforming subsistence farming into commercial agriculture (Nepal & Thapa, 2009; Shrestha, et al., 2008). As a result, commercialisation has become emerged slowly in certain geographic areas and in some sectors. In areas surrounding the big cities and along the corridors of national highways, people have become involved in specialised market production. Producers' organisations, particularly commodity-based cooperatives, small collectors, and dairy companies are involved in marketing vegetables, dairy products, and high value commodities such as cardamom, ginger, NTFPs, and herbs (Pandit, Albano, & Kumar, 2008). However, rural producers still mainly supply the primary raw materials while urban traders supply the value-added manufactured goods and services to the rural areas. Consequently, urban traders reap a major portion of the increased value of these products (Dhital, 2004; Paudel et al., 2009; Regmi & Garforth, 2010). Increased opportunity to market these products can be attributed to a host of reasons, such as the expanding road network, other infrastructure growth, remittance leading to a wider circulation of cash, and growing markets.

**3.2 Urbanisation:** Nepal has experienced rapid urbanisation in recent years although it remains one of the least urbanised countries in the world. The urban population of Nepal was only 2.9% in 1954; it had increased to 13.9% in 1991 and is 36.8% today (CBS, 2014). Similarly, the number of municipalities has substantially increased since 1991 (from 33 to currently 191). In addition, smaller towns/business centres are emerging together with extended rural roads to existing and potential agricultural areas. The growing urbanisation has put pressure on the rural economy by siphoning cash from rural areas. As well, the rural population is increasingly using health, education, and communication services to which they formerly had limited access. The growth of urban centres is supposed to create markets for rural produce, but as in many other countries, the Nepalese urban markets are dominated primarily by imported goods or goods manufactured in few urban centres (Dhital, 2004). Apart from a few small areas containing vegetables, poultry and dairy farms, farmers in most rural areas have not benefited from the growing urban markets.

**3.3 Monetisation:** Monetisation generally refers to a situation where goods and services are sold for cash rather than bartered (Pailwar, 2012). The Nepalese rural economy has been experiencing rapid monetisation that is replacing the traditional barter system. Increasing commercialisation of goods and services contributes to local market development; however, it is a matter of concern in areas where there are little or no activities to compensate for the outflow of cash or to replenish it for increasing consumer demands. Agricultural intensification, expanding banking services, remittance, and flooding of consumer items in the market place have supported rapid monetisation of the rural economy in Nepal (Muzzini & Aparicio, 2013).

**3.4 Migration:** There have been three major types of migration in Nepal: Hills-Terai, rural to urban, and temporary labour migration abroad. While different drivers may have induced the specific type of migration, the search for better economic opportunities and employment are central to all of them. The early phase of the Hills-Terai mass migration started in the 1950s when rapid population growth in the hills led to food shortages, with a vicious cycle of poverty and environmental degradation due to farming on steep slopes endangering fragile mountain ecosystems (Blaikie & Brookfield, 1987; Eckholm, 1976). Devastating floods and landslides in the hills further contributed to the environmental degradation (Massey, Axinn, & Ghimire, 2010). Consequently, the Nepal government encouraged migration through a resettlement programme that continued at a volunteer level even after the formal programme ended (Gurung, 1989). Rural to urban migration continues to grow with increasing access to urban opportunities (e.g., employment, health, security and educational facilities) (Kollmair, Manandhar, Subedi, & Thieme, 2006). In recent years, temporary migration to international labour markets in the Gulf countries[2] (mainly in Qatar, Saudi Arabia, and United Arab Emirates) and Malaysia has increased substantially (Kollmair et al., 2006; Sharma, 2012).

*3.4.1 Deagrarisation:* Despite its critical importance to the food supply and income for millions of Nepalese, agricultural growth has virtually stagnated for the past two decades (Karkee, 2008). Consequently, the percentage of the population involved in agriculture has decreased from 90% in the 1980s to 64% in 2014 (Satyal, 2010; UNDP, 2014). The growing economic value of land, especially in urban, peri-urban and increasingly along the highway areas, has seriously hampered agricultural growth. This is compounded by the changing aspirations of the younger generation who want to escape from agriculture (Gartaula, Niehof, & Visser, 2012). Migration of the able and economically active male population from the villages, low agricultural productivity in relation to investment for inputs (fertiliser, labour, and capital), and lack of critical infrastructure such as irrigation and supportive agricultural market

2 Gulf countries include seven Arab States which border the Persian Gulf: Kuwait, Bharain, Iraq, Oman, Qatar, Saudi Arabia and the United Arab Emirates (Henderson, 2014).

mechanisms have all contributed to the decline of agriculture (Deshar, 2013). Recent male migration in search of jobs abroad and movement of their immediate family members to cities has led to more land being fallow in the rural hinterland (Tamang, Paudel, & Shrestha, 2014).

*3.4.2 Feminisation:* Due to the overwhelming migration of young males starting in the mid-1990s, women as well as older males and children have become the main agricultural labour force in most Nepalese households (FAO, 2010; Tamang et al., 2014). Consequently, women are increasingly involved in farming, forest management, looking after their families and managing social affairs (Basnett, 2013; Giri, 2012; Tamang et al., 2014); however, women have limited control over the necessary resources such as land and land-based resources. Hence, they face critical constraints in making strategic decisions. Although this paper presented some of the issues in relation to gender dynamics and feminisation, this paper has not explored in detail the influence of feminisation on community forestry. This is a limitation of this paper.

### 3.5 Livelihoods diversification

Livelihoods diversification is the norm in most of the cases. Today, there are hardly any households drawing solely from any single source, or hold their wealth in any single form or invest it to any specific area (Barrett & Reardon, 2000).

Adoption of multiple sources of livelihoods is generally caused either by the need or the opportunity created by changing access to technology and markets. Traditionally, need-based livelihood diversification was induced by rural population growth, fragmentation of farmlands, declining farm productivity, and greater agricultural risks. Decreasing access to productive lands and associated resources has been the key phenomena (Barrett & Reardon, 2000; Ellis, 2000). There are equally compelling social and cultural reasons for looking at diversification apart from agriculture. Escaping agriculture is regarded as an indication of development and modernisation, particularly among the youths (Gartaula et al., 2012). Nevertheless, there are few encouraging cases where youth entrepreneurs, especially those returned from their overseas work, have become involved in new business, especially in agricultural activities (Chalise, 2014; Sedhai, 2014; Tiwari, 2014).

In recent years, people in rural areas of Nepal have adopted diverse economic activities both on-farm and off-farm. The first category includes a shift from conventional farming of staple crops to cash crops (e.g., vegetables, fish, dairy, poultry, timber and non-timber forest products, ecotourism, and agricultural wage labour). The second category includes non-agricultural wage employment, small business, and cash transfers in the form of social security, which plays strong role in diversifying livelihoods (Gauli & Hauser, 2009; Nepal, 2012; Regmi, 2006; Upreti et al., 2010).

Not all socio-economic groups of people have enjoyed the opportunity to diversify their livelihoods. Poor people have difficulty investing in off-farm activities. They have either low levels of education reducing employment opportunities outside the farm or limited access to networks and information that can be instrumental in providing support to business or employment. Members of poor households cannot invest in value chain optimisation based on contractual overseas jobs. They have access only to the low paid labour jobs in Nepalese towns or in Indian cities. Moreover, not all diversification initiatives are helpful in addressing food scarcity and poverty. For example, the shift to cash crops has made farmers more vulnerable to international markets and price fluctuations (Pant & Panta, 2009; USAID, 2011). Likewise, unsustainable harvesting of NTFPs has led to unsustainable management of resources overall (NFA, 2009). Remittance and cash transfers have increased dependency on outside sources and in some cases has minimised the motivation and incentive to work in agriculture (Gartaula et al., 2012).

## 4. Changing rural landscape: Consequence for people and CF

Changing rural dynamics has brought forward diverse repercussions on CF management. Commercialisation, urbanisation, monetisation, and migration has contributed to increase cash flow that has changed lifestyles and increased purchasing power of many households. Moreover, there is a substantial increase in housing due to expanding cities and newly bourgeoning towns along roads. Consequently, there is substantial increase in timber demand both for construction and furniture, causing the price of timber to dramatically increase.

Historically, rural people throughout Nepal have relied heavily on wild products for food, fibre, and medicine. Along with increasing purchasing power and changing lifestyle, wild products (e.g., food, fibre, and medicine) have begun to be recognised as having high social value. Wild mushrooms, wild fruits and wild vegetables, for example bamboo shoots, fetch a high price in Kathmandu and other urban centres. With increasing media focus on pesticide use for agricultural products, people are placing higher values on natural products. Unfortunately, there is limited research on the current level of harvest, consumption, and trade of these products in Nepal.

Similarly, animal husbandry has been gradually shifting towards commercial enterprises. In particular, poultry, goat, dairy cattle, and buffalo have been flourishing along the roads and in certain other areas with good access to markets. The substantial increase in the price of milk, goat and buffalo meat, and increasing cooperatives and private companies in dairy processing have expanded market access for animals and animal products (See Chapter 7 of this book by Rasali). As animal feed is increasingly expensive, farmers want to substitute green grass and fodder. As a result, the role of CF in providing grass and fodder has become more important.

Increasing income, urbanisation, changing lifestyles and a growing interface with the outside world has resulted in increased recreational values of the forests and natural areas in Nepal. Community forests, especially surrounding the Kathmandu valley and major cities, have begun to attract tourists. For example, in 2011, the Baghmara CF in Chitwan earned Rs. 8.7 million from 78,000 visitors, Jamunbari CF in Jhapa earned Rs 2.5 millon from 13,000 visitors and Kankali CF in Chitwan earned Rs 1.0 million from 15,000 visitors (Paudel & Ojha, 2013).

# 5. Prospects of CF contributing to rural livelihoods

In view of the changing rural dynamics, CF can provide a range of direct and indirect products and services that contribute to food security and livelihoods.

## 5.1 Wild food and edible items from CF

Given the rich ecological and biological diversity in Nepal, its forests provide a wide range of wild fruits, vegetables, mushrooms, honey, fish, insects, animal products, and starchy root crops particularly *Dioscorea sp. (Tarul, Githa, Vyakur).* Wild foods are tasty, nutritious, and valuable, particularly to the poor, during difficult economic times (Paudel et al., 2014).

Historically, there has been a rich culture of managing, harvesting, consuming and even selling these products in local markets. However, management interventions in CF are generally oriented to managing trees (e.g., thinning, pruning, weeding, and construction of fire lines). The CF policy and regulatory framework is largely silent with respect to conserving, managing, and utilising valuable wild food products. In addition, farming-related activities are strictly prohibited on CF lands. Some of the legal provisions highlighted below strongly discourage management of edible items in forests that could otherwise have directly contributed to local food security.

- If a User Group desires to plant any cash crops *other than food crops* which yield products for a long time without adversely affecting the crown cover and production of forest products, the details should be included in the work plan (GoN, 1995: Article 28).

- Any clearance of forest areas for *agricultural purposes,* building any huts and houses, and taking any action that may cause soil erosion is prohibited (GoN, 1995: Article 31/1).

- *No agricultural crop* can be grown in CF land. However, cash crops such as fodder, grass, cardamom, broom grass, medicinal plants, and fruit trees can be grown in land allocated to identify poor households (MoFSC, 2009: 45).

- Perennial plants *other than food crops,* such as bamboo, fruits, and NTFPs can be grown in CF under the conditions that would not affect the density and production of the main forest products (MoFSC, 2009: 48).

- *No cereal crop* (e.g., rice, maize) and those crops which involved tilling of land (e.g. ginger and turmeric) can be grown on CF land (MoFSC, 2009: 55).

## 5. 2 Enhancing agriculture through increased forest-farm interface

Historically, rural communities in Nepal relied heavily on forests for basic forest products such as grass, fodder and fuelwood that formed the basis of forest-farm linkages (Bajracharya, 1983; Bartlett & Malla, 1992; Fox, 1993; Karki, 2002; Mahat, 1987; Metz, 1989). Forest policies in the 1970s and 1980s acknowledged the intricate relationship of forest management and agriculture (HMGN, 1989).

One of the important ways of linking the forest and farms is through livestock. The numbers of livestock per household varies by the economic status of the household; normally poor people own less. A national survey on CF contributions to livelihoods found that the extremely poor group had lower numbers of households with livestock (84%) than relatively better off groups (95%). Also, high proportions of better off groups stall-feed their livestock (64%). There was a predominance of stall-feeding (about 57%), with about 27% of households using both grazing and stall-feeding across all well-being groups (MoFSC, 2013).

Similarly, leaf litter is one of the important forest inputs to farming, vital for maintaining soil fertility and texture. Although people, particularly in accessible areas, are increasingly using imported chemical fertilisers, many cannot access a supply of fertiliser or afford it when it is available. Most of people use a combination of organic and chemical fertilisers. An analysis shows that Dalits and Janajatis tend to rely more on farmyard manure (MoFSC, 2013).

While rural livelihoods have changed considerably, livestock enterprises (mainly goat, dairy cattle and buffalo farming) continue to expand. However, the current CF policies and programme priorities have not adequately appreciated the intricate relationships between the forest and farms (Dhakal, Bigsby, & Cullen, 2010). The Forest Sector Master Plan encouraged “reducing and controlling livestock numbers” of mountain farmers (HMGN, 1989) even though livestock farming was the basic engine of mountain economy (Dhakal et al., 2010).

Analysis of the rules of 24 CFUG's in Kavre and Lamjung on grazing and fodder management revealed a very low appreciation of the intricate forest-farm relationships in the CF management (Khatri, Paudel, Shrestha, Ojha, & Paudel, 2014). According to this study, grazing was prohibited in almost all CFUGs, with fines imposed in case of violations. However, a few CFUGs have provisions for rotational grazing in specified forest areas. These forests are either pine forests or Sal forests. An analysis of the forest management activities of these CFUGs shows that they emphasised only forest trees for plantations and other silvicultural operations. There were no activities for plantations or management of fodder trees, grass, or grazing zones. These findings are not atypical. Overall, there is narrow focus on fodder trees in CF management (Paudel et al., 2013). Consequently, promotion of CF institutions in the hills of Nepal has resulted in a decrease in the number of livestock (Adhikari, Williams, & Lovett, 2007; Dhakal et al., 2010; Thoms, 2008). As a result, the large tracts of forestland provide little support for livestock management compared to its potential to do so.

### 5.3 Forest-based income and employment

Forest-based income and employment generation is another important approach to enhance food security of forest dependent people. While there are multiple streams of benefits from CF, timber is the key economic product especially in Terai and the hills. Timber has remained an important source of government revenue since the 1950s. Analysis of the government's forest sector revenue for the last 15 years shows that more than 80% of the revenue to both government and CFUGs comes from the sale/distribution of timber (Banjade, 2012). For example, wood products represented over 90% of the total forestry sector revenue in 2008/09. The timber-based industries including plywood, veneer, katha (catechu), sawmills and furniture generated employment for over 150,000 people in Nepal (Bhatta, 2011). Another study in the Tanahu district also showed that timber was the most significant product of CF (Pokhrel, 2010). A nationwide study (G. Paudel et al., 2013) revealed that the total annual allowable harvest (AAH) of Nepal's CFs was about 11 million cubic feet (311 thousand cubic metres). If all of the AAH was harvested and sold at the current market price it could generate NRs 27 billion revenue and 21,000 jobs annually.

The high potential for timber management in CFs has not fully realised for various reasons. Firstly, the policies and procedures for timber harvest and sale are complex and tedious requiring frequent visits to DFO for permission (Mahapatra, 2001; Nagendra, 2002; Neupane, 2000). Secondly, the process of determining annual increment and annual allowable cut (AAC) of timber in CFs is conservative. Thirdly, the government's ad hoc policy decisions (e.g., blanket ban on timber harvest) are unpredictable and often restrictive. Such restrictions may prohibit CFUGs from removing timber identified in their operational plan (OP) for harvesting. Finally, many forest technicians, CFUGs, and the general public have a protection orientation and prefer lower levels of timber harvest.

The CF OP is the key document prepared by the CFUGs. It is approved by the DFO and guides and regulates forest management activities (GoN, 1995: Rules 28; HMGN/MoLJ, 1993: Article 25). The OP contains the basic information on the forest (history, area, map, type, aspects dominant species, biodiversity, major forest products etc.), some specific forest-related data (blocking, calculation of block-wise forest inventory data: growing stock, annual increment, calculation of annual allowable harvest level, etc.), and management prescriptions (silvicultural operations). Approved approaches for calculating growing stock, annual increment and AAC areas are vague in places and therefore invite potential misuse.

The CFUGs have to go through a series of application and approval process involving: application to DFO for marking, DFO's decision for marking, marking in the field, CFUG's application to DFO for a harvesting permit, issuance of a harvesting permit by DFO, and harvesting and logging in the field. Additional processes involved in the sale of timber include paper work for auction, permission for auction, permission for transport, grading, certificate of origin, quantity and quality, etc. Every step for timber harvesting and trade must go through Range Post to the Ilaka Forest Office[3] and finally to DFO for approval. This multiple-layered administrative process often results in delays in document processing. Given the unequal power between the DFO and the CFUGs, these steps can incur huge transaction costs and delays, sometimes even involving corruption.

As described above, the scientific norms and the bureaucratic practices that are coded in the forest regulatory provisions have seriously constrained harvesting of forest products that limit the potential of CFs in generating income and employment.

3 Administrative unit of District Forest Office comprising of several range posts of a certain area.

## 6. Exploring the relevance of CF

Although lack of food is a historical phenomenon in Nepal, it has become increasingly severe in recent years when larger numbers of people experienced food scarcity for longer periods than in the past. While acute food scarcity may be limited to few social groups in specific geographical regions, the problem of malnutrition is much wider nationally. Rural poverty is higher in areas where land is the primary source of livelihoods and over 76% of the households are engaged in agricultural activities (CBS, 2012). Hence, lack of food security and hunger is more chronic in the hills and mountains, and has been increasing in recent years. At least 33 districts (out of 75 in total) are marked as food insecure; most of them are in the mid and far western hills and mountains (MoAC & WFP, 2011). In these areas, almost 80% of the household income is spent on food items and yet over 40% of the children under 5 years of age are stunted due to malnutrition. Moreover, as staple food (e.g. lentils, rice, and vegetable) constitutes 72% of the diet, current intake is highly imbalanced and nutritionally poor[4] (NPC, 2013).

Access to productive land is the key indicator of economic status in rural households. However, access to agricultural land has been gradually decreasing. For example, the number of households with landholdings of <0.1 ha, <0.5 ha and <1 ha increased from 1996 to 2011 and the number of farmers with greater than 1 ha of land decreased during the same period (CBS, 1996; CBS, 2004; CBS, 2012).

There exists a strong correlation between poverty and food insecurity. For example, 25% ofhouseholds in the lowest expenditure quintile have poor food consumption compared to only 1% in the wealthiest group. While 86% of the poor have a very high staple diet, only 10% of the wealthy have such poor diet (NPC, 2013).

Agriculture, the mainstay of rural livelihoods is gradually changing. The decreasing area of the farmland and declining productivity are the two key challenges for producing food. First, due to faster population growth than growth in food production and access to land resources has decreased. The holding sizes are getting smaller primarily due to division of parental land among offspring. Also, farmland is being reduced by erosion, landslide, urbanisation, and conversion from farm to non-farm purposes. Secondly, farm productivity of all key products is quite low and is declining. For example, the average productivity of agriculture, fisheries and forest-related activities in Nepal are currently quite low compared to its neighbours (ADB, 2011). Broader use of community forestlands and resources thereon may provide some solutions for addressing the food scarcity problem.

## 7. Gap in knowledge, policy and everyday practice of CF

The successful CF programme on the one hand and the increasing chronic problem of food scarcity on the other appears ironic given the prospects being offered by CFs and the proven success of the traditional integrated forest-livestock-crop production system intertwined with CFs, especially in the Nepalese hills. Despite this historical relationship, Nepalese forest policies and practices have not supported this traditional farming system.

[4] In a developed country, staple food constitutes only 30% of the daily diet (FAO, 1996).

The notion of 'forest', as developed in Western Europe, represented a special category of land that was largely managed for power, pleasure, and rentals by the kings and nobles, often excluding the common people. It had little to do with nature or ecology and was used mainly to represent the symbolic relations of power, where some enjoyed privilege and others were excluded (Fay & Michon, 2005). This narrow notion of 'forests' was applied to large landscapes bringing them into a legal category that suited the dominant political and economic interests of the time. This definition of forest as a legal category helped states to shape particular social relationships with natural resources and the people dependent on it. It narrowly valued trees, above-ground vegetation, and biomass which gradually became an ideology that could neither respect the ecosystem integrity nor the socio-economic and cultural values of any society (Michon, de Foresta, Levang, & Verdeaux, 2007). That definition of a forest often considered agriculture and its associated activities and actors such as peasants and local communities as the enemy (Westoby, 1979).

Following in this tradition, Nepal's forest sector also appears to have conceptualised forests narrowly, limiting itself to forest stock, crown cover, biomass, and biodiversity in the broadest sense. Forest authorities generally appear to be little concerned with the wider economic and social dynamics and usually do not assume responsibility for addressing the socio-economic objectives of local poor and women (Malla, 2000; Malla, Neupane, & Branney, 2003) and supporting local and national economies that could be induced through the judicious use of common forest resources (Kennedy, Thomas & Glueck, 2001). Consequently, forests are not fully accessible and supportive of agricultural activities. This gap has limited the full potential of CFs in meeting food security and livelihoods of local communities.

## 8. Conclusions and recommendations

The purpose of  paper was to analyse CF evolution, rural landscape transformative elements, and potentials of CF to support rural livelihoods in Nepal. CF in Nepal has evolved towards supporting rural livelihoods and promoting grassroots democracy. However, there have been changes in rural livelihood patterns over the last few decades, influenced by a host of factors, (e.g. commercialisation, urbanisation, migration, progressively monetisation of rural economy, and consumerism). Although there has been transformation of the rural socio-economic landscape and diversification of livelihoods, food scarcity has remained a critical challenge in rural areas, especially in the hill and mountain regions. Farmland fragmentation, shrinking access to productive land and declining farm productivity, increasing population, and limited access to farm inputs are the major reasons for declined production. This is coupled with much wider issues of poverty, powerlessness, and limited livelihoods among a significant portion of the population in Nepal.

CFs are important common land-based resources, involving almost 35% of the rural households who have limited livelihoods options. Management of these forestlands and resources may provide good prospects for addressing the food scarcity problem. Empirical evidence increasingly suggests that management of timber, NTFPs, and enhancing recreational values, and other ecosystem services including wild food can potentially address the problem of food security, improve nutrition for the rural poor, and promote income generating activities. Conservation and management of wild food, enhancing the farm-forest interface to support agriculture, and increasing forest-based income and employment are three available strategies to link CFs with food security.

Even though CF is constantly evolving, current policy and practices are still hindering the development of CF towards meeting the livelihood needs of rural communities in Nepal. This situation can be partly attributed to the deep-rooted narrow conceptualisation of the Western notion of ‘forests’ on one hand and the insensitivity of the policy makers and local leaders towards the intricate forest-farm-people interface on the other. Consequently, forestlands that occupy about 40% of Nepal’s landmass, have not been contributing greatly to the resolution of the socio-economic problems of the country.

Conventional forest management science does not adequately appreciate the productive and sustainable relationships possible in a forest-farm system. As a result, the regulatory provisions of CF are not supportive of producing and managing wild food, increasing the forest-livestock-farm link, and increasing forest-based income and employment for local poor. Rather, the existing regulatory provisions narrowly aim at enhancing forest stock, crown cover and biodiversity. Interestingly, the regulatory provisions appear restrictive even for the management of timber, which can potentially provide opportunities for income and employment for the local poor.

Although CF has been globally recognised for its ability to conserve forests, support local livelihoods and institutionalise grassroots democracy, it still needs to be transformed to better fit with the changing rural economy, society and environment. In general, there is a need for reorientation of the conceptualisation of forests and forestlands, and greater policy sensitivity towards poverty and hunger among citizens in Nepal. At the practical level, proven resource management models and an institutional arrangement that visibly increases the productivity of CF without compromising the long-term sustainability of the landscape should be in place. Long-term, participatory action research that explores production processes, institutional mechanisms and market arrangements may help increase CF relevance for enlarging the livelihood options for the poor rural people in Nepal.

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## References

ADB. (2011). *ADB 7762-NEP Inception Report, Assessment Report: Technical assistance for the preparation of the Agricultural Development Strategy*. Manila, Philippines: Asian Development Bank (ADB).

Adhikari, B., Williams, F., & Lovett, J. C. (2007). Local benefits from community forests in the middle hills of Nepal. *Forest Policy and Economics, 9(5),* pp. 464-478.

Agrawal, A., Cashore, B., Hardin, R., Shepherd, G., Benson, C., & Miller, D. (2013). *Economic contributions of forests. Background paper prepared for the United Nations Forum on Forests AHEG-2 Meeting in Vienna, Austria, January 13-17, 2013.* New York, USA: United Nations Forum on Forests.

APROSC & JMA. (1995). *Nepal agriculture perspective plan (Final Report)*. Kathmandu: Agricultural Projects Services Centre (APROSC) and John Mellor Associates (JMA).

Bajracharya, D. (1983). Fuel, food or forest? Dilemmas in a Nepali village. *World Development, 11(12),* pp. 1057-1074.

Banjade, M. R. (2012). Discourse and discursive practices over timber in Nepal. *Journal of Forest and Livelihood, 10*(1).

Barrett, C. B., & Reardon, T. (2000). *Asset, activity, and income diversification among African agriculturalists: Some practical issues, project report to USAID BASIS CRSP*. Madison: University of Wisconsin, Land Tenure Centre.

Bartlett, A. G., & Malla, Y. B. (1992). Local forest management and forest policy in Nepal. *Journal of World Forest Resource Management, 6,* pp. 99-116.

Basnett, B. (2013). Taking migration seriously: what are the implications for gender and community forestry?. [online]. Available at *:http://www.cifor.org/publications/pdf_files/infobrief/4183-infobrief.pdf. Info brief no. 65. Retrieved 28 February 2015.*

Bhatta, S. (2011). Timber worth two billion unattended. *Nagarik Daily,* Kathmandu: Republic Media.

Blaikie, P., & Brookfield, J. (1987). *Land degradation and society.* London: Methuen.

CBS. (1996). *Nepal living standards survey (1995/96).* Kathmandu: Central Bureau of Statistics (CBS), Government of Nepal.

CBS. (2004). *Nepal living standards survey (2003/4)*. Kathmandu: Central Bureau of Statistics (CBS), Government of Nepal.

CBS. (2012). *National population and housing census 2011.* Kathmandu: Central Bureau of Statistics (CBS), Government of Nepal.

CBS. (2014). *Population monograph of Nepal Vol I: Population dynamics.* Kathmandu: Central Bureau of Statistics (CBS), Government of Nepal.

Chalise, B. (2014). Remittance and its effect on entrepreneurial activities: a case study from kandebas village development committee, Nepal. *Izmir Review of Social Sciences, 2(1),* pp. 59-74.

Deshar, B. D. (2013). An overview of agricultiural degradation in Nepal and its impact on economy and environment. *Global Journal of Economic and Social Development., 3(1),* [online]. Available at: *http://www.ripublication.com/gjesd/gjesdv3n1_01.pdf. Retrieved 25 October 2014. pp. 1-20.*

Dhakal, B., Bigsby, H., & Cullen, R. (2010). Forests for food security and livelihood sustainability: policy problems and opportunities for small farmers in Nepal. *Journal of Sustainable Agriculture, 35(1),* pp. 86-115.

Dhital, R. (2004). Rural urban agriculture market system: challenges and opportunities a case study: Eastern Nepal. Masters Dissertation, Yale School of Forestry and Environmental Science.

DoF. (2008). English brochure: The 5th national community forestry workshop. [online]. Available at: *http://www.forestrynepal.org/images/Workshop%20Brochure%20%28English%29.pdf. Retrieved 25 October 2014.*

DoF. (2011). Status of Community Forests, Kathmandu, Nepal: The Department of Forests (DoF).[online]. Available at: *http://dof.gov.np/image/data/Community_Forestry/cfdatabase.pdf. Retrieved February 28, 2015.*

Eckholm, E. P. (1976). *Losing ground: environmental stress and world food prospects (1st ed.).* New York: Norton.

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries.* Oxford: Oxford University Press.

FAO. (1996). *Declaration on World Food Security.* World Food Summit, Rome: Food and Agricultural Organization (FAO).

FAO. (2010). *A rapid situation assessment on agriculture and migration in Nepal.* Food and Agriculture Organization of the United Nations. Kathmandu, Nepal: Food and Agricultural Organization (FAO). [online]. Available at: *.ftp://ftp.fao.org/TC/CPF/Country%20NMTPF/Nepal/thematic%20studies/Migration%20_Final_.pdf. Retrieved 25 October 2014.*

Fay, C., & Michon, G. (2005). Redressing forestry hegemony: when a forestry regulatory framework is best replaced by an agrarian one. *Forests, Trees and Livelihoods, 15(2),* pp. 193-209.

Fox, J. M. (Ed.). (1993). *Legal frameworks for forest management in Asia: case studies of community/state relaions.* Hawaii: Honululu, East West Center.

Gartaula, H., Niehof, A., & Visser, L. (2012). Shifting perceptions of food security and land in the context of labour out-migration in rural Nepal. F*ood Security, 4(2),* pp. 181-194.

Gauli, K., & Hauser, M. (2009). Pro-poor commercial management of non-timber forest products in Nepal's community forest user groups: factors for success. *Mountain Research and Development, 29(4)*, pp. 298-307.

Gautam, K. H. (2006). Forestry, politicians and power—perspectives from Nepal's forest policy. *Forest Policy and Economics, 8(2),* pp. 175-182.

Giri, K. (2012). *Gender in forest tenure: prerequisite for sustainable forest management in Nepal. Brief No. 1 of 4.* June 2012. Washington, DC: Rights and Resources. [online]. Available at: *http://www.rightsandresources.org/documents/files/doc_5220.pdf. Retrieved 28 February 2015.*

GoN. (1995). *Forest regulation 1995.* Kathmandu: Government of Nepal, Ministry of Forest and Soil Conservation

Gurung, H. B. (1989). Regional patterns of migration in Nepal. *Papers of the East-West Population Institute, 0732-0531, No. 113.* Honolulu: East-West Center.

Henderson, S. (2014). *Understanding the Gulf States.in Focus Quarterly Spring 2014, VIII (2)*. [online]. Available at: *http://www.jewishpolicycenter.org/5208/gulf-states. Retrieved 28 February, 2015.*

HMGN. (1989). *Master Plan for the Forestry Sector, Nepal: Main report.* Kathmandu: Government of Nepal/Ministry of Forests and Soil Conservation.

HMGN/MoLJ. (1993). *Forest Act 1993.* Kathmandu:Government of Nepal (HMGN)/ Ministry of Law and Justice (MoLJ).

Joshi, A. L. (1993). Effects on administration of changed forest policies in Nepal. In: Paper presented at *the Policy and Legislation in community forestry, January 27-29, 1993.*

Kanel, K. R., & Acharya, D. P. (2008). Re-inventing forestry agencies: institutional innovation to support community forestry in Nepal. In: P. Durst, C. Brown, J. Broadhead, R. Suzuki, R. Leslie & A. Inoguchi, Eds., *Re-inventing forestry agencies-experiences of institutional restructuring in Asia and the Pacific.* Bangkok: Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, pp. 133-160.

Karkee, M. (2008). *Nepal economic growth assessment agriculture.*[online]. Available at: *http://pdf.usaid.gov/pdf_docs/PNADN016.pdf. Retrieved 25 October, 2013*

Karki, A. (2002). Movements from below: land rights movement in Nepal. *Inter-Asia Cultural Studies, 3(2),* pp. 201-217.

Kennedy, J. J., Thomas, J. W., & Glueck, P. (2001). Evolving forestry and rural development beliefs at midpoint and close of the 20th century. *Forest Policy and Economics, 3(1–2),* pp. 81-95.

Khatri, D. B., Paudel, N. S., Shrestha, K. K., Ojha, H. R., & Paudel, G. R. (2014). Why has community forestry made limited contribution to food security in Nepal?. In: *Paper presented at the the World Agroforestry Conference, 10-14 Feb, 2014.*

Kollmair, M., Manandhar, S., Subedi, B., & Thieme, S. (2006). New figures for old stories: Migration and remittances in Nepal. *Migration Letters, 3(2)*, pp. 151-160.

Mahapatra, R. (2001). Betrayed: Nepal's forest bureaucracy prepares for the funeral of the much-hailed community forest management programme. *Down To Earth,* 9(22).

Mahat, T. B. S. (1987). Forestry-farming linkages in the Mountains. *ICIMOD Occasional Paper No. 7. Kathmandu*: ICIMOD.

Malla, Y. B. (2000). Impacts of community forestry policy on rural livelihoods and food security in Nepal: forests, food security and sustainable livelihoods(English ed.) special issue. *Unasylva, 51(202),* pp. 37-45.

Malla, Y. B., Neupane, H. R., & Branney, P. J. (2003). Why aren't poor people benefiting more from community forestry? *Journal of Forest and Livelihood, 3(1),* pp. 78-93.

Massey, D., Axinn, W., & Ghimire, D. (2010). Environmental change and out-migration: evidence from Nepal. *Population and Environment, 32(2-3),* pp. 109-136.

Metz, J. J. (1989). Himalayan political economy: more myths in the closet? *Mountain Research and Development, 9(2),* pp. 175-186.

Michon, G., de Foresta, H., Levang, P., & Verdeaux, F. (2007). Domestic forests: a new paradigm for integrating local communities' forestry into tropical forest science. *Ecology and Society, 12(2),* pp. 1.

MoAC, & WFP. (2011). *Nepal Food Security Bulletin. Issue 33, November 2011*. Kathmandu: Ministry of Agriculture and Cooperative (MoAC) and World Food Programme (WFP).[online]. Available at: *http://documents.wfp.org/stellent/groups/public/documents/ena/wfp246335.pdf. Retrieved 5 January 2014.*

MoFSC. (2009). *Community forestry guideline. Kathmandu:* Ministry of Forest and Soil Conservation (MoFSC).

MoFSC. (2013). P*ersistence and change: Review of 30 years of community forestry in Nepal.* Kathmandu: Ministry of Forest and Soil Conservation (MoFSC).

MoFSC/FAO. (2008). *The future of Nepal's forests - outlook for 2020. Asia forestry outlook study 2020: country report Nepal*. Bangkok: Ministry of Forests and Soil Conservation (MoFSC)/Food and Agriculture Organization (FAO) of the United Nations, Regional Office for Asia and the Pacific.

Muzzini, E., & Aparicio, G. (2013). *Nepal's urban growth and spatial transition: an initial assessment.* Washington, D.C., The World Bank.

Nagendra, H. (2002). Tenure and forest conditions: community forestry in the Nepal Terai. *Environmental Conservation, 29(4),* pp. 530-539.

Nepal, R. (2012). *Remittances and livelihood strategies: a case study in Eastern Nepal.* Germany: Kassel University Press Gmbh.

Nepal, R., & Thapa, G. B. (2009). Determinants of agricultural commercialization and mechanization in the hinterland of a city in Nepal. *Applied Geography, 29(3),* pp. 377-389.

Neupane, H. R. (2000). *Factors that Influence the Poorer Households Benefit from Community Forests: An Analysis of Forest Management and Benefit Sharing Processes.* Unpublished MPhil thesis. The University of Reading.

NFA. (2009). *Report of the task force on democratising forest sector. Report submitted to the Ministry of Forest and Soil Consevation.* Kathmandu: Nepal Foresters' Association (NFA).

NPC. (1997). *Ninth plan,* Kathmandu: National Planning Commission (NPC),Government of Nepal.

NPC. (2002). *Tenth plan,* Kathmandu: National Planning Commission (NPC), Governmentof Nepal.

NPC. (2007). *Interim three year plan (2007-10).* Kathmandu: National Planning Commission (NPC), Government of Nepal.

NPC. (2013). *Nepal Thematic Report on Food Security and Nutrition 2013*. Kathmandu: Nepal Planning Commission (NPC), Government of Nepal.

Ojha, H. (2011). *Aid dilemma: has foreign aid contributed to community forestry development in Nepal, Research and policy brief 6.* Kathmandu: Alliance for AID monitor.

Ojha, H., & Kanel, K. (2005). 25 Years of community forestry in Nepal: A review of fourth national workshops proceedings. *Journal of Forest and Livelihood, 4(2)*, pp. 56-60.

Pailwar, V. K. (2012). *Economic environment of business, Third edition.* New Delhi: PHI Learning Private Limited

Pandit, B. H., Albano, A., & Kumar, C. (2008). *Improving forest benefits for the poor: learning from community-based forest enterprises in Nepal.* Bogor: Center for International Forestry Research.

Pant, B., & Panta, R. K. (2009). Export diversification and competitiveness: Nepal's experiences, *NRP Economic Review: Occasional paper No. 21, 52-58.*

Paudel, A., Subedi, B. P., Gyawali, S., Thapa, G. K., & Sharma, M. B. (2009). Value chain analysis of non-timber forest products in Baglung district, Nepal. *Banko Janakari, 19(2),* pp. 33-41.

Paudel, G., Khatri, D. B., & Paudel, N. S. (2013). *Analysis of economic value and employment opportunity of timber in Nepal's community forests.* Kathmandu: ForestAction Nepal.

Paudel, N. S. (2005). *Conservation and Livelihoods: Exploring local peoples responses to conservation interventions in Royal Chitwan National Park, Nepal.* Unpublished PhD thesis. University of Reading, Reading.

Paudel, N. S., Karki, R., Paudel, G., Ojha, H., & Shrestha, K. (2014). Reframing the farm -forest interface: How can community forestry better address food security and livelihoods in Nepal? In:*Paper presented at the sixth national community conference, 16-18 June 2014.*

Paudel, N. S., & Ojha, H. (2013). Community forestry, ecosystem services and poverty alleviation: evidence from Nepal. In: *Paper presented at the biannual conference of the International Association of the Study of the Commons, 3-7 June 2013.*

Pokhrel, R. K. (2010). Generating income from Nepal's community forestry: Does timber matter? *Journal of Forest and Livelihood, 9(1),* pp. 16-20.

Regmi, B. N. (2006). *Problems and prospects of tree integration on farm for rural livelihoods:* A study of Chitwan district, Nepal. Unpublished PhD thesis. University of Reading, Reading.

Regmi, B. N., & Garforth, C. (2010). Trees outside forests and rural livelihoods: a study of Chitwan district Nepal. *Agroforestry System, 79(3),* pp. 393-407.

Regmi, M. C. (1984). *The state and economic surplus: production, trade and resource mobilization in early 19th century Nepal.* Varanasi: Nath Publication House.

Satyal, V. R. (2010). Agriculture in decline. *Economic Journal of Development, 11 and 12(1 and 2 combined),* pp. 144-157.

Sedhai, R. (2014). Back for good. eKantipur, [online] Available at: *http://year2014.ekantipur.com/detail.php?art=33&cat=returnees. Retrieved 28 February 2015.*

Sharma, A. R. (2010). *Community forestry: glamour and gripes (case study from Nepal)*. Germany: LAP Lambert Academic Publishing.

Sharma, J. R. (2012). Nepal: Migration History and Trends. In I. Sirkeci, J. H. Cohen & D. Ratha, Eds., *Migration and Remmitances during the global financial crisis and beyond* Washington DC: The World Bank, pp. 137-140.

Shrestha, K. K., & McManus, P. (2006). Collective action of local communities in forest conservation and utilisation: critical reflections from Nepalese Community Forestry.In: *Paper presented at the small-scale forestry and rural development: the intersection of ecosystems, economics and society. IUFRO 3.08 Conference hosted by Galway-Mayo Institute of Technology, Galway, Ireland, 18-23 June 2006,* pp. 458-477.

Shrestha, N., et al. (2008). Poverty alleviation through agriculture and rural development in Nepal.In: *Paper presented at the regional meeting towards a joint regional agenda for the alleviation of poverty through agriculture and secondary crop development.CPSA Monograph No. 50: UNESCAP-CAPSA.*

Tamang, S., Paudel, K. P., & Shrestha, K. K. (2014). Feminisation of agriculture and its implications for food security in rural Nepal. *Journal of Forest and Livelihood, 12(1)*, pp. 20-32.

Thoms, C. A. (2008). Community control of resources and the challenges of improving local livelihoods: A critical examination of community forestry in Nepal. *Geoforum, 29(3)*, pp. 1452-1465.

Timsina, N. P. (2003). Promoting social justice and conserving montane forest environments: A case study of Nepal's community forestry program. *Geographical Journal, 169(3),* pp. 236-242.

Tiwari, A. (2014). Remitting knowhow. *Nepali Times, Issue number 723, 5-11 September,* 2014.[online]. Available at: *http://nepalitimes.com/regular-columns/Cross-Cutting/returning-migrants-bring-back-positive-social-norms-skills,356. Retrieved 28 February 2015.*.

UNDP. (2014). *Nepal human development report: beyond geography, unlocking human potential.* Rome: United Nations Development Programme (UNDP)

Upreti, B. R., KC, S., Mallett, R., Babajanian, B., Pyakurel, K., Ghimire, S., et al. (2010). *Livelihoods, basic services and social protection in Nepal, Working Paper 7,* Nepal Centre for Contemporary Research and Secure Livelihood Consortium. London: Overseas Development Institute.

USAID. (2011). *Value chain market analysis of the ginger sub-sector in Nepal*. Kathmandu: General Development Office, United Staes Agency for International Development (USAID).

Westoby, J. C. (1979). Forest industries for socio-economic development. *Commonwealth Forestry Review,* 58(2), pp. 107-116.

9

# How Much Heterogeneity? Caste and Participation in Community-Based Forest Management in Nepal

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## Abstract
We explore the impact of village caste heterogeneity on social capital formation using micro data from community forest user groups from Nepal. We adopt an alternative index for caste heterogeneity that captures both evenness and proportional abundance of the ethnic groups in the villages. Econometric evidence shows that the relationship is non-linear. It follows an inverted U shape. We also find that this pattern is very general and also applies when we consider the caste groups individually. Some important caveats are also highlighted.

Key words: community forestry, caste, collective action, social capital, Nepal

## 1. Introduction
The role of social capital has emerged as a key concept in combating a vast array of political, social and economic problems. Social capital encapsulates the idea that social bonds are important for communities (Pretty, 2001; Coleman, 1988). Generalised trust and access to social networks are both important for higher levels of performance in several areas, such as education, health, development, and public policy at large (Paraskevopoulos, 2007). Further, it has been argued that trust, the nature of exchange relations, the cultural significance and institutional constraints of a society shape the individual's expectations with regard to use of the natural environment (Adger, 2003). Communities that have higher levels of social capital are more likely to overcome opportunistic behaviours and enforce management rules (Bromley, 1993; Pretty & Ward, 2001).

Scholars have discussed the direct application of the concept of social capital such as social norms and networking for efficiency, equity and sustainability of common pool resource (CPR) management (Ollagon, 1991; Ostrom, 1992; Adger, 2003). Community-based management of common pool resources (CPRs) has been regarded as an appropriate system to achieve economic, environmental and social development goals and to overcome the 'tragedy of the commons' situation because of the existence of social capital in many rural settings that promote generalised trust and reciprocity (Ostrom, 1990, 1992; Berkes, 1989; Wade, 1988; Jodha, 1986; Baland & Platteau, 1996; Chakraborty, 2001; Agrawal, 2001; Edmonds, 2002). During the past decades, there has been, indeed, overwhelming evidence of groups' formation for managing a wide range of local commons. Recent empirical evidence from the Indian Himalayas found that such institutions tend to improve some of the dimensions of the conservation of forests. Baland et al. (2010) indeed showed that forests managed by local communities were better managed than state controlled forests.

While the role of social capital has been acknowledged for addressing social problems and facilitating collective action, relatively few empirical studies examine how institutional and social structure of the community affect social capital formation. Particularly, the relationships between social capital and socially constructed inequalities such as caste have not been fully elucidated.[1] Do these inequalities hinder or facilitate the emergence of social capital? Economists, political scientists and sociologists have advanced opposing views. On one hand, ethnic diversity[2] is often viewed as not conducive to social capital formation as individuals tend to distrust members from other groups (Portes, 1998: Abrams et al., 2005). The idea is that social capital is likely to be weaker in heterogeneous communities where people have less trust and feel uncomfortable interacting with other members who are different than themselves (Coffe, 2008). Therefore, increasing ethnic diversity undermines trust and social capital (McLaren, 2003; Putnam, 2007; Nelson, et al., 2004, Kanbur, 1992). Intra-group relationships allow the bonding of common interests and more homogeneous communities thus foster greater levels of social capital production (Costa & Kahn, 2003). This view is supported by some existing empirical evidence. This shows (at the aggregate level - countries or counties), that cultural or ethnic diversity is negatively correlated with different forms of social capital[3] (Alesina et al, 1999; Alesina & La Ferrara, 2000; Easterly & Levine, 1997; Miguel & Gugerty, 2004).

The relationship could also, however, go in the opposite direction. For instance, inter-group relationships can reduce prejudice and increase cohesion. This can be particularly relevant in community based management systems, where individual of different caste interact to manage a local common. As diversity increases, the likelihood of interethnic relationships (and bonds) increases. These can prevent negative perceptions (or incorrect information) regarding other ethnic groups

[1] Earlier focus on the study of social capital was more dominated by the structural approach (e.g. network connection, group size). This approach did not take into consideration the underlying institutional or social context in which these relationships are embedded (Ballet et al., 2007).

[2] In this paper we will use the terms ethnic heterogeneity and ethnic diversity interchangeably.

[3] Naidu (2009) found, in Indian communities, that moderate levels of social diversity are associated with low collective management. While high levels of social diversity, are associated with high collective management. It should be stressed that collective management activities are very diverse. They incorporate participation in meetings, labour allocated to the management of the resource, engaging in planting trees and fencing parts of the forests (maintenance activities), meeting with forest officials and NGO employees (administrative activities), preventing and fighting forest fires (forest protection activities), and monitoring use of the forest (monitoring activities).

(Allport, 1954; Gordon, 1964; Varshney, 2003). Therefore, it has been found that ethnic diversity is positively correlated with social capital (Marshall & Stolle, 2004; Hewstone et al., 2005).

This paper aims to contribute to this debate by providing some empirical evidence on the relationship between caste diversity and social capital formation using Nepal as a case study. The focus on caste systems seems obvious because Nepal has a distinct social stratification based on this specific system and encompasses a wider socio-economic heterogeneity (Adhikari & Lovett, 2006). The caste system is a centuries-old institution that helps maintain power relations among different communities. The Nepalese government has taken some action and declared the caste system 'non-existent' many years ago. As a result, the social barriers between higher and lower castes are gradually breaking down (Adhikari & Di Falco, 2009).

The social barriers were also lowered by the implementation of the community forest program (CF). The program envisioned a more inclusive approach to forest management by providing equal opportunities to various low-caste people, landless migrants or other ethnic groups in forest management decisions. This includes the participation in the management of the local forest. Participation in community activities was defined by Putnam (2000) as "bridging social capital." This is opposed to 'bonding social capital' that glues together more homogenous groups within a community. Bridging social capital is defined as actions that reinforce bonds of connectedness that are formed across diverse social or ethnic groups (Bryant & Norris, 2002). This seems to be one of the most important dimensions of social capital formation in community forests of Nepal. In this paper we empirically address the following question: How does the existence of caste heterogeneity affects household's participation in crucial forms of community-based actions? More specifically, how does belonging to a more or less ethnically diverse community affect a households' decision to participate in activities that require interaction with other ethnic groups?

Compared to the existing literature this paper offers three elements of novelty. First, it provides micro evidence. Indeed, most of the evidence builds upon data from countries. We argue that micro analysis is crucial to understand how individual households' engagement in social capital activities are affected by the level of ethnic heterogeneity in their village. Second, we allow for non linearity in this relationship. Existing studies assume that ethnic diversity and social capital are monotonically related. This may be an important simplification. The direction of this correlation may be sensitive to how much diversity there is in a given community. There may be, for instance, a threshold level of diversity that may invert the direction of this relationship. Third, we adopt an ethnic diversity index (Shannon diversity index) that captures the evenness of the distribution of the different ethnic groups in the village. Arguably, the choice of an index is always somewhat arbitrary. In this setting, however, it is very important to distinguish the number of ethnic groups from how evenly these groups are represented.

While the details of our results are presented herein we find that the relationship between social capital formation and caste heterogeneity is nonlinear. It, indeed, follows an inverted U shape. Therefore, a lower level of heterogeneity is associated with increasing level of household participation in social capital formation. After a threshold level, however, the relationship is inverted and more heterogeneity is detrimental for social capital formation. This result seems remarkably relevant. However, we need to flag some important caveats. First, our evidence is based upon cross sectional evidence.[4] Arguably, some of the effects of ethnic diversity on social capital formation are instead dynamic. Second, community diversity is treated as exogenous to the household. This seems plausible from a theoretical perspective, and it is corroborated by the inclusion of community fixed effect. Nevertheless, we cannot exclude all the possible avenues of endogeneity. Therefore, we invite the readers to take these results with caution. Third, our results are from two areas of Nepal and one very specific dimension of heterogeneity (caste heterogeneity). Therefore, the external validity should be considered somewhat limited.

The paper proceeds as follows. The next section will present a brief description of the concept of social capital and its relation with caste heterogeneity in natural resource management. This is followed by a description of the survey method and variables used in analysis. We then present the estimation strategy and the results. We conclude with a discussion on our findings in section six with some policy implications.

## 2. Background on social capital, caste and natural resource management

Although there are different definitions of social capital (Paldam, 2000), the concept generally describes the relations of trust, network, authority, relations, norms, solidarity, reciprocity, voluntary participation in the group and the evolution of common rules (Coleman, 1990; Putnam, 1993; Paldam, 2000; Adger, 2003). Social capital can be identified at different scales (from the micro-institutional to more macro scales) that examine its role in the formation of state-civil society relations and economic development in certain regions (Reimer et al., 2008). This concept has been applied in a variety of contexts such as family, education, ethnicity, democracy, health, happiness, crime and economic performance to explain the ability of communities to solve the problems of collective action. Findings from earlier research showed that increased social capital-measured most frequently by indices combining trust and civic engagement promoted better political and economic outcomes (Nelson et al., 2004). In his work on democracy and civic traditions in modern Italy, Putnam (1993) highlighted a long-standing regional variation in the propensity for civic engagement between Northern and Southern Italy. He concluded that historical variations in civic engagement contribute significantly to the persistent gap in economic outcomes and governmental effectiveness between different regions (cited in Killerby & Wallis, 2002). Knack (2002) discussed that reciprocity in the form of trust such as volunteering and census responses were associated with differences between government performances in American states.

[4] It should be also noted that the number of observations is not very large.

Scholars of commons and institutional theorists have shown that social capital facilitates a range of cooperative actions including crafting of institutions for sustainable management of natural resources at the community level (Ostrom, 1992). Moreover, social norms and institutions enhance the ability of community groups to develop factors preventing over appropriation from CPRs and help achieve sustainable and efficient outcomes (Ostrom, 1992, McKean, 1992; Agrawal, 1999; Sethi & Somanathan 1996; 2006; Oses-Eraso & Villadrich-Grau, 2007). The level of social capital in a community influences institutional arrangements and interpersonal trust and thus strengthens social bonds between members (Baland & Platteau, 1996; Pretty, 2001; Pretty & Ward 2001; Uphoff & Wijayaratna, 2000). Arefi (2003) identifies consensus building, defined as developing a shared interest and agreement among various actors to induce collective action, as a direct positive indicator of social capital. Social capital has a stock that can lead to a flow in the form of economic returns. Society or communities that have social bonds, trust and connectedness are more likely to overcome opportunistic behaviours and enforce rules with regard to the efficient utilisation of environmental resources. If members of a resource-managing institution are able to form rules, agree to abide by them, and succeed in excluding those who do not follow these rules, then there is creation of values such as trust and reciprocity in that group (Ostrom, 2000). On the contrary, erosion of values like reciprocity may lead to destruction of a resource or public good (Oakerson, 1992).

One contested dimension is socio-economic heterogeneity and the formation of social capital at the community level. Some authors argued that heterogeneous communities have lower levels of trust because diversity and inter-group conflict created barriers to the virtuous circle of higher social capital and better performance (Nelson et al., 2004; Kanbur, 1992). For instance, in their study of growth strategy and ethnic divisions in Africa, Easterly and Levine (1997) found that ethno linguistic fractionalisation greatly reduced growth rates in the post-colonial period. However, another strand of literature suggests that heterogeneity facilitates group actions because actors with more economic interests and power usually initiate collective action (Olson, 1965). This is also examined by Baland and Platteau (1997) who argued that it may be true in situations where collective action involves large start-up costs. Based on analysis of data collected from 307 Flemish municipalities, Coffe (2008) found that those municipalities with a more heterogeneous population indeed had lower levels of social capital. Stolle and Rochon (1998) observed that heterogeneous associations promote generalised trust and reciprocity.

Andrews (2009) tests the assumption that political participation and associational activity can minimise negative externalities for social capital associated with ethnic heterogeneity, such as mistrust and lack of respect. He found that civic engagement can moderate negative externalities for social capital associated with ethnic heterogeneity. Other scholars have contended that institutions are embedded in the antecedent decisions and culture of the societies in which they emerge (Adger, 2003, p. 388). Bourdieu (1980, 1986) explained the social and cultural capital with an argument that cultural capital features among homogeneous social groups should be taken into account as they have to be transformed into ‘symbolic’ features to be assimilated by the members of the group and attributed among them and to each other in order to link them together (cited in Ballet et al., 2007, p.357). To date, little research has addressed the knowledge gaps regarding the potential for civic engagement to moderate negative externalities for social capital associated with ethnic heterogeneity such as mistrust and lack of respect (Andrew, 2009; Putnam, 2007).

Although there are different forms of heterogeneity (see Adhikari & Lovett, 2006), here we consider a particular dimension of socio-cultural heterogeneity, notably how the caste system influences the creation of social capital at the community level. There are four divisions of caste according to the Hindu religion: the Brahmans (priests, teachers, and scholars), the Chettris (or Kshatriyas - kings and warriors), the Vaishyas (traders) and the Shudra (peasants, labourers and service providers) who were made outcasts depending on the professions they were associated. For instance, communities that professed non-polluting jobs were integrated as Sudhra and those associated with polluting professions (working in what were seen as unhealthy, unpleasant jobs such as cleaning, sewage etc.) were considered ‘untouchable’ (Adhikari & Di Falco, 2009). Caste generally governs the beliefs and practices about rights and responsibilities, and powers and privileges with respect to the different resource management activities (Singh, 2004). Caste differences, therefore, could be an important determinant of participation of households in various forms of collective action (Baker 1997; Adhikari & Di Falco, 2009).

Our measure of social capital in this paper is the interest group participation in various forms of community meetings related to the CF management. Our approach in measuring the social capital is similar to that of Ruston (2002) who considered social participation, social engagement, and commitment as one of the five specific themes of social capital. In their study of the role of social capital in household outcomes in rural Tanzania, Narayan and Pritchett (1999) constructed the social capital variable by a weighted average of memberships in various groups and the characteristics of these groups.

The caste system in the Indian sub-continent is one major component of ethnic heterogeneity. The role of caste is highly contested with some considering it an economic vehicle which provides opportunities for work specialisation. Others view caste as bonds of connectedness, a sort of support system that people use to deal with society and the state. Vaidyanathan (2002) treated the caste system as a valuable social fabric, which helps provide a cushion for individuals and families to deal with society and the state. The positive side of the caste system is self-help within a similar caste. A handful of experiences from community-based approaches to local development demonstrate that the caste system acts as social glue that enables cohesive communities to pull together, help distressed members, mediate conflicts, penalise deviant behaviour and reward desirable behaviour, far more efficiently and cheaply than formal institutional arrangements (TTI, 2000). However, the association between ethnic heterogeneity and the level of social capital has also been scrutinised in the literature. For instance, members of minority groups have been found interacting only with members of that minority because of shared common interest and greater empathy towards individuals who remind them of themselves (Costa & Kahn, 2002).

In their study of networks of social affinity, Arora and Sanditov (2009) argued that, “many caste headmen, through active participation in and control of village level institutions, buttress their caste-derived authority with newer forms of prominence in a South Indian village” (p.33). Although the caste is an ancient social institution in South Asia, it has been closely associated with a variety of ritual practices and with cultural beliefs about a person’s station in life (Béteille, 1969). Challenging dominant social theories of caste, Natarajan (2010) described how caste systems emerged as cultural phenomenon so that the culture of a caste is produced, organised and naturalised in the process of transforming *jati* (fetishized blood and kinship) into *samaj* (fetishized culture). It is therefore caste that is shown to be embedded in a specific ecological and cultural niche of the community. Although previous research has addressed moderating effects of civic engagement on negative externalities associated with social capital at the individual level (Anderson & Paskeviciute, 2006), few studies have examined their presence at the aggregate level (Andrews, 2009). In this context it seems interesting to examine whether or not the caste system facilitates participation in the creation of social capital. Furthermore, the empirical evidence on the relationship between the levels of social capital and resource extraction will help identify opportunities that can move the natural resource management agenda in this area forward.

## 3. Site and variables description

Social capital is a multidimensional concept that means different things to different people (Dasgupta & Serageldin, 1999). Admittedly, in this study we narrow our focus on one specific dimension: bonds of connectedness of the household with the rest of the community. We argue that the level of existing social capital within a community is the product of the households’ participation in its formation. One way of measuring this type of social capital is the number of community meetings attended by village members for the management of the community forests. We consider the formation of Community Forest Users Group (CFUG, hereafter) group meetings, as well as various programs by communities as part of the process of creating and accumulating social capital at the village level. Data for this analysis is drawn from a survey conducted in two districts in the middle hills of Nepal, Kavre Palanchok and Sindhu Palchowk. The middle hills comprise the central area of Nepal with a mixture of agricultural and forested land. The majority of the populations in this area are subsistence farmers, depending on the surrounding agricultural and forested land, with livestock playing an important part in their livelihood options. The middle-hills run from east to west across the centre of the country, wedged between the low-lying Gangetic plains (Terai) and the snow-capped Himalayan Mountains. Altitude in the middle-hills ranges from 300 m in river valleys to 5,000 m on hill tops. Land uses in this region are categorised as cultivated land, non-cultivated inclusions, grasslands, forestland, shrub lands, and ‘other’ types of land use (Collett et al., 1996).

In order to address the research questions posed in this paper, we use data from eight CFUGs. Four CFUGs (Saradadevi, Jyala Chiti, Mahavedsthan and Thuli Ban) in the Kavre Palanchok districts and four (Gaurati, Shree Chhap, Janghare and Karki Tar) in the Sindhu Palchowk district. The characteristics of community forests and user groups are presented in Table 1. The area of community forests varies from 44 to 185 hectares and number of households varies from 133 to 292 with forest land per capita ranging from 0.33 to 1.29 hectare respectively. Three different forest types, i.e. coniferous forest (dominant species *Pinus roxburghii*), broad-leaved forest (dominant species *Schima wallichii* and *Castanopsis indica*) and broad leaved and coniferous mixed forests were observed in the study sites.

Bridging social capital is captured by household participation in village meeting related to the management of the forest. This is calculated as the number of meetings attended by the household. On average the households attended around four meetings. Every household did attend at least one meeting. This is no coincidence, as one of the requirements of the implementation of community forests in this area of Nepal.

**Table 1:** Characteristic of FUGs

| S.N. | Name of Forest User Groups | District | Forest Area (Hectare) | Number of Households | Forest types |
|---|---|---|---|---|---|
| 1 | Saradadevi FUG | Kavre Palanchok | 44 | 133 | Broad-leaved |
| 2 | Jayala Chiti FUG | Kavre Palanchok | 25.9 | 222 | Broad-leaved |
| 3 | Mahadevsthan FUG | Kavre Palanchok | 72.3 | 147 | Mixed |
| 4 | Thuli Ban FUG | Kavre Palanchok | 54 | 292 | Coniferous |
| 5 | Gaurati FUG | Sindhu Palchok | 88.8 | 144 | Coniferous |
| 6 | Shree Chhap FUG | Sindhu Palchok | 45.0 | 216 | Mixed |
| 7 | Janghare FUG | Sindhu Palchok | 124 | 255 | Broad-leaved |
| 8 | Karki Tar FUG | Sindhu Palchok | 185.3 | 140 | Broad-leaved |

The caste and ethnic groups represented, the number of households in each groups, and the percentage of the total households for the sample of 309 households are shown in Table 2. These data illustrate the diversity of caste groups in each study site. The data reflect the dominance of upper caste (Brahmans and Chhetris), which represents more than half of the sample of 309 households. Several minority ethnic groups appear under the Vaishyas and Sudra caste groups in the sample. The settlement patterns of each caste/ethnic group differ in that lower caste or households belonging to ethnic groups live in more isolated or higher altitude locations and the Brahmans and Chhetris frequently live near more accessible valley floors, which are often more productive, and contain infrastructure facilities.

**Table 2:** Distribution of household by caste group per forest

| FUGs | Brahmin | Chhteri | Vaishyas | Sudra |
|---|---|---|---|---|
| Saradadevi FUG | 15 | 11 | 2 | 2 |
| Jayala Chiti CFUG | 4 | 19 | 14 | 6 |
| Mahadevsthan CFUG | 21 | 3 | 2 | 5 |
| Thuli Ban CFUG | 39 | 9 | 2 | 8 |
| Gaurati CFUG | 0 | 4 | 25 | 0 |
| Shree Chhap CFUG | 21 | 10 | 11 | 0 |
| Janghare CFUG | 4 | 18 | 11 | 14 |
| Karki Tar CFUG | 14 | 11 | 2 | 2 |
| % All sites | 38 | 28 | 22 | 12 |

Households are the final sampling units in the sampling design in our analysis. Within these CFUGs a sample of households was randomly selected for interview. A total of 309 randomly selected households were interviewed, with twenty one questionnaires being excluded from the final analysis because they were incomplete. After taking into account outliers and missing value 230 observations remained (Table 3).

**Table 3:** Characteristics of sample respondents (household survey)

| Attributes of respondents | | Average value |
|---|---|---|
| Age | | 43.43 |
| Average family education (# of school years) | | 4.4 |
| Household size (# of individual in a family) | | 6.4 |
| Education | | |
| | Illiterate (%) | 28.0 |
| | Primary school (%) | 40.8 |
| | High school (%) | 23.0 |
| | College (%) | 4.9 |
| | University (%) | 3.2 |
| Caste | | |
| | Lower caste (%) | 12 |
| | Higher caste (%) | 88 |

Lower caste participation in decision-making aspects of CF management was also measured by the lower caste households represented in the executive committee of the CFUGs. While representation of the upper caste households is homogeneous, representation of lower caste households in CFUG executive committees is more heterogeneous.[5] From the survey a set of variables was selected for inclusion in the econometric model, see equation (1) below. Variables definition and summary statistics is reported in Table 4.

5 For this area, the issue of caste and representation in the executive committee was addressed in Adhikari and Di Falco 2009.

**Table 4:** Definition summary statistics for the explanatory variables

| Variables | Definition | Mean | Std deviation | min | max |
|---|---|---|---|---|---|
| Social Capital | Household participation in village meeting related to the management of the forest – number of meetings attended by the household | 4.6 | 5.04 | 1 | 36 |
| Income from other sources | Income from non agricultural activities – in Nepalese rupees | 58290.4 | 61028.1 | 1000 | 420000 |
| Income from agricultural activities | Income from agricultural production and husbandry - in Nepalese rupees | 34245.4 | 42965.9 | 0 | 248150 |
| Education | Average education of adult family members - in years | 4.64 | 3.92 | 1 | 16 |
| Village caste Heterogeneity | Shannon Index for Ethnic Diversity | 1.09 | 0.33 | 0.23 | 1.74 |
| Age | Age of the household head (in years) | 43.71 | 12.9 | 22 | 84 |
| Technology | Cost of tools used in forestry operation (proxy for technology of harvesting) - in Nepalese rupees | 81.2 | 60.09 | 0.3 | 385 |
| Distance | Distance between community Forests and house - in km | 0.71 | 0.54 | 0.01 | 3 |
| Trees | Number of trees of private land | 87.91 | 142.41 | 0 | 1632 |
| Migration | Member of the household migrated – 1=yes; 0 = otherwise | 0.8 | | 0 | 1 |

There are four castes in this setting: The Shudra, the Vaishyas, the Chhetris and the Brahmans. The survey explicitly asked to which caste group the household did belong. This was cross validated by with criteria such as occupation. The caste household is combined to construct the caste village heterogeneity variable. In the existing literature, the role of heterogeneity is captured by a fragmentation index (e.g. Alesina,et al., 2002, Easterly and Levine, 1997).[6] It is calculated as one minus the Herfindahl index of ethnic group $Frag_j = 1 - \sum_{i=1}^{I} s_j^2$ shares, thus, where sij is the share of households in village j belonging to the caste i – this index represents the probability that two randomly drawn households belong to different caste. This index ranges between 0 and 1. This index is also called Simpson index has been widely used in ecology (to measure species diversity). It is an index of proportional abundance.However, the Simpson index is heavily weighted toward the most abundant group or caste in the sample while being less sensitive to group richness (Magurran, 1988). Its use is therefore not suitable when one ethnic group is relatively more frequent.

Moreover, proportional dominance is one specific (and limited) aspect of ethnic diversity. In this setting, understanding how evenly represented the caste are is of paramount importance. The concept of heterogeneity is thus more complex than proportional abundance. We need to capture both abundance and evenness of groups within a given village. The latter concept is very important as it identifies how the number of households are distributed among the different caste groups. How equally (or unequally) they are represented. We therefore adopt an alternative measure of ethnic fragmentation: $Frag^{*}{}_j = -\sum_{i=1}^{I} s_j^2 \log(s_j^2)$ . This is index encapsulate both evenness and relative abundance of the household for a given caste. It will therefore increase when more groups are represented in a given community. It will also increase when the community is more evenly distributed across the different groups. This index has been widely used in the ecological literature (called Shannon's index)[7] especially when some species are much more abundant.

We control for age and education. We present a model specification that incorporates the average years of education for the adults in the household and the age of the household head as covariates. Household income is divided into two categories: income from agricultural activities and income from other sources (i.e. off-farm income etc.). We include these variables as controls. This should provide information on forest dependency. Other control variables in (1) also included, the cost of tools to proxy for technology endowment, the number of trees that the households own on private land, and the distance to the forest. The inclusions of these controls should increase our confidence on the estimated effect of ethnic diversity on participation in social capital formation. Clearly some of these controls can be endogenous (education or income). However, we are not attaching any causal interpretation to the controls. Our coefficient estimate for the key variable 'caste heterogeneity' should still have causal interpretation as long as is not correlated with the mean error term (conditional mean independence assumption) (Table 5).

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6 A thorough and exhaustive analysis of the indices of fractionalisation is provided by Bossert et al. 2006

7 It should be noted that both indices belong to the Hill family of indices, they ''can be linked to a more general information theory'' and to a generalised formulation of entropy (Keylock, 2005).

**Table 5:** Correlation between caste heterogeneity and socio economic characteristics

| Variables | Heterogeneity |
|---|---|
| Age | 0.11 |
| Education | 0.06 |
| Income from agricultural activities | -0.03 |
| Income from other sources | -0.07 |

## 3. Estimation strategy

We analyse the issue of caste heterogeneity and socio economic characteristics on bridging social capital formation. Let Si represent the household's participation in social capital then:

$$S_{ij}=\alpha H_j+X_i'ß+ u \qquad (1)$$

$S_{ij}$ is our metrics of bridging social capital of the household *i* in the forest user group *j*. $H_j$ represent the Shannon index for ethnic diversity in the j group. $X_i'$ is a vector of controls (socio economic characteristics) for household and u is the random disturbance. We will refer to (1) as the participation equation. We tested for alternative functional forms, also including interaction terms among explanatory variables. We found that the presented specification was more robust. From an econometric standpoint, estimation of this equation poses at least two challenges. First, heterogeneity can play an important role in this analysis (Edmonds, 2002). There can be institutional and other unobservable effects of CFUGs correlated with both social capital and ethnic diversity. We therefore insert CFUG fixed effects in the estimating equation.[8] This will remove all the village/forest invariant un-observable effects. Moreover, socio economic characteristics can be correlated with ethnic diversity. The extent of such correlation needs to be investigated. For instance, villages with a specific level of heterogeneity may, perhaps, be associated with lower level of income or education and so on. None of the found correlation seems high. We report the correlation in the table 5 and let the reader decide on the extent of the problem in our setting.

We also attempted to investigate the possibility of endogeneity bias of the diversity variable. It could be argued that social characteristics such as village heterogeneity are not choice variables. In a sense, a given household does not determine its caste nor the ethnic composition of the village. We should therefore expect that the level of ethnic heterogeneity to be exogenous. Households can, however, choose to migrate and this can indirectly cause some endogeneity bias in the caste composition variable. We observed that the level of migration across the survey village is quite small. Instead, a broader issue is migration out of the villages. This can impact the caste composition of the village. To control for such possibility we inserted the variable migration (out of the rural areas) as control. Moreover, the inclusion village fixed effects will remove village-specific unobserved heterogeneity.

8 Because of collinearity some of the village dummy variables were dropped.

Thus, possibly reducing the correlation between explanatory variables and the error term (Hsiao, 1986). This indicates that endogeneity bias – if existing – may be less severe.

It should be stressed, moreover, that in this context finding suitable instruments is very difficult. On one hand, the absence of lagged values reduces the possibility of candidate instruments. Screening the database reveals the number of potential instruments was very limited.[9] It is very difficult to find some variables that can confidently be excluded from the equation of interest while being correlated with caste heterogeneity. Unfortunately, we are not in the position to implement a credible formal testing procedure. For all these reasons, we invite the reader to take the results with some caution as we cannot entirely discard the possibility of endogeneity bias. Finally, given that we observe multiple households operating in the same forest, we relax the assumption that the error term is *iid* and clustered the standard errors at the forest level. We therefore allow for the errors to be correlated in some 'unknown' fashion.

# 4. Results

Table 6 reports the role of socioeconomic variables on social capital formation. To probe the robustness of our estimates we gradually insert non-linear term and more controls. The results are broadly consistent. The estimated coefficients are very stable and robust to different specifications. We find evidence that caste diversity affects social capital in a non-monotonic fashion. Both linear and quadratic terms are highly statistically significant (one %). The relationship between ethnic diversity and social capital formation is an inverted U shape. At a first stage, it is associated with lower level of heterogeneity. Then, after a threshold level, the relationship is inverted and more ethnic heterogeneity is associated with lower levels of participation. This pattern is consistent across different specifications with different controls.

**Table 6:** Caste heterogeneity and bridging social capital

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **Dependent variable: Social Capital** | | | | | | |
| **Ethnic Diversity** | -1.046 | 278.6*** | 337.5*** | 340.2*** | 355.5*** | 357.0*** |
| | (1.640) | (85.00) | (24.68) | (60.50) | (74.64) | (58.88) |
| **Ethnic Diversity^2** | | -121.1*** | -146.9*** | -148.2*** | -154.8*** | -155.4*** |
| | | (36.73) | (10.66) | (26.07) | (32.18) | (25.35) |
| **Age** | | | 0.00169 | 0.00223 | 0.00301 | 0.00110 |
| | | | (0.00400) | (0.00444) | (0.00493) | (0.00483) |
| **Education** | | | 0.0345** | 0.0329* | 0.0328* | 0.0375* |
| | | | (0.0141) | (0.0158) | (0.0165) | (0.0189) |

[9] In the hope to find some possible instruments, we explored other existing databases such as the World Bank Living Standards Measurement Survey (LSMS) for Nepal. Unfortunately, this survey are around three years apart from the one used in this paper. Moreover, there was not enough spatial overlap.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Income from agricultural activities** | | | 0.0522*** | 0.0583*** | 0.0553*** | 0.0575*** |
| | | | (0.0122) | (0.00999) | (0.00868) | (0.00842) |
| **Income from agricultural activities** | | | 0.100* | 0.101 | 0.116* | 0.0863 |
| | | | (0.0457) | (0.0553) | (0.0541) | (0.0491) |
| **Technology** | | | | 0.000805 | 0.000810 | 0.000359 |
| | | | | (0.00143) | (0.00148) | (0.00142) |
| **Trees** | | | | 0.000247 | 0.000219 | -0.000144 |
| | | | | (0.000660) | (0.000653) | (0.000721) |
| **Distance** | | | | 0.0332 | 0.0279 | 0.0540 |
| | | | | (0.116) | (0.118) | (0.122) |
| **Migration** | | | | | 0.135 | 0.0506 |
| | | | | | (0.161) | (0.147) |
| **Untouchable** | | | | | | -0.0759 |
| | | | | | | (0.0982) |
| **Chetri** | | | | | | 0.613*** |
| | | | | | | (0.140) |
| **Bramin** | | | | | | 0.201 |
| | | | | | | (0.144) |
| Village fixed effects | yes | yes | yes | yes | yes | yes |
| Constant | 2.176 | -158.7*** | -193.4*** | -195.0*** | -204.0*** | -204.8*** |
| | (1.959) | (49.04) | (14.54) | (35.00) | (43.38) | (34.14) |
| N | 304 | 304 | 230 | 224 | 224 | 224 |
| **adj. $R^2$** | 0.068 | 0.073 | 0.104 | 0.114 | 0.103 | 0.158 |
| Community Clustered Robust Standard errors in parentheses * *p*< 0.10, ** *p*< 0.05, *** *p*< 0.01 | | | | | | |

Crucially, the estimated coefficients are always statistically significant. We estimated the marginal impact (at the sample mean) and found that is positive. Indeed, the marginal impact is 21.95. So estimated at the average value (1.074), we find that heterogeneity is positively correlated with participation in social capital formation. The existence of an inverted U shape implies that this marginal impact changes for different values of our heterogeneity metrics. The impact of heterogeneity on participation becomes indeed negative when the value of the Shannon index becomes larger than 1.15. This is well within the values of the sample (the maximum is 1.7). Looking at the other controls we find that both education and the variable ‘income from agricultural activities’ are positively correlated with participation. The former seems to confirm that more education is generally combined with a higher evaluation of one’s own ability to influence socio-political outcome and therefore results in a higher level of social interaction (Alesina

& La Ferrara, 2000). Households with larger income are also associated with larger social capital formation. The latter seems to confirm some earlier observations of the effects of 'income or wealth' in initiating collective action. Better off households would invest more in commons management. Olson (1965) observed that the greater the share in the benefits of a collective action for any single member, the greater the propensity of this 'large' member to bear the costs involved in commons management. On the other hand, groups that depend heavily on daily wage labour find it difficult to attend a variety of community meetings, not because they do not have interest in collective action, but rather due to their income and livelihood constraints. As mentioned earlier, the interpretation of these estimated coefficients of these controls should be taken with extra caution. They indeed may be endogenous. Nevertheless, we stress that the estimated coefficients of the heterogeneity variables are very stable across the different specifications.

The statistical significance of the coefficient estimated income from other sources is rather weak and statistically not significant. This may indicate that households with a wider range of employment opportunities are reducing the forest dependency and therefore are less involved in the management of the resource. The findings that more educated and have a positive estimated coefficient in the social capital equation may indicate the importance of 'elites' in such a context. These are the households that are participating more in the activities in the village. They show this by actively participating in the meetings that are important for the village livelihoods. It should be noted that agricultural income can be correlated with some of the other explanatory variables (income from other sources and education). All these correlations were all around 0.2. While this is not a level of correlation that implies severe collinearity, it can have an effect on the estimates' accuracy. We therefore ran an auxiliary regression between 'income from agricultural activities' and the correlated variables and used the residuals to 'instrument' for it.

**Table 7:** Heterogeneity and social capital per different caste groups

| | Lower Caste | Chettris | Brahmans |
|---|---|---|---|
| | **(1)** | **(2)** | **(3)** |
| **Dependent variable: Social Capital** | | | |
| Ethnic Diversity | 377.6*** | 796.7*** | 498.9*** |
| | (45.09) | (93.87) | (64.38) |
| Ethnic Diversity^2 | -162.1*** | -345.8*** | -218.7*** |
| | (19.51) | (40.61) | (27.92) |
| Age | -0.00702 | -0.0129 | 0.0164** |
| | (0.00471) | (0.0114) | (0.00569) |
| Education | 0.0402 | 0.0941** | 0.0131 |
| | (0.0251) | (0.0384) | (0.0212) |
| Income from agricultural activities | 0.0218 | 0.133*** | 0.0430 |
| | (0.0128) | (0.0298) | (0.0336) |
| Income from agricultural activities | -0.0192 | 0.203* | 0.0926 |
| | (0.0923) | (0.0934) | (0.0896) |
| Constant | -218.2*** | -457.9*** | -284.3*** |
| | (25.22) | (54.69) | (37.86) |
| N | 88 | 64 | 75 |
| adj. $R^2$ | 0.171 | 0.184 | 0.078 |

Community Clustered Robust Standard errors in parentheses * $p< 0.10$, ** $p< 0.05$, *** $p< 0.01$

Next, we controlled if the household caste had an impact on the findings above. We found that the inverted U shape relationship is robust to these controls. The results are reported in the column (6) of Table 6.

We questioned if these results are sensitive to the different caste group. We thus explored if ethnic heterogeneity would affect participation in social capital formation differently if we look at households from different caste.  This can be implemented as a robustness check. We thus rerun the models per each caste group. We pooled together the two lower caste groups (Shudra & Vaishyas). We kept in two different categories Chettris and Brahmans. These are the upper caste group. To conserve space we only present the results (shown in the Table 7) from the replication of model (3). What pattern are we looking for? We speculate that the measure of heterogeneity could affect ethnic groups with different modalities. These may be a reflection of different attitudes to diversity.  But this also, following Alesina and La Ferrara 2000, can reflect different degrees of excludability of the different groups (Chettris and Brahmans, for instance).

The estimated coefficients are again very consistent. We find that the existence of an inverted U shape holds irrespective of the caste group we consider. The results are qualitatively very similar. The marginal effect (estimated at the sample mean) is 29.4 for the lower caste, while it is 53.22 and 29.13, respectively for the two upper caste groups, Chettris and Brahmans. This implies that —at the sample mean—the impact of heterogeneity is positively correlated with the lower caste participation. This may indicate a similar attitude towards diversity among different caste groups. It should be stressed, however, that as a result of splitting the sample we end up with quite a small number of observations.

## 5. Conclusion

Community-based management of common pool resources has been gaining momentum in many developing countries due to its contribution to rural livelihoods, environmental conservation and development. In Nepal, the community forest programs have been implemented for more than twenty years. There is a growing consensus that these programs are helping to reconcile the goals of social justice, equity, improving local livelihoods, empowerment and environmental sustainability in the mid-hills. This success is due to local ownership over these resources, as well as efforts in strengthening local institutions through social cohesion within the community. We argue that the institutional and social context of social capital formation can be crucial. An important related issue is how the formation of social capital is affected by ethnic heterogeneity. Screening the literature, we found limited empirical evidence (mostly based on aggregate data) purporting opposing views.

Ethnic diversity can indeed be viewed as not conducive to social capital formation as individuals tend to distrust members from other castes. More inter-group relationships, however, can reduce prejudice and increase cohesion. This paper aimed to contribute to this literature by providing some micro evidence from Nepal. To measure ethnic diversity, we adopt a more refined fragmentation index that encapsulated information on evenness of the caste groups and their abundance. We argue that is an important feature. This index can control for both the proportional abundance of the groups and how evenly these groups are distributed within a village. We find that the relationship between heterogeneity and social capital is non linear. It follows an inverted U shape. At the beginning these two variables seem to go hand in hand. More ethnic diversity is conducive for more participation in bridging social capital activities. After a threshold level, however, more diversity has a detrimental impact on social capital formation. This may indicate that the extent of heterogeneity matters in determining the direction of the empirical relationships. We also find that this pattern is very general and applies to all the different caste groups. One of the main contributions of the paper is to provide empirical evidence for the link between caste and participation of household in a variety of meetings related to CF management (our measure of social capital), on the one hand, and the relationship between heterogeneity and participation in collective action, on the other.

At this point some caveats are crucial. First, our evidence is based upon cross sectional evidence. Arguably, some of the effects of ethnic diversity on social capital formation are instead dynamic. Second, community diversity is treated as exogenous to the household. This seems plausible from a theoretical perspective, and it is corroborated by the inclusion of community fixed effect. Nevertheless, we cannot exclude all the possible avenues of indigeneity. Therefore, we invite the readers to take these results with caution. Third, our results stem from two areas of Nepal and one very specific dimension of heterogeneity (caste). Therefore, the external validity should be considered somewhat limited. Further micro level research—ideally based on larger panel data set—is needed to shed additional light on the mechanism behind the relationship of interest. Moreover, further insights on the link between institutional and social structure and performance of community-based groups such as CFUGs would also help to guide the optimal policy design in this area.

## References

Abrams, D., Hogg, M.A., & J.M. Marques (2005). *The social psychology of inclusion and exclusion, New York: Psychology Press.*

*Adger, W.N., (2003). Social* capital, collective action, and adaptation to climate change. *Economic Geography,* 79(4), pp. 387-404.

Adhikari, B., (2005). Poverty, property rights and natural resource: Understanding distributional implications of common property resource management. *Environment and Development Economics 10*: pp. 7–31.

Adhikari, B & Di Falco, S.,(2009). Social inequality, local leadership and collective action: An empirical study of forest commons. E*uropean Journal of Development Research, 21*, pp. 179-184.

Adhikari, B., &Lovett, J.C. (2006). Transaction costs and community-based natural resource management in Nepal, *Journal of Environmental Management 78 (1)*, pp. 5-15.

Adhikari, B & Lovett, J.C., (2006). Institutions and collective action: does heterogeneity hinders community-based resource management? J*ournal of Development Studies, 78 (1),* pp. 5-15.

Agrawal, A., (2001).Commons property institutions and sustainable governance of resources. *World Development, 29 (10),* pp. 1649-1672.

Agrawal, A., (1999). *Greener pastures: Politics, markets, and community among a migrant pastoral people,* Durham, NC: Duke University Press.

Alesina, A., Baqir, R. & Easterly, W.(1999). Public goods and ethnic divisions. *Quarterly Journal of Economics, 114 (4)*, pp. 1243-84.

Alesina, A. & La Ferrara, E. (2000). Participation in heterogeneous communities. *Quarterly Journal of Economics, 115,* pp. 847–904.

Alesina, A. & E. La Ferrara, E. (2002). Who trusts others? *Journal of Public Economics, 85,* pp. 207–234.

Allport, G. W. (1954). *The nature of prejudice. Cambridge,* MA: Addison-Wesley.

Anderson, Christopher J., & Aida Paskeviciute. (2006). How linguistic and ethnic heterogeneity influences the prospects for civil society.*The Journal of Politics 68 (4)*,pp. 783-802

Andrews, R., (2009). Civic engagement, ethnic heterogeneity, and social capital in urban areas: evidence from England. *Urban Affairs Review, 44 (3)*, pp. 428-440.

Arefi, M., (2003). Revisiting the Los Angeles neighbourhood initiative (LANI): lessons for planners. *Journal of Planning Education and Research, 22 (4)*, pp. 384.

Arora, S. & Sanditov, B., 2009. Caste as community? Networks of social affinity in a South Indian Village. *Working Paper No. 37*, Maastricht, The Netherlands: United Nations University - Maastricht Economic and Social Research and Training Centre on Innovation and Technology Keizer Karelplein

Baker, M., (1997).Persistence, transformation and demise within the gravity flow irrigation systems (Kuhls) of Kangra Valley, Himachal Pradesh, India. In: *Workshop on co-operative management of water resources in South AsiaDecember 15-17, 1997,*Vancouver: Centre for India and South Asia Research (CISA), University of British ColumbiaCanada.

Baland, J. M. & Platteau, J., (1996). *Halting degradation of natural resources: Is there a role for rural communities?"* New York: FAO, Oxford University Press.

Baland, J.M. & Platteau, J., (1997). Wealth inequality and efficiency in the commons, part I: *the unregulated case. Oxford Economics Paper 49,* pp. 451-482.

Baland J.M., Bardhan, P. Das S., & Mookherjee, D.,(2010). Forests to the people: Decentralization and forest degradation in the Indian Himalayas. *World Development 38(11),* pp. 1642-1656

Ballet, J., Sirven, N., & Requiers-Desjardins, M., (2007). Social capital and natural resource management: a critical perspective. *The Journal of Environment and Development, 16 (4),* pp. 355-374.

Bardhan, P. & Dayton-Johnson, J.,(2000). *Heterogeneity and commons management, Berkeley:* Department of Economics, University of California, Berkeley, USA, mimeo.

Berkes, F., Ed.,(1989). *Common property resources: Ecology and community based sustainable development,* London: Belhaven Press.

Béteille, A., (1969) Castes, Old and new: *Essays in social structure and social stratification,* Bombay: Asia Publishing House.

Beteille, A., Ed., (1983). *Equality and inequality: Theory and practice*. Delhi, India: Oxford University Press.

Bossert W., D'Ambrosio, C., and La Ferrara, E., (2008). *A Generalized Index of Fractionalization. Cahiers de recherche 01-2008,* Montreal : Centre interuniversitaire de recherche en économie quantitative, CIREQ.

Bourdieu, P., (1980). Le capital social, notes provisoires: [The social capital, provisional grades]. Actes de la Recherche en Sciences Sociales, 31, pp 2-3.

Bourdieu, P., (1986). The forms of capital. In J. Ridchardson (Ed.), Handbook of theory and research for the sociology of education. Westport, CT: Greenwood, pp. 241-258.

Bouma, J., Bulte, E., & Soest, D. van (2008). Trust and cooperation: Social capital and community resource management, *Journal of Environmental Economics and Management, Volume 56, Issue 2,* pp. 155-166

Bromley, D. W. (1993). Reconstituting economic systems: Institutions in national economic development. *Development Policy Review 11,* pp. 131-151.

Bryant, C., & Norris, D. (2002). Measurement of social capital: The Canadian experience. In: *Paper presented at the International Conference on Social Capital Measurement, 25-27 September, London, UK.*

Coffe, H., (2008). Social capital and community heterogeneity. *Social Indicator Research.* Volume 91, Number 2, pp. 155-170

Coleman, J. S., (1988). Social capital in the creation of human capital. *American Journal of Sociology 94*, pp. S95-S120.

Charnley, S. & Poe, M.R., (2007). Community forestry in theory and practice: where are we now? *Annual Review of Anthropology, 36*, pp. 301–36

Collett, G., Chhetri, R., Jackson, W.J. and Shepherd, K.R., (1996). NACFP: *Socio-Economic Impact Study.* Canberra, ACT, Australia: ANUTECH Pty Ltd.

Costa, D.L., & Kahn, M.E. (2003). Civic engagement and community heterogeneity: an economist's perspective. *Perspectives on Politics, 1 (1),* pp. 103-111.

Dasgupta, P. & Serageldin., I. Eds., (2000). *Social capital: A multi-faceted perspective,* Washington, D.C.: The World Bank.

Easterly, W. and Levine, R.,(1997). Africa's growth strategy: policies and ethnic divisions. *The Quarterly Journal of Economics, 112 (4),* pp. 1203-1250.

Edmonds, E., (2002). Government-initiated community resource management and local resource extraction from Nepal's forests. *Journal of Development Economics, 68,* pp. 89–115.

Gordon, M. (1964). *Assimilation in American life: The role of race, religion and national origins.* New York: Oxford University Press

Hewstone, M. et al. (2005). Intergroup contact in a divided society: challenging segregation in Northern Ireland. In: Abrams, D., Marques, J. M. and Hogg, M. A., Eds., *The social psychology of inclusion and exclusion. Philadelphia, PA:Psychology Press,* pp. 265–292.

Hsiao C. (1986). *Analysis of panel data.*Cambridge: Cambridge University Press.

Jodha, N.S., (1986). Common property resources and the rural poor in dry regions of India. *Economic and Political Weekly, 21 (27),* pp. 169-181.

Kanbur, R., (1992). Heterogeneity, distribution and cooperation in common property resource management, *Background paper for the 1992 World Development Report.* Washington, DC: The World Bank.

Keylock C.J. (2005). Simpson diversity and the Shannon–Wiener index as special cases of a generalized entropy. *Oikos 109,* pp. 1.

Killerby, P., & Wallis, J., (2002). Social capital and social economics. *Forum for Social Economics, 32 (1)*: September, 2002.

Knack, S., (2002). Social capital and the quality of government: evidence from the states. *American Journal of Political Science, 46 (4),* pp. 772-285.

Magurran A. (2004). *Measuring ecological diversity.* Blackwell Publisher UK

Marshall, M. & Stolle, D. (2004) Race and the city: Neighbourhood context and the development of generalised trust, *Political Behaviour, 26(2),* pp. 125-153

McKean, M., (1992). Management of traditional common lands (Iriachi), in Japan', in National Research Council. In: *Proceedings of the conference on common property resource management,* Washington DC: National Academic Press, pp. 533–589.

McLaren, L. M. (2003). Anti-immigrant prejudice in Europe: contact, threat perception, and preferences for the exclusion of migrants. *Social Forces, 81,* pp. 909–937.

Miguel, E., & Gigerty, M.K. (2002). Ethnic diversity, social sanctions, and public goods in Kenya. Unpublished manuscript: University of California, Berkeley.

Naidu, S., (2009). Heterogeneity and collective management: Evidence from common forests in Himachal Pradesh, India. *World Development* Vol. 37, No. 3, pp. 676–686.

Narayan, D. & Pritchett, L.(1999). Cents and sociability: household income and social capital in rural Tanzania. *Economic Development and Cultural Change, 47 (4)*, pp. 871-897.

Natrajan, B., (2010). *Crafting Caste in India: Caste as Cultural Community.* New Delhi: Routledge

Nelson, B.J., Kaboolian, L., & Carver, K.A. (2004). *Bridging social capital and an investment theory of collective action*: *evidence from the Concord project.* Chicago: American Political Science Association.

Neba, N.E., (2009). NGO input and stakeholder participation in natural resource management: Example of North West Cameroon. *International NGO Journal, 4 (3),* pp. 050-056.

NPC, (2007). *InterimPlan,* Kathmandu: National Planning Commission, Government of Nepal.

Oakerson, R., (1992). Analyzing the commons: a framework. In: D. W. Bromley, Ed., *Making the commons work: Theory, practice and policy,* USA: Institute for Contemporary Studies, pp. 41-59.

Ollagon, H., (1991). Toward to patrimonial management of forests: biological quality protection. *Arbres, Forets et Communautes Rurales, 3,* pp. 32-35.

Olson, M., (1965). *The logic of collective action: Public goods and the theory of group.Cambridge:* Harvard University Press.

Ostrom, E., (1990). *Governing the commons: The evolution of institutions for collective action*, Cambridge: Cambridge University Press.

Ostrom, E., (1992). *Crafting institutions for self-governing irrigation systems*. Institutions for Contemporary Studies Press. San Francisco, USA.

Paldam, M., (2000). Social capital: one or many? Definition and measurement. *Journal of Economic Surveys, 14 (5),* pp. 629-653.

Paraskevopoulos, C.J., (2007). Social capital and sustainable development in Greece. [online]. Available at: *http://www.lse.ac.uk/collections/ESOCLab/pdf/SOCCOH%20Social%20capital%20and%20economic%20development%20in%20Greece.pdf*

Portes, A., (1998). Social capital: its origins and applications in modern sociology. *Annual Review of Sociology,* 24:1-24.

Pretty, J. & H. Ward,(2001). Social capital and the environment. *World Development, 29 (2),* pp. 209-227.

Pretty, J., (2003). Social capital and collective management resources. Science, 302 (5652): pp. 1912-1914.

Putnam, R., (2007). E pluribus unum: the evolution of social capital in contemporary society. *Political Studies, 59 (4),* pp. 1143-72.

Putnam, R., (2000). *Bowling alone: the collapse and revival of American community*. New York: Simon and Schuster.

Reimer, B., Lyons, T., Ferguson, N., & Polanco, G. (2008). Social capital as social relations: the contribution of normative structures. *Sociological Review, 56(2),* pp. 256-274

Ruston, D., (2002). *Social capital matrix of surveys.* London: Social Analysis and Reporting Division, Office of National Statistics.

Sethi, R. & Somathan,E., (1996). The evolution of social norms in common property resources. *American Economic Review,* 86 (4).

Singh, N., 2004. *Water management traditions in Rural India: valuing the unvalued*. Sweden: Department of Land and Water Resources Engineering, Royal Institute of Technology

Stolle D. & Rochon T. (1998). Are all associations alike?: Member diversity, associational type and creation of social capital, *American Behavioral Scientist, 42,* pp. 47-65

TTI, (2000). Harness the caste system. *The Times of India*, June 4, 2000.

Uphoff, N., & Wijayaratna, C.M.,(2000). Demonstrated benefits from social capital: the productivity of farmer's organizations in Gal Oya, Sri Lanka. World Development, 28 (11), pp. 1875-1890.

Varshney, A (2003). *Ethnic conflict and civic life: Hindus and Muslims.* 2nd edition. New Haven: Yale University Press.

Wade, R., (1988). *Village Republics: Economic Conditions for Collective Action in South India,* Cambridge: Cambridge University Press.

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# REDD+ as a Development Tool to Improve Rural Livelihoods in Nepal

N. P. Dhital, H. L. Shrestha, B. M. Shrestha, S. Gautam and B. R. Rijal

## Abstract
REDD+ initiative is being implemented in forest rich developing countries since 2007. Under this program, developing countries receive economic incentives for enhancing carbon sequestration or reducing greenhouse gas (GHG) emissions from their forests. This incentive could play an important role in improving the livelihood of forest dependent communities in those countries. Carbon trading mechanism of the REDD+ considers the sequestered carbon as a marketable commodity where developing countries can be benefitted for environmental services provided by their forests. Nepal is one of the focal countries for REDD+. Due to its successful community forestry initiative, it has started receiving the REDD+ monetary benefits. However challenges remain on accounting carbon stock in the forests in a spatio-temporal scale to claim reasonable carbon credits as well as distributing REDD+ benefits in an equitable manner. As the scale of the REDD+ implementation is not yet clear, in this chapter, we aim to assess the existing practices of REDD+ initiatives, identify major gaps and provide alternative options to enhance the opportunities for sustainable livelihoods in rural Nepal based on the review of published evidence.

Keywords: REDD+, carbon sequestration, deforestation, livelihood, Nepal

## 1. Introduction
Forests are not only linked closely to the rural livelihood but are also important sink of atmospheric carbon dioxide ($CO_2$). Recognising this fact, United Nations Framework Convention on Climate Change (UNFCCC) introduced a program entitled Reducing Emissions from Deforestation and Forest Degradation (REDD) in 2005 and later upgraded to REDD+ to accommodate other ecosystem services of forests such as forest conservation, sustainable management of forests, enhancement of forest carbon stocks, and reduction of greenhouse gas (GHG) emissions (UNFCCC, 2007). The REDD+ mechanism has emphasised participatory conservation activities by providing incentives to local communities, securing land tenure rights to them, and maintaining good governance (Eliasch, 2008). The Green Climate Fund (GCF) has also been introduced to support developing

countries to limit or reduce their GHG emissions from forests and to adapt the impacts of climate change, taking into account the needs of those countries particularly vulnerable to the adverse effects of climate change (UNFCCC, 2007). The participating developing countries receive financial support from this fund to execute policies and measures (PAMs) to optimise net carbon balance in their forests. Under the REDD+ mechanism, forest rich developing countries have a high potential to be benefitted through carbon trading (Gibbs et al., 2007; Gullison et al., 2007; Canadell & Raupach, 2008; Malhi et al., 2008).

The net carbon balance should be measurable, reportable and verifiable. The creditable carbon is estimated by comparing current deforestation and forest degradation rates with baseline or reference scenario (Peskett et al., 2008). Emission reductions can only be achieved when enforcement and/or opportunity costs are covered by payments. It means that the major drivers of deforestation (such as logging and agricultural expansion) are controlled through policies and measures that include reward and compensation functions. Rewards can introduce positive change in behaviour such as sustainable forest management practices, whereas compensation can help to cover the opportunity costs forgone while introducing new measures.

REDD+ as an emission reduction mechanism can be implemented at a project, sub-national and/or national levels based on the options and effectiveness of the project(s). Linking the performance of each sub-national initiatives to the performance of the country as a whole and vice-versa is a key for the success of REDD+. Acknowledging the heterogeneity among the communities and localities, a three-phased approach of REDD+ implementation was suggested (UNFCCC, 2010) with the assumption that it would help countries to prepare for REDD+ implementation through capacity building. If REDD+ were applied in phases, it could use both fund-based and market-based financial resources. However, the way and the order in which these phases will be applied depend on the situation of the site and opportunities available for funding. The phased approach generally consists of a preparatory or ‘readiness’ phase, policies and measures phase and performance based carbon payments phase (Gordon & Tam, 2010). Currently, a number of developing countries including Nepal are working for REDD+ readiness (Dangi & Acharya, 2009).

Since forests in developing countries like Nepal and elsewhere are closely linked to the livelihoods of local communities, inclusiveness is a pre-condition for its successful implementation. Nepal may have some comparative advantages as the country’s highly rated community forestry program is praised for its inclusiveness (Shrestha et al., 2012). Since this program is also eligible under the REDD+ mechanism, revenue from carbon trading could be a good motivation for the communities to be the part of this new mechanism. After all, they can use this revenue for the improvement of the livelihood of their own communities in addition to sustainable management of their forests. Indeed, sustainable forest management is required to reduce the likelihood of natural disasters, conserve biodiversity and eventually enhance their forest carbon stock, which is the basis of the payment.

Introducing REDD+ mechanism covers a wide range of activities which might require a greater degree of expertise from the outset. Reliable baseline data and a robust method are required to quantify net annual carbon balance in different forest types in the country. Baseline data is the backbone of the whole initiative as it provides the basis for payments. REDD+ has changed the notion of forests from local livelihoods to forests for global environmental services (Paudel et al., 2015). In this context, emerging challenges to implement REDD+ include governance at multiple scales, rights to carbon credits and tenure security, benefit sharing at different scales and equity.

Nepal has made significant progress towards readiness for the REDD+ and has already started some pilot projects. However, some scholars argue that elite dominance in the process of contract negotiation could result in the left out of the marginalised communities, who depend on forests for their livelihood (Paudel et al., 2015). Moreover, forests put under REDD+ mechanism are locked for longer period of time further restricting the access of the traditional users regardless of market price of a carbon credit (Paudel et al., 2015).

In this chapter, we critically evaluate the existing practices of REDD+ initiative in Nepal, identify major gaps and provide options to enhance the opportunities for sustainable livelihood in rural Nepal and elsewhere through this innovative mechanism.

## 2. Developing a REDD+ project

Developing a REDD+ project is a complex process requiring expertise on multiple disciplines such as law, business, social science and forestry. It requires complying with rigorous standards and carrying out the challenging work of conservation and development in the field. It further requires carbon credits to be quantified using complex methodological approaches as elaborated in a project design document (PDD). The PDD also includes a comprehensive monitoring plan for the measurement of carbon benefits actually occurring on the ground. It needs to be independently validated and/or verified. For the issuance of carbon credits after implementation of a project, periodic monitoring reports need to be verified by independent third party auditors and this process continues until the end of the crediting period. Figure 1 outlines the major steps to be followed to develop and implement a REDD+ project.

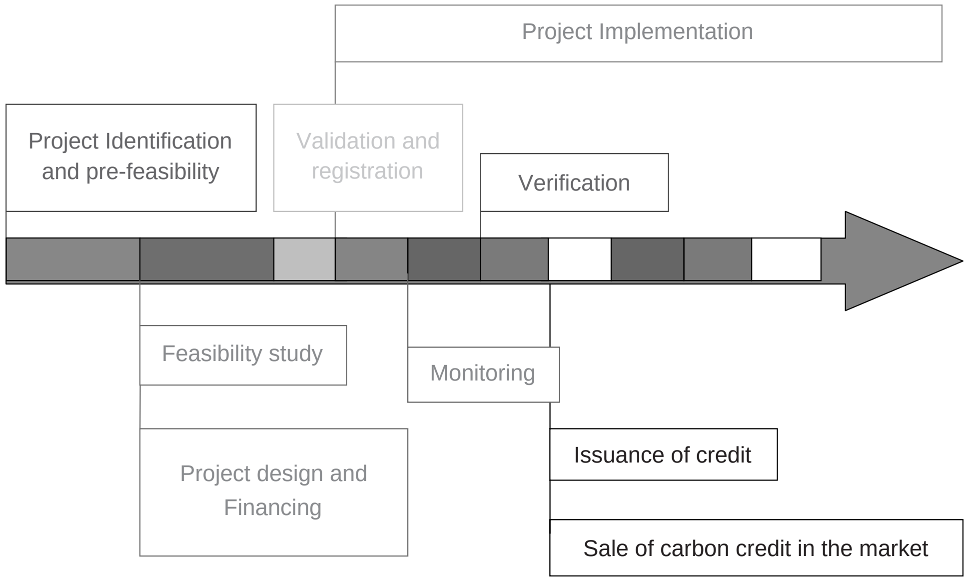


Figure 1: Chronology of development of a REDD+ project
(modified after Olander & Ebeling 2011).

Note: First four blocks from left to right (blue, purple, yellow and green) represent four initial, distinct and important steps of a REDD+ project development. A block of three coloured boxes that follow to the right (red, blue and white) represent a block of periodic repetitive actions. Green coloured box represents continuous project implementation until the end of crediting period.

The first step of a REDD+ project development is to conduct an assessment whether or not the developed project idea is feasible. Key action in this step is to analyse the drivers of deforestation and the potential for emission reductions. This step may result in a REDD+ project idea note (R-PIN). Once the R-PIN is developed, the second step is to conduct a detailed feasibility study that may include financial, social and environmental potentials. This step produces a PDD. Once the PDD is on hand, the proponent may approach a third party validator to validate the PDD to ensure that the emission reductions claimed in the PDD are valid. Once the validation report is produced with a positive outcome(s), the proponent may head towards project registration in a carbon registry such as voluntary carbon standard or UNFCCC. In general, project implementation follows the registration of the project. Once the implementation is started, the proponent requires monitoring the project as outlined in the monitoring plan of the PDD. This data is used by a third party verifier to verify whether the real emission reduction took place over that period. Once the verification produces a positive result, emission reductions may be credited to the proponent by the registrar. The process of monitoring, verification and issuance of carbon credits (blocks of red, blue and white boxes in Figure 1) continues until the end of the crediting period of the project. See Olander and Ebeling (2011) for the details of the process.

## 3. REDD+ development in Nepal

Forests in Nepal have been historically managed for fuel-wood and fodder production, as an integral part of the farming systems. As the country is located in the younger and fragile mountainous region, role of forests in conservation of landscape has been historically acknowledged. However, acknowledgement of its role in mitigating GHG emissions is relatively new. It started getting recognised some 2-decades ago, particularly after Nepal's adoption to UNFCC in 1994. After adoption of the convention, Nepal initiated activities targeted towards the reduction of GHG emissions. In 1994/1995, it produced the report of national inventory of GHG emissions, first of its kind for the country. This inventory report (GON, 2004) showed the net $CO_2$ emission from forestry and land use change to be 8,117 Gg. Similar emissions from fossil fuel consumption was 1,465 Gg (APN, 2009). Of the total $CO_2$ emitted from forestry sector (22,895 Gg), about 65% (14,738 Gg) was sequestered by forest. It demonstrates the importance of forestry sector in mitigating the emission of GHG in the country (APN, 2009). Increasing forest cover and biomass increases the carbon sink. Hence the forest management and conservation can have value addition through carbon trading in addition to ecosystem conservation and socio-economic development (APN, 2009). Likewise, improved farming (e.g., fertiliser, waste and water management) and livestock systems help improve the GHG budget (APN, 2009).

### 3.1 Risk and vulnerability of projected climate change in Nepal

Nepal is situated in the northern border of the tropical climate and represents the transition of eastern and western bio-climatic and vegetation zone (Sundberg et al., 1993b). Due to its topographical and geomorphological variations such as elevation and land terrain, the local climate varies from tropical (southern plain) to alpine (Himalayan range) within an average width of 150 km (Bhattarai et al., 2012). Bhattarai et al. (2012) reported that temperature in Nepal increased at the rate of 0.03-0.05$^0$C year-1 during the period from 1976 and 2005. Temperature and rainfall determine the types of vegetation, their growth and water budget. Rise in temperature is expected to increase the risk of changes in species composition including extinction of already vulnerable species in the region (UNFCCC, 2007). This change will have an ultimate impact on forest based livelihoods. In Nepal, increasing temperature in the north is expected to be more detrimental as it will increase the risk of glacial flooding from the Himalayan chain resulting in loss of vegetation and habitat as well as farming systems downstream. It is predicted that the rise in 3-4$^0$C temperature by the end of this century may cause a loss of roughly 58% of snow and 70% of the glaciers in the Himalayas (APN, 2009).

The changes in climatic pattern will have an ultimate impact on the livelihoods of people as it will affect all spectrum of life. Agriculture production is expected to decrease due to loss of top soil (fertile layer) from frequent floods and landslides. The risk of diseases such as malaria, kalajwar and Japanese encephalitis is expected to increase due to rising temperature and hydrological anomalies (WHO, 2010). A study by Strengthened Actions for Governance in Utilization of Natural Resources (SAGUN), a program of the USAID (SAGUN, 2009), found that temperature is increasing across the country over the last 30-years with winter temperature increasing more than mean annual temperature. Similarly, rainfall patterns are changing with altered/delayed monsoon, shorter rainfall season and erratic pattern of the rainfall. This change in climatic pattern has resulted in increased drought, fire, landslides and river bank erosion. It also resulted in changed hydrological regime. SAGUN (2009) further suggested that impact of climate change (threat to agriculture, biodiversity, health and infrastructure) has severely impacted livelihoods of the local people. Frequent floods washed away agriculture lands, destroyed crop yield and took lives of human and livestock. Drought resulted in decline in crop production. SAGUN (2009) found that impact of the changes in climatic pattern was disproportionate among the genders, occupational groups and the people of different economic classes. In Nepal, women are responsible for fetching drinking water and taking care of children as men out-migrate for labour work (See Chapter 8 by Naya et al. and Chapter 12 by Mahat). Changes in hydrological regime and outbreak of disease made them more vulnerable than men. Washing away the productive agriculture land of the small holders made them more vulnerable than well off farmers as they have lesser livelihood options than the relatively rich (SAGUN, 2009).

Altogether, although the net GHG emissions in Nepal is far less than any developed country or any of the emerging economies, it is vulnerable to climate change in different spheres such as public health, livelihood strategies and environment. Its fragile landscape, excessive glacial run-off, forest and agriculture based subsistence economy warrants early action to reduce such vulnerability.

### 3.2 Forest condition and emission trading potential

Forests are an integral part of the farming system in Nepal. Farmers must have access to forest products such as leafy biomass for fodder and animal bedding, fuel wood for energy, and timber for building and agricultural implements (Mahat, 1987; Malla, 2000). In response to increasing concerns over the degradation of national forests, developing countries around the world started decentralisation of natural resource management (Ribot, 2004). Nepal also initiated such practice in 1978 with the provisions in the Forest Act of the roles of decentralised political units in forest management. These provisions were integrated in the form of community forests in the Forest Act 1993. It proved to be a tremendous success to keep the trees standing in the mountainous regions. However, challenges remain in the southern part of the country where population is denser and value of tree species in the forest is higher. A bold and innovative initiative (similar to community forestry) is needed to solve the deforestation and forest degradation crises in Siwalik and Terai particularly in the face of current ‘Chure’ crises. Chure is a transition zone between southern plain and northern mountainous area of Nepal. This geologically fragile zone covers about 13% landmass of the country and a critical ecosystem to sustain the livelihood of people in the southern plain as it provides vital water resources and is rich in biodiversity (Gautam, 1996). Population pressure due to migration of people from hilly region and Southern neighbour in the Terai region was putting pressure in this zone since early 1960s (Gautam, 1996). Recent rampant deforestation and random extraction of soil, sand, gravel and stone to use in the construction industry or to export to India only made the situation worse which we would like to refer here as ‘Chure Crisis’.

Systematic deforestation in Nepal started after proclaiming the Forest Nationalisation Act 1957. Declaration of the eradication of malaria from the country shortly after added the momentum to deforestation in southern part of the country. However, we do not have accurate data to quantify the forest coverage in 1957. The first survey of the forest coverage carried out by the Water and Energy Commission secretariat in 1964/65 showed that 45% of the country's land mass was covered by forest. The Land Resource Mapping Project (LRMP, 1986) showed that the forest cover was about 43% of the country's landmass. Reports show that the deforestation rate has slowed down over the years. It was 1.7% per year between 1978 and 1994 (Acharya & Dangi, 2009; Dhital, 2009) and 1.23% per year during 1990-2010 (FAO, 2010). Again, the rate of deforestation varies geographically. For example, during the period 1978-1990, deforestation rate in the Terai was 1.3% whereas it was 2.3% in the hilly region (FRIS, 1999; Dhital, 2009). The difference is mainly explained by the expansion of farm-based economy in the hilly region and limited commercial exploitation in theTerai during that period (Sundberg et al., 1993). If we account only the forests (excluding shrub lands), the forest coverage is substantially reduced from 45% in 1965 (FRA, 1964) to 29% in 1990s (NFI, 1994).

Different studies have accounted for forest stocks in terms of carbon storage at tree and/or stand level. For example, the mean carbon stock per mature tree was found to be 1894.08 kg C in a study in sub-tropical region of southern Nepal which is equivalent to 200 ton C ha-1 (Bautista, 2012). Similar study in a temperate climate in central Nepal found a carbon stock of 117.44 ton C ha-1 (Shrestha et al., 2012). These studies show a good potential for Nepal to be engaged in incentive based emission reduction initiatives such as REDD+ as there seems significant amount of carbon stored in Nepal's forests.

### 3.3 Nepal's initiative in GHG emissions reduction through REDD+

From the outset of the Earth Summit in 1992, Nepal has been actively participating and taking necessary actions against the GHG emissions. Being the first party to ratify Kyoto Protocol in 2005 among South Asian nations, Nepal showed its concerns over climate change. The Kyoto Protocol enforces to increase the carbon sink by afforestation and reforestation activities. It was estimated that afforestation and reforestation projects will absorb about 15% of the global carbon emission (Sundberg et al., 1993a). The Kyoto Protocol set binding emission targets for developed countries that would reduce their emissions on average 5.2% below 1990 levels by the year 2012. But it disregarded the necessity of binding regulation to emerging economies such as China and India. Focusing on afforestation and reforestation activities, the Kyoto Protocol did not take into account the deforestation and forest degradation (Penman et al., 2003), whereas there has been over 13 million hectares of forest disappeared annually contributing to roughly 18% of the global GHG emission (FAO, 2010; IPCC, 2007). The scope and importance of the deforestation and forest degradation was recognised by the UNFCCC in its 11th Conference of Parties (CoP 11, Montreal, 2005) and related discussion was started for REDD. In the CoP 13 in Bali (2007), REDD was expanded to REDD+ which included the activities related to conservation and sustainable management of forests and enhancement of forest carbon stocks.

Nepal government's Ministry of Environment, Science and Technology (MEST) is designated as a line ministry to deal with Kyoto Protocol. Ministry of Forest and Soil Conservation (MoFSC) has been mandated to look after the REDD+ related activities. From the Ministerial Decree, the MoFSC has established a three-tiered institutional mechanism for implementing REDD+. It consists of the REDD Coordinating and Monitoring Committee in the apex, the REDD Working Group at the operational level, and the REDD Implementation Center as the coordinating institution under the MoFSC. In addition to these bodies, a stakeholder forum has been established to engage a wide range of stakeholders in the entire REDD+ processes (MFSC, 2009).

### 3.4 REDD readiness process in Nepal

The first step in the REDD+ readiness process is the finalisation of REDD Readiness plan (RRP). RRP is a national strategy to prepare for a result based payment mechanism for the REDD+. The ultimate goal of REDD Readiness process is to prepare National REDD Strategy (MFSC, 2009). It requires the demonstration of country's willingness, and technical and institutional capacity to execute REDD+ activities. 'Readiness' is normally focused on the following national-level priority issues;

- Preparation of national strategies through local stakeholder consultations to reduce GHG emissions
- Institutional, technical, human capacity building
- Designing/implementing monitoring, reporting, and verification (MRV) systems, and national forest carbon accounting systems
- Developing national systems for determining baselines and/or reference emissions levels
- Transparent, equitable and accountable benefit sharing mechanisms
- Developing safeguards and grievance mechanisms to protect the interests of forest communities and the poor
- Clarifying national land, forest and carbon tenure rights

Nepal has now finalised the REDD Readiness proposal (Gautam, 2011; Gurung & Kokh, 2011). The vision for Nepal's REDD strategy is:

By 2013 and beyond, our greenhouse gas emissions resulting from deforestation and forest degradation will be significantly reduced by forest conservation and enhancement, by addressing the livelihoods concerns of poor and socially marginalised forest dependent people, and by establishing effective policy, regulatory and institutional structures for sustainable development of Nepal's forests under the forthcoming new constitutional framework.

It has proposed the activities including awareness, capacity building, governance structure from national to district level, strategy development, implementation mechanisms and determination of reference emission level based on LRMP 1978 data. More than 18,000 community forestry user groups are identified as local stakeholders, who require capacity building trainings.

## 4. Forest inventory as a foundation for REDD+ activities in Nepal

### 4.1 National forest inventory and quantification of carbon pools

The latest national forest inventory (NFI), expected to be released by 2015, will provide authentic information on forest growing stock at the country level until 2010. The last NFI was released in 1994. Apart from a release in 2005 by the department of forests (DOF) of a comparison of land cover changes in Terai region between 1990 and 2000, no authentic information of the NFI has been released since.

However, some independent initiatives are ongoing. Integrated Mountain Development (ICIMOD), FECOFUN and ANSAB[1] came up with the guidelines for the forest carbon quantification and annual monitoring of forest carbon in 2010. Worldwide Fund for Nature (WWF) Nepal is working on some other landscapes such as Terai arc (TAL), Sacred Himalayas, Chitwan Annapurna Landscape (CHAL) etc. It has extensive data on the land use cover of those areas and also conducted a rapid forest inventory to get the baseline information on forest and soil carbons (Gurung & Kokh, 2011; Gurung & Acharya, 2011). After completion of a NORAD[2] funded REDD+ project implemented in 3-watersheds based in Gorkha, Chitwan and Dolakha districts, ICIMOD has taken initiative to use these sites as study sites for further research mainly on developing spatially explicit forest monitoring systems including the scopes of application of remote sensing, geographic information system (GIS) and other available tools to estimate forest biomass and carbon stocks.

Community forestry also requires up to date information on forest inventory for handover and/or renewal of public forest to its user groups in a periodic basis. Depending on the availability of resources, tools and expertise, different organisations involved in forest management in Nepal pertaining to REDD+ either at a pilot scale or supporting forest user groups (such as the government of Nepal, ICIMOD, WWF, ANSAB etc.) use different tools ranging from cruising to airborne Lidar technology in order to obtain the most accurate information on forest cover.

### 4.2 Decadal land cover data generation

In line with the Government's National Land Use Policy (2012), ICIMOD has prepared the decadal land cover data for entire country from 1990 to 2010 (Figure 2). There are other ongoing projects (e.g., national land use project (NLUP)) to

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[1] 1 ICIMOD is International Centre for Integrated Mountain Development based in Kathmandu, Nepal, FECOFUN is the Federation of Community Forestry Users in Nepal, ANSAB is Asia Network for Sustainable Agriculture and Bio resources based in Kathmandu, Nepal, WWF is Worldwide Fund for Nature based in Switzerland but operates a chapter in Nepal too.

[2] NORAD is a Norwegian Agency for Development and Cooperation.

prepare such products. NULP is active since 2006. They have prepared district-wise land cover maps as a continuation of Land Resource Mapping Project (LRMP). The Village Development Committee (VDC) level land use zoning activities are also ongoing at different level.

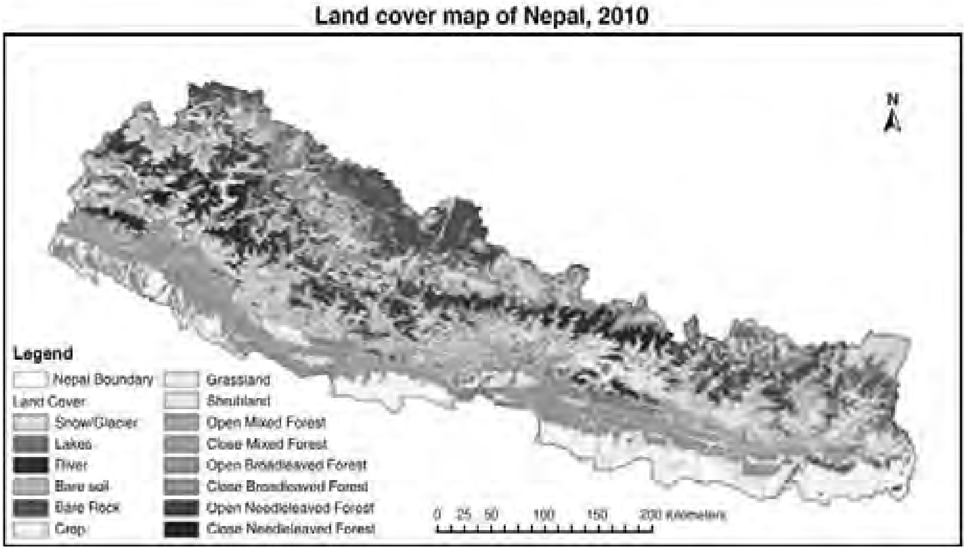


Figure 2: Land cover map of Nepal (ICIMOD 2010)

### 4.3 Linking deforestation and forest degradation to land cover changes

Deforestation can be quantified as the negative changes in forest cover over time (Penman et al., 2003). Similarly, forest degradation signifies the deterioration of forest stock (including carbon) over time (Penman et al., 2003). Forest restoration includes afforestation, reforestation and protection of forests that alters the process of deforestation and forest degradation. As an example, Nepal's community forestry program has tremendously contributed in increasing the forested area through reforestation and afforestation.

Therefore, studies on land use and land cover changes highlight not only the changes in quantity and quality of forests, but also the land use and land cover dynamics as a whole. These studies mainly use the data from national forest inventories which are derived mainly from traditional sample plot based inventories and modern satellite images of different resolutions. Although some studies on the rate of deforestation and forest degradation in Nepal exist, precise information on the rate of deforestation in different physiographic regions and to the spatial extent of the country is still lacking.

### 4.4 Piloting REDD+ in Nepal

The estimation of the forest carbon and its role in climate change mitigation werewell demonstrated by the studies conducted jointly by National Trust for Nature Conservation (NTNC) and ICIMOD in Lalitpur, Manang and Ilam districts (Karky & Skutsch, 2009). These studies mainly focused on the scope of community forestry program in mitigating carbon emissions related to forestry. The Norwegian

Agency for Development and Cooperation (NORAD) funded project carried out a pilot study focusing on carbon measurement, payment mechanism and fund mobilisation. This project was implemented by a consortium of ICIMOD, ANSAB and FECOFUN. The project reported 3-years continuous measurement of the aboveground and belowground forest carbon in three watersheds in Nepal namely Ludikhola (Gorkha), Kayarkhola (Chitwan) and Charnawati (Dolakha). The Pilot study also introduced REDD+ Networks in the communities, established Forest Carbon Trust Fund (FCTF), developed payment mechanism that reaches up to the communities, community MRV framework and also developed REDD+ Project Development Document (PDD). Meanwhile, WWF Nepal has also implemented community level carbon measurement in the Terai Arc Landscape (TAL) project area of southern Nepal.

### 4.5 REDD readiness plan

Nepal is preparing for a full-fledged implementation of the REDD+. It began the process with the establishment of REDD, Forestry and Climate Change Cell under the Ministry of Forests and soil conservation as a separate institution to work on the issues related to REDD+. REDD Cell has already organised many stakeholder consultations and working in line with the REDD Readiness plan of the government.

The REDD Readiness Proposal (RRP) prepared after the formation of REDD Cell (MoFSC, 2009) was submitted to Forest Carbon Partnership Facility (FCPF), which decided to fund the proposal. Some important studies were conducted as a preparation for the implementation plan of REDD+ in the country. Following are some of the studies carried out by the REDD Cell of the government;

- Study on Drivers of Deforestation and Degradation of Forests in High Mountain Regions of Nepal (available at http://mofsc-redd.gov.np/wp-content/uploads/2013/12/Drivers-of-Deforestation-in-HIgh-Mountains.pdf)

- Study on Invasive Alien Species (IAS) as Drivers to Deforestation and Degradation of Forests in Different Physiographic Regions of Nepal (available at http://mofsc-redd.gov.np/wp-content/uploads/2013/12/Invasive-and-Alien-Species-as-Drivers.pdf)

- A Study on The Demand and Supply of Wood Products in Different Regions of Nepal (available at http://mofsc-redd.gov.np/wp-content/uploads/2013/12/Demand-and-supply-of-wood-products.pdf)

- Environmental Safeguards in Forestry Projects in Nepal (available at http://mofsc-redd.gov.np/wp-content/uploads/2013/12/Environmental-Safeguards-in-Forestry-Projects.pdf)

- REDD+ feasibility study (available at http://mofsc-redd.gov.np/wp-content/uploads/2013/11/REDD-plus-feasibility-study.pdf)

- Piloting REDD+ (available at http://mofsc-redd.gov.np/wp-content/uploads/2013/11/REDD-plus-piloting-Report.pdf)

- Role of forest on climate change adaptation (available at http://mofsc-redd.gov.np/wp-content/uploads/2013/11/Role-of-forest-on-climate-change-adaptation-Report.pdf)

Nepal recently prepared an Emission Reduction Project Idea Note (ERPIN) and presented in the FCPF Carbon Fund meeting held in Brussels on 7th March 2014. This note covers twelve districts of TAL area in southern Nepal. The FCPF meeting decided to fund the ERPIN to prepare Emission Reduction Project Document (ERPD) which includes REDD+ Package and payment mechanism. ERPIN envisions payments in 2020, 2025 and 2030 on emission reduction performance (MoFSC, 2014).

### 4.6 Other issues related to REDD+

#### *4.6.1 MRV and REL: national, sub-national and community*

Measurement, Reporting and Verification (MRV) is a system that measures the real carbon stock changes. Although Reference emission level (REL) is not a part of MRV, REL is required to compare the future emissions and removals related to a REDD+ project. REL is, in fact, an expected business-as-usual scenario of the carbon balance resulting from the anthropogenic activities in forests at national or sub-national level. Since performance of a REDD+ project is assessed against the pre-established REL, 19th Conference of Parties (-/CP.19) established that MRV and REL must be consistent (UNFCCC, 2013). One way of making REL and MRV estimates consistent is to use same methodology for estimating forest cover changes. However, preliminary estimates of forest cover changes presented in MRV project report in Nepal are not consistent with the estimates presented in REL project report (Agriconsulting, 2014). The international trend of REDD+ discourse is on landscape approach. Nepal is also following the international trend and set up the Reference Emission Level (REL) for sub-national and national levels such as Terai-Arc-Landscape (Camco, 2015). It is also developing the measurement, reporting and verification (MRV) system of forest cover changes at national and sub-national level (Agriconsulting, 2014). However, no community or local level REL has been defined.

There is no agreement among the scholars on how the REL should be determined. REL is basically the business as usual scenario in the absence of REDD+ activity. However, deforestation is such a complex phenomenon that it requires different and interrelated variables to be considered for modelling. Since deforestation is not predictable as easily as the emission from fossil fuel consumption which is highly correlated with the gross domestic product of a country, more sophisticated modelling approach is required to model the REL which could account for the dynamics of deforestation from one year to another.

#### *4.6.2 REDD+ financing and benefit sharing*

The discussion is ongoing on the modality of REDD+ financing both at international and national levels. Two options of REDD+ financing under discussion in international level include market based and fund based approaches.

Fund-based approach advocates for a fund that distributes payments to participating governments on the basis of performance within REDD+ regime. A number of financing alternatives have been proposed under this option such as developed nations' official development assistance, revenue from carbon permit auctions and funding from international institutions. This approach has been disregarded, alleging that it is difficult to raise enough money compared to market-based approach. Other issues that are used to argue against fund-based approach include the difficulty of inclusively governing an international fund with regard to the representation of donor and recipient countries, civil society and international organisations such as the World Bank and International Monetary Fund and its disbursement procedure (Swickard & Carnahan, 2010). However, Durban Agreements encouraged global environmental facility (GEF) and green climate fund (GCF) to provide result-based finance to REDD+.

A market-based approach is another way of generating financing for REDD+ activities where proponents sale the REDD+ certified emissions reductions (CERs) to private and public actors. These actors can use these CERS to meet their emission reduction targets under national cap-and-trade systems. Market-based approaches are often criticised with the argument that it may disempower the forest dependent communities by recentralisation and land grabbing for carbon. Nepal advocates for a fund-based REDD+ financing option and is working on developing this option. A pilot REDD+ project was developed and implemented in central Nepal by Federation of Community Forestry Users Nepal (FECOFUN), International Centre for Integrated Mountain Development (ICIMOD), and Asia Network for Sustainable Agriculture and Bio-resource (ANSAB) in 2009. This project introduced the concept of forest carbon trust fund (FCTF) as a performance based financial mechanism for local communities to get incentives for their efforts in avoiding deforestation.

Benefit sharing has been one of the key contentious issues in implementation of community forestry in Nepal which is likely to be an issue in implementation of REDD+ as well. The conflict arises between the government and community forest user groups (CFUGs), among the CFUGs and within the CFUG members. REDD+ benefit sharing is important as it influences the participation of women and marginalised section of the population in the process.

In NORAD funded REDD+ pilot projects in central Nepal, 40% of the payments have been channelled for forest development and 60% for community development by following different social criteria such as ethnic diversity, women`s participation in the process and the incidence of poverty within the group (Patel et al., 2013). However, it is still to be decided at the national level whether the benefit of avoided deforestation or reduction in emission is to be channelled through the national budget, in the form of payment to community or pro-poor payment directly as in this pilot project.

#### *4.6.3 Forest governance and security of forest tenure in Nepal in the context of REDD+*

Existing legislation in Nepal, specifically the Forest Act of 1993, defines forest products as all the products available in the forest including timber, leaf, branches, sand, soil, minerals, wild animals and water. This definition does not include carbon as a forest product. It is understandable because carbon transcends the focus of this definition that targets for the physical products. Government has not decided whether it will treat carbon as a product by extending this definition or treat it as a new legal category. The same legislation classifies forest into different tenure systems such as state managed forest, community forest, leasehold forest etc. Community forests are the government forests handed over to community forest user groups (CFUGs) with the responsibility of managing that forest and rights of using forest products (defined above) under the terms set in a forest operational plan. These plans are generally for 5-years renewable upon the implementation of the plan to the satisfaction of the government. Community forestry is the major forest management strategy of the country under which about 16 million hectares of forest across the country has been handed over to about 17 thousand CFUGs. These CFUGs represent about 40% of the country`s population residing in 2.19 million households (DOF, 2012). The community forestry program of Nepal has been praised globally for its decentralised governance system and its inclusiveness, although critics point out sporadic problems including elite dominance in decision making and disproportionate benefit sharing among CFUGs (Paudel et al., 2015). Although use rights are handed over to the CFUGs, land titles are always with the government. There are some regressive provisions in the legislation which have been misused at times by some authorities to withdraw the use right from the CFUGs. Moreover, renewal of the operational plan has never been guaranteed in the legislation. It demonstrates the shaky tenure arrangement of the community forestry program. Improvement in this system is required to ensure the community participation in the REDD+ initiative as their engagement is a pre-condition for its success (Pokharel et al., 2007). We argue that government should extend the existing definition of forest product and provide the right of carbon credits to the CFUGs to ensure the sustainable management of forest resources in the country as evidenced by the community forestry program. This will address the issues raised by some critics that REDD+ will recentralise power over the access and control of forest resources thereby increasing the vulnerability of forest dependent communities (Bastakoti & Davidson, 2014).

REDD+ as a global framework of climate change mitigation poses a serious challenge to the decentralised management of forest resources such as community forestry in Nepal. It will require a new legal framework and will have ramifications for the system of existing forest governance and tenure (Bastakoti & Davidson, 2014). Entering into the global carbon market through REDD+ will push back livelihood activities of forest dependent communities as the priority objective of the forest management system in favour of enhancing carbon stock. Increased vulnerability of marginalised sections of the CFUG was evident in the Ludhikhola watershed of Gorkha district (Nepal) due to stricter rules in forest product utilisation and grazing imposed by the elite groups in the CFUGs (Paudel et al., 2015).

### 4.7 Some bilateral projects working on REDD+ implementation in Nepal

The Hariyo Ban Program is being implemented in Nepal with the support of USAID as a joint venture of WWF Nepal, NTNC, FECOFUN and Care Nepal. The project area extends Terai-Arc and Chitwan-Annapurna landscapes in the country which mainly cover the watersheds of Rapti and Gandaki rivers. This project works in different thematic areas such as biodiversity conservation, sustainable landscape management and climate change mitigation and adaptation. Under the theme of ensuring sustainable landscape management, the project supports the formulation and implementation of policies, strategies, and working guidelines that reduce emissions from deforestation and forest degradation (REDD+), development national capacity for forest inventory management, greenhouse gas monitoring, and equitable distribution of climate finance benefits among all stakeholders, including Community Forest User Groups, bio-gas users, and the Government of Nepal, analysis and addressing systematically the factors contributing to deforestation and forest degradation and develop, test, and expand sustainable methods for payment for carbon credits (USAID, 2015[3]). According to USAID website (see foot note 3), this project has enabled about 1,630,000 of the poorest and most vulnerable people to build the resiliency they need to thrive.

Multi Stakeholder Forestry program (MSFP) with the supports from Swiss, British and Finnish governments is being implemented with the aim of improving livelihoods and resilience of poor and disadvantaged people in Nepal. It also aims to develop Nepal`s forestry sector contribution to tackle climate change. The Forest Carbon Partnership Facility (FCPF) of the World Bank has decided to fund the landscape level emission reduction project document development recently. The World Bank is working to develop this project in partnership with multi stakeholder forestry program, Hariyo Ban program/USAID and other stakeholders. Once implemented, this project will serve as a pilot project to test the feasibility of performance based payment to ecosystem services such as carbon storage and sequestration provided by forests.

## 5. REDD+ and rural livelihoods in Nepal

REDD was originally put forward as an affordable mechanism to mitigate global emission of greenhouse gases (GHGs) as more than 15% of the GHG emission originated from deforestation and forest degradation (IPCC, 2007). It is now expanded to REDD+ by including enhancement of carbon stocks, conservation and sustainable management of forests (UNFCCC, 2007). With expansion in its scope, several subsidiary benefits are likely to occur from this mechanism which include sustainable forest sector development, enhancing rural livelihoods and conserving biodiversity (Paudel et al., 2015).

Under the REDD+ scheme, sequestered and stored carbon is quantified and traded as a commodity where party involved in the process receive direct payments from the buyers of the credits (Wunder, 2005). It provides an economic incentive to the management practices in such a way that the services sustain for the long-term (Pagiola, 2008). A study by Shrestha et al. (2012) in Dolakha district, Nepal suggests that two tonnes of carbon can be sequestrated per year per hectare by

3 http://www.usaid.gov/nepal/fact-sheets/hariyo-ban-project

the current community forest management practices in Nepal. If gross revenue of a tonne of carbon is $10, communities can generate $20 extra revenue annually by managing a hectare of their forest. Community forest user groups (CFUGs) should be able to use that additional income for the improvement of the livelihoods of their members as they do with the income from the sale of forest products. Forest cover in community forests has been increased as opposed to government managed forest (Nagendra et al., 2008). It has a positive impact on livelihoods and food security in the mountainous areas of the country (Ojha et al., 2009). It has also improved the ecological condition of the forest (Pokharel et al., 2007; Subedi, 2006). Community forests have up to 77% canopy cover within 14 years (Gautam & Watanabe, 2002).

REDD+ initiative is an interface among international, national and local interests. It emphasises the involvement of local and indigenous people in the process. In this context, it should not jeopardise the local forest management objective of securing livelihood means of the forest dependent communities in favour of corporate interest. It should also ensure the equitable benefit sharing among the stakeholders through institutional arrangements identifying clearly the rights, responsibility and ownership of the forest resources including carbon credits. Pokharel and Baral (2009) emphasise the guarantee of rights of the local people over forest resources, capacity building of the stakeholders at different level, alternative means of reducing poverty of the forest dependent communities and a real and verifiable emission reduction for a REDD+ initiative to be successful.

Nepal's R-PIN emphasises carbon credit systems to be an instrumental tool in promoting the sustainable development of the country while encouraging the conservation of additional forests. Both tangible and intangible benefits should reach to the poorest of the poor and marginalised groups through a decentralised governance structure. It strongly advocates for meaningful local participation in REDD+ activities through creating an enabling environment for effective and equitable benefit sharing, capacity building, advancing technologies with ground verification, developing and adopting community based methodologies and improving social infrastructure.

Although REDD+ initiative is praised for its potential to improve the livelihoods of the communities involved in the process, research shows that it has disproportionately affected the livelihoods of the forest dependent communities. For example, communities were restricted from grazing in forested areas and were controlled in the collection of wood for charcoal making during the piloting REDD+ in Ludhikhola Watershed in Gorkha district in Nepal. REDD+ has also affected the traditional goat/sheep herders and blacksmiths to the extent that they areforced to migrate from their homes (Paudel et al., 2015). Proponents in this pilot project used gender, ethnicity and occurrence of poverty within the CFUG as criteria to determine the quantity of compensation for the REDD+ activity. It created tension among the CFUGs as people of a caste/ethnicity facing similar economic despair were deprived of the compensation due to their caste/ethnicity. A better approach of the determination of compensation would be based on the proportion of opportunity costs foregone by a particular gender, caste or ethnicity due to the implementation ofa REDD+ project.

## 6. Conclusion

Community forestry (CF) programs in Nepal are likely to have sequestered a substantial amount of carbon, enhancing total carbon stocks, over the past three decades due to the strong focus on conserving forests, increasing forest area through afforestation/reforestation and managing the forests by using different silvi-cultural tools. This 'enhanced carbon stock' has the potential of being rewarded from the carbon credits under the UNFCCC's REDD+ initiative. Additional revenue received through the trade of carbon will provide much needed financial resources for the people involved in forest conservation and management to improve their living conditions.

However, there are challenges and limitations: Community forestry is a project based approach and benefit sharing mechanism under the REDD+ are being discussed at national or sub-national level. Entering global carbon market will pushback livelihood as the main forest management objective. Efforts are needed to ensure that the REDD+ benefits penetrate down to the people involved in forest management and conservation. Universally agreed baseline data and deforestation scenarios in the absence of the REDD+ project must still be established in the country. Forest inventory information is not yet updated. Additionally, a reliable monitoring system for reporting verifiable emission reduction on an annual basis is still to be established. Critics point out that there is a danger that forest dependent communities and indigenous people may be excluded during contract negotiations and eventually from the REDD+ benefits. They might lose their access to the forests they have been dependent on for so long. After all, CF is also sometimes blamed for elite dominance in decision making and benefit sharing. Above all, much needed finance to implement REDD+ is not yet secured. What will be the role of REDD+ initiative in future climate change treaties is uncertain. Therefore, concerted effort and careful planning are needed from all concerned parties to make REDD+ a success. Furthermore, it warrants more robust participatory action research to fill the gaps and for leveraging benefits from REDD+ to local communities' livelihoods.

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## References

APN, (2009). Assessment of role of community forests (CFs) in $CO_2$ sequestration, biodiversity and land use change. In: Network, A.P. Ed.. Asia Pacific Network,

Bautista., (2012). *Biomass/carbon estimation and mapping in the subtropical forest of Chitwan, Nepal: A comparison between VHR GeoEye satellite images and airborne LiDAR data.* Ontario: Advanced Agriculture Leadership Program.

Bhattarai, T., Skutsch, M., Midmore, D., Rana, E.B., (2012). The carbon sequestration potential of community based forest management in Nepal. International Journal of Climate Change, 3, pp. 233-254.

Canadell, J.G., &Raupach, M.R., (2008). Managing forests for climate change mitigation. *Science, 320,* pp. 1456-1457.

Dangi, R.B., & Acharya, K.P., (2009). A quick review of potential benefits and costs of REDD in Nepal. In: Acharya, K.P., Dangi, R.B., Tripathi, D.M., Bushley, B.R., Bhandary, R.R., Bhattarai, B., Eds., Ready for REDD? *Taking stock of experience, opportunities and challenges in Nepal.* Kathmandu: Nepal Foresters' Association, pp. 9-19.

Eliasch, J., (2008). Climate change: Financing global forests: the Eliasch review. *Earthscan*. [online]. Availableat: *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228833/9780108507632.pdf*

Gautam, B.R., (2011). LiDAR-Assisted Multi-source Program (LAMP) for FRA Nepal. *Forest Resource Assessment (Bulletin)*.Kathmandu: Department of Forest Survey, Government of Nepal, pp. 6-8.

Gibbs, H.K., Brown, S., Niles, J.O., & Foley, J.A., (2007). Monitoring and estimating tropical forest carbon stocks: making REDD a reality. *Environmental Research Letters,* 2, 045023.

Gordon, A., Tam, S., (2010). *Forest Carbon Partnership Facility: Demonstrating activities that reduce emissions deforestation and forest degradation.* Washington, D.C.: Forest Carbon Partnership Facility, The World Bank, pp.17.

Gullison, R.E., Frumhoff, P.C., Canadell, J.G., Field, C.B., Nepstad, D.C., Hayhoe, K., Avissar, R., Curran, L.M., Friedlingstein, P., & Jones, C.D., (2007). Tropical forests and climate policy. *Science, 316*, pp. 985.

Gurung, B.R., & Kokh, M., (2011). *Forest carbon accounting study report: Baseline, optimum sequestration potential and economics of REDD+ in the Terai Arc landscape of Nepal*.Kathmandu: World Wildlife Fund for Nature Conservation (WWF).

Gurung, M.B. & Acharya, R., (2011). *Pilot inventory report: REDD+ readiness in the sacred himalayan landscape of Nepal.* Kathmandu: World Wildlife Fund for Nature Conservation, Nepal.

LRMP, (1986). *Land utilisation report.* Kathmandu: Land Resouces Mapping Project.

Mahat, T.B.S., (1987). *Forestry-farming linkages in the mountains*.

Malhi, Y., Roberts, J.T., Betts, R.A., Killeen, T.J., Li, W., & Nobre, C.A., (2008). Climate change, deforestation, and the fate of the Amazon. *Science*, 319, pp. 169-172.

Malla, Y.B., (2000). *Impact of community forestry policy on rural livelihoods and food security in Nepal.* UNASYLVA-FAO-, pp. 37-45.

MFSC, (2009). Readiness preparation proposal for FCPF. In: Conservation, MoFSC, Ed.. *REDD Cell*. Kathmandu: Ministry of Forests and Soil Conservation.

Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., & Tanabe, K., (2003). *Good practice guidance for land use, land-use change and forestry.* Kanagawa, Japan: Institute for Global Environmental Strategies.

Peskett, L., Huberman, D., Bowen-Jones, E., Edwards, G., & Brown, J., (2008). Making REDD work for the poor, poverty and environment partnership. *(PES) Policy Brief.* London: ODI.

Ribot, J.C., (2004). *Decentralization of natural resource management: Encountering and countering resistance.* World Resources Institute, Washington DC.

Sundberg, B., Ericsson, A., Little, C.H.A., Nasholm, T., & Gref, R., (1993a). The relationship between crown size and ring width in *Pinus sylvestris L.* stems: dependence on indole-3-acetic acid, carbohydrates and nitrogen in the cambial region. *Tree Physiology.* 12, pp. 347-362.

Sundberg, B., Ericsson, A., Little, C.H.A., Näsholm, T., & Gref, R., (1993b). The relationship between crown size and ring width in *Pinus slvestris* stems: dependence on indole-3-acetic acid, carbohydrates, and nitrogen in the cambial region. *Tree Physiology*. 12, pp. 347-362.

UNFCCC, (2007). *Report of the conference of the parties on its thirteenth sesson Conference on Parties (COP), Bali, Indonesia* [online],Available at: (*http://unfccc.int/resource/docs/2007/cop13/eng/06.pdf).*

WHO 2010. *Evaluation of the Effects of Climatic Factors on the Occurrence of Diarrheal Diseases and Malaria: A Pilot Retrospective Study in Jhapa District, Nepal. WHO center for Health Development, Kathmandu, Nepal.* [online]. Available at: *(nhrc.org.np/files/download/74ae1e58756d738)*

*Wunder, S., 2005. Payments for environmental services: Some nuts and bolts. Occasional Paper No.42. Bangkok: CIFOR.*

# Theme III:
## Development Policies, Human-Resources and Sustainable Livelihoods

11

# Rural Development Policies, CBOs and Their Sustainability in Nepal[1]

Krishna Adikari

## Abstract

Rural and community development policies in Nepal of last six decades are reviewed in this paper, examining them through the lens of institution building at the grassroots level. Despite providing relief in the short term, many of the initial rural development initiatives failed to make an impact and often disappeared without creating any local institutions as soon as donor funding came to an end. However, since the 1980s, there has been a growing emphasis on utilising Community-Based Organizations (CBOs) as the vehicle for community development. As a result, CBOs have become ubiquitous. Despite having greater roles in local community development, they have received relatively little attention in the policy and research arena. This paper attempts to explore their evolution, map their growth and examine their patterns of sustainability. Analysing the pathways the CBOs utilise, this paper suggests that CBOs tend to shrink in terms of membership, activities, participation and resources as they grow older. Government and development agencies involved need to focus their help in supporting CBOs to sustain themselves.

## 1. Introduction

Planned rural development in Nepal has a history of over six decades, which began with the opening up of Nepal to the outside world in 1951. During this period (as will be discussed in detail later), frequent experimentation and dynamic shifts in international development discourses occurred resulting in several rural development policies and programmes with different models that were tried, often

[1] Some portions of this paper were reported previously in Adhikari (2005, 2007) and they are reproduced here with due permission. While the second one is my PhD research, the first one was conducted through Rural Self-Reliance Development Centre (RSDC) with the support form DFID-ESP, of which I was the principal investigator. The views expressed in this article are my own and the organisations bear no responsibility for them. I would like to thank Prof. David Gellner for his valuable comments and feedback for editing English, which have greatly helped to improve the paper. I also would like to thank Drs. Govinda P. Dahal, Kalidas Subedi, Bishwa Regmi and Ishara Mahat from CFFN, Ottawa, Canada for their valuable comments. Again, I am alone responsible for any errors.

with the direct support and involvement of international aid agencies. The search for solutions in to the dismal failures of the early days, which were characterised by 'top-down' policies, central control and direct external involvement, has gradually given rise to decentralised and 'people-centred' development policies (Esman & Uphoff, 1984). As a result, there has been an increasing emphasis on the rhetoric of community participation, self-help development and local self-governance (Chambers, 1983; Korten, 1990). This contemporary emphasis on 'bottom-up' approaches is implemented through the creation of CBOs as a vehicle for local service delivery and sustainable means of promoting local livelihoods (Garforth & Munro, 1995). Consequently, the past four decades have witnessed the emergence of groups of various nature, size, composition, and activism in different sectors, often overlapping with each other in almost every village of Nepal (Adhikari, 2007; Biggs, Gurung, & Messerschmidt, 2004; Sah, 2003). Over time, the CBOs not only became numerous but some of them are believed to have successfully stood the test of time, particularly the stressful 10 years of civil war, exhibiting resilience as the agency of local self-governance.

The long list of references cited in this paper shows that the literature on Nepal's development seems to be continuing to expand exponentially with the increase in the interest and involvement of local researchers and development agencies. Almost all universities in Nepal now offer degrees in development studies and a large number of local Non-governmental Organizations (NGOs) are engaged in this field. However, work in this field is often limited to the evaluation of projects, tailored to measure progress against set indicators for the consumption of donors. There are also reports available on sector-wide, project-specific community development practices, such as community forest management and micro-finance. (For example see Jha et al., 2009; Lama, Dhakal, & Rai, 2005; Pyakurel, 1998; Sah, 2003; Sharma, Bhattachan, & Shrestha, 2001; Subedi, 1999; Wehnert & Shakya, 2001). However, there is still insufficient systematic research in many aspects of rural development in Nepal, there is also little documentation about it linking historical process and evolution to present-day policy process and future sustainability. It is highly relevant for policymakers, development agencies, and researchers alike to understand: how rural development policy has evolved over time eventually promoting the idea of grassroots organisations for community development, what methods and components are relatively successful and how sustainability can be supported.

This paper shows that despite CBOs in Nepal being in much larger numbers (even more than NGOs) and having their importance in the community development process, they have received relatively little attention in the policy and research arena. This paper attempts to present a picture connecting above-mentioned aspects of rural development in Nepal. The paper begins with describing historical processes and accounts of rural development policies to situate the discussions that follow. At the same time, because the literature on the subject is sparse, giving a glimpse of all related polices in one place may be useful for researchers and students of rural development in Nepal. The paper examines major state promoted and donor sponsored rural development projects in order to understand the rise of participatory process and emergence of CBOs in community development in Nepal. As well as reviewing the degree of prevalence and trend of existence of various local and community development organisations in Nepal, the paper analyses the nature of, and efforts for, the survivability and sustainability of CBOs.

This paper is based on a review of the literature as well as two field studies conducted by the author in Nepal at different times between 1988 and 2014. One of the research studies has attempted to map some aspects of induced CBOs through a national-level (quantitative) survey in 2004 involving 39 leading community development agencies (Adhikari, 2005). Further, empirical materials used in this paper come from micro level fieldwork conducted in 14 villages of two Village Development Committees (VDCs) of southern Nepal in 2004, 2005 and 2006 (Adhikari, 2007). The micro study included both quantitative surveys and ethnography.

## 2. Revisiting 60 years of rural development policies in Nepal

Nepal started planned development only after the end of the 104-year Rana oligarchy and establishment of democratic system in 1950 (Panday, 1999). The Ranas did very little, if anything, for the welfare and development of its people even though the latter had to regularly pay tax revenues and provide free labour as and when they were ordered (Regmi, 1978). The governance of local affairs was commanded through the village headmen who worked as the functionaries of the government at the centre. People looked after their local affairs, managed local resources, and provided for themselves by developing and maintaining various customary collective institutions (see Table 1). Despite some exceptional progressive moves, such as the abolition of slavery in 1921 (Kshetry, 2013) and the opening up of a few educational institutions towards the end of Rana period, the country was so much under-developed that only 2% of the population aged between 6 and 10 were literate in 1951 (Sharma, 1990; Wood, 1959).

In the 1950s, over 95% of the population was dependent on agriculture, and two-thirds of them lived in the middle hills of Nepal (Ministry of Agriculture [MoA], 1958). Obviously, the priority of the government was on agriculture and food production, which were linked to other rural development programmes, such as irrigation, intensive crop production, and land reform. This was continued in the First Five Year Plan (1956-61) (Dahal, 1997). Similarly, education was also accorded a high priority with the opening of primary schools across the country, the establishment of the Education Planning Commission, and setting the goals of free, universal and compulsory education for all.

In line with the global development thinking of the 1950s and 60s that held that a ‘technological and resource gap' hindered the development of underdeveloped countries (Esman & Uphoff, 1984), Nepal, too formally started to receive international support to fill these gaps.[2] In 1951, Nepal and the USA signed a technical assistance agreement[3], following which in 1953, the USAID supported to

[2] International technical support from the British-India, Canada, and the United States of America (USA) had already started in 1934, when Nepal was badly hit by a large earthquake.

establish the *Tribhuvan Gram Vikas Karyakram* (Tribhuvan Village Development Programme or TVDP) as the first village development programme of Nepal. The TVDP trained Village Development Workers to carry out agriculture extension and facilitate other central government-led development projects, such as building roads, drinking water systems, schools and health-posts (Tatsumi & Joshi, 2010). Similarly, in 1954, USAID supported the establishment of the Rapti Dun Integrated Development Plan (RDIDP) in order to facilitate the resettlement of flood victims, and to support agricultural productions through cooperative farms.

Following the adoption of Panchayat system in 1960, the local development programmes were recalibrated. For example, in order to reflect the new political structure at the local level, the TVDP was renamed as *Panchayat Bikas Karyakram* (Panchayat Development Programme or PDP). In the early 1960s, two policies with far reaching consequences to social and rural development were initiated: caste-based untouchability was outlawed by an amendment to the Civil Code (*Muluki Ain*) in 1963 and the Land Reforms Programme was implemented bringing about several changes in the land tenure system, among others, placing a ceiling in the size of land ownership by an individual in 1964. In addition, in order to promote the Panchayat's project of national integration, priorities were laid on infrastructure development, e.g. building roads, communication infrastructures, and power supply (IIC-JICA, 2003).

Likewise, as a soft means "to strengthen and popularise the sentiment of nationalism and national unity", the Back to Village Campaign was launched in 1967 (Shroff, 2007). Containing a 10-point programme, the campaign was designed to be a vehicle for creating social awareness in order to make rural people active in, and provide support for the implementation of many of the flagship rural development initiatives, *interalia*, social reforms, land reforms, forest conservation, agriculture (production), and cottage industries (ibid). However, by 1975 the campaign was limited to nominating local government functionaries, and even this was abandoned in 1980, when direct elections were introduced.

Among rural development projects of the 1970s the National Development Service (NDS) was launched in 1974. It was a mandatory programme in which fresh graduates of Tribhuvan University were required to go to the remote schools for several months with a view to sensitise rural people for educational and community development. The NDS programme became very successful in mobilising communities and gaining credibility, nationally and internationally (Maskay, 1998). Unfortunately, it became the victim of its own success, when the government decided to abandon this programme due to fear of its effect on increased mass awareness against the establishment of the Panchayat system (Amatya, 1989; Yadama & Messerschmidt, 2002).

Furthermore, in two national plans implemented in the 1970s (the Fourth, 1970-1975 and the Fifth, 1975-1980) the concept of 'regional development' was introduced and Nepal was divided into four Development Regions in order to

[3] Initially the work was conducted through the United States Operation Mission (USOM), which later became U.S. Agency for International Development (USAID).

promote a balanced regional development and national integration. By the 1970s, internationally, there had been shifts from the mere focus on the 'technology and resources', to 'local organisations' and 'people's participation' (Esman & Uphoff, 1984). In Nepal the Swiss Development Agency (SATA) had been a pioneer with its Integrated Rural Development Programme (IRDP) from 1958 to 1970 in Jiri. Following their lead, the 1970s saw a steep rise in the implementation IRDP as it was expanded to other parts of the nation with the support of international donor agencies making it one of the largest development interventions until early 1980s (Adhikari, 2000)[4]. The IRDP model continued even in the 1990s with donors' support. However, this model could not produce positive results as expected due to high dependency on the central planning and weak participatory institutional mechanism at the local level (Tanner, 2001; Uphoff, 1991).

Following ILO's initiatives to improve the situation of rural poor (Blaikie et al., 1979), the Government in its Sixth Five-year Plan (1980-85) focussed on meeting the basic needs of the people, and committed to achieve "Asian standards of living by the year 2000" (World Bank, 1989). However, this approach also failed to fulfil its commitments and was abandoned by the end of 1980s (Devkota, 1994).

As the precursor to the decentralisation process in Nepal, towards the late 1970s, previously nationalised forest management was delegated to the local Panchayats. Subsequently, the Decentralisation Act was enacted in 1982 and implemented in 1984 with two important milestones: opening up integrated rural service centres *(Sewa Kendra)* in every district to provide technical and other services at the local level and implementation of small local projects, such as drinking water systems, through Users' Committees. Similarly, the fifth, Far-West Development Region was created with the aim to achieve equitable development outcomes. With some limited success, the decentralised programmes could not produce expected outcomes, mainly due to the lack of funding from the centre and absence of local revenues (World Bank, 1989). Ironically, the central government continued to handle local development projects, which amounted to two-thirds of all local projects by 1988/89 (World Bank, 1989). The Seventh Five-Year Plan (1985-1990) continued to pursue poverty reduction as a top priority alongside the adoption of the neo-liberal measures.

The neo-liberal account of state failure that became dominant in the 1980s gave a push to Structural Adjustment Programmes (SAP) globally. As a result, in 1985, Nepal signed for loans with the World Bank and International Monetary Fund (IMF) to implement the SAP. The precondition of the loan was that efficiency had to be the top priority of the government, which, as a result, saw the curtailing of government subsidies and an increase in the involvement of private providers in the supply of agriculture inputs. The impact it had on the vast number of rural peasants was very severe with increased income inequalities and stratification.

[4] Major agencies that supported expansion of the IRDP in Nepal are: International Development Agency (IDA), United Nations Development Programme (UNDP), Asian Development Bank (ADB), European Economic Council (EEC), World Bank (WB), UK Government, Canadian International Development Agency (CIDA), and USAID.

The 1990 people's movement overthrew the 30 years old Panchayat system, replacing the local Panchayats with the Village and District Development Committees. In the liberal environment, the number of NGOs had increased exponentially and became the partners in rural and community development. Different types of NGOs have received direct funding from the donors and worked as the intermediary facilitators, in many cases, replacing both the international organisations and government agencies. Local government laws were revised in 1992 and 1999, giving relatively more autonomy to the local governments units (LGU) for self-governance and local development (Shakya, 2008).

In the 1990s, a large number of CBOs have been induced as the grassroots self-help organisations. Many of these groups have been successful in governing their collective affairs at the bottom of the LGUs, without a formal structural link between the two. Community forestry is one such example in which users have successfully managed their local forestry reversing earlier failures of government control (Dahal & Adhikari, 2012). One major change in the 1990s was that the LGUs started receiving resources from the central government with the encouraging results of the first flagship programme Let Us Build Our Village Ourselves. They also have received more power to manage local development affairs. As a result, substantial infrastructures, such as rural roads have been built. The funding that the LGUs receive has increased over time, now reaching between 1.5 and 3 million per Village Development Committee (VDC) (Inlogos, 2009). In the absence of accountable elected local governments for the past 12 years, these funds are considered to be prone to abuse as corruption has become a common and widespread phenomenon (Thapa & Rijal, 2015)[5].

Nepal's local development process was interrupted due to the 10-year long civil war. With the on-going transition of the post-conflict peace process, donors' priorities have been geared towards the empowerment of disadvantaged groups, and to mitigating inequalities in terms of caste/ethnicity, gender, and region. The global movement for indigenous peoples' rights has also had profound effects in Nepal’s current development policies. The centrality of the ethnicity agenda in restructuring the country triggered fierce debates and produced disagreements, eventually preventing an agreement on a constitution in 2012, and substantially delaying the formulation of federal constitution (Adhikari & Gellner, forthcoming). Though no serious debate has taken place regarding the structure of local government, it can be expected that the new model will entail devolution of more power at the local level, reshaping the rural and community development policy process.

The brief review of the past policies has shown that Nepal's rural development programmes have three important aspects: they are externally supported from the beginning, they are changing in line with the shift in international discourse on development and often, particularly since the 1960s, they have been used as political

[5] The fact that corruption at the local level has been rampant is not a secret now. Kantipur (10 Jan 2012) estimates as much as 50 billion rupees a year is embezzled at local level. From the chief of the anti-graft body to the prime minister have made open remarks about such problems. According to Thapa and Rijal (2015) there are 11,000 corruption cases registered with the Commission for Investigation and Abuse of Authority (CIAA).

projects adopting top-down mechanisms. It is evident from the above discussion that the past policies were able to deliver only very limited outcomes. While international support continues in the recent decades, rural development policies are becoming increasingly 'bottom-up' with the growing involvement of CBOs.

## 3. Mapping community-based organisations in Nepal

Local-level organisations are a cardinal aspect of community development and their roles have increased exponentially in recent years. These organisations are not only a vehicle for the delivery of services provided by the central government and international donors, they are also the means and the end of community development programmes (CDP).

Various types of informal institutions including CBOs have long been a feature of social organisation in Nepal through the system of cooperation and collective action even though the political system prior to 1950 strictly restricted the formation of organisations (Biggs et al., 2004; Food and Agriculture Organization [FAO], 2004; Mishra, 2001). (See Table 1 for various customary practices and institutions of community development and local self-governance). In the open environment of the 1950s, the formation and running of organisations including political parties was allowed, but with the introduction of party-less Panchayat in 1960, they were banned. Nonetheless, the restoration of democracy in 1990 ensured freedom of organisations and large number of organisations of different types in regard to local community development have emerged. (See Figures 2 to 6).

**Table 1:** List of some customary institutions in Nepal.

| Name of the organisation | Description | Ethnic /caste groups |
|---|---|---|
| Ama Samuha | Mother's groups | Gurung |
| Bhajana Mandali | Traditional/folk form of singing religious hymns in an organised way | Various Hindu and Buddhist groups |
| Bheja | Social, cultural, religious, political and economic organisation | Magar |
| Chhatis Mauja Irrigations System | Social organisation (to manage irrigation) | Tharus |
| Choho | Ritualistic, administrative and judiciary organisation | Tamang |
| Chumlung | Social organisation | Kirat |
| Dharma Bhakari | Collection of food grains in a group to use during the times of food shortages | Various groups |
| Dharma Panchayat | Local-level political organisation | Thakali |
| Dhikur | Rotating credit association | Thakali |
| Guthi | Religious/cultural organisation | Newar and others |
| Khel | Social organisation | Tharus |
| Kipat | Communal land tenure system | Kirat |
| Kulo Samiti, Kulo Samuha | Irrigation management associations | Various groups |
| Maijan | Social organisation | Various group in Terai |
| Nangkhor, Banpale, Ban Heralu, Ban Samiti, Ban Samuha, Ghar Lahure | Traditional forest management groups and norms | Various groups |
| Panchayat | Local collective governance | Various groups |
| Parma, Pareli, Huri and Nogyar | Labour exchange system related to agriculture | Various groups |
| Posang and Mirchang | Social organisations | Marphali |
| Shramadan, Badghar, Jhara, and Maha-Jhara | Community labour groups | Various groups |
| Tho, Gola and Rodhi | Social organisations | Gurung |
| Tumyangbhang | Pancha bhaladmi [Community judiciary group of noblemen] | Limbu |

(Source: Adhikari, 2007) (Adapted from Biggs et al., 2004; Bhattachan, 2001; Pokharel & Willet, 1996; Yadama & Messerschmidt, 2002).

Although the IRDPs that began in the 1950s did not adopt a group-based approach until 1989, the Small Farmers Development Programme (SFDP) initiated in the mid-1970s, with the support from IFAD, adopted a group-based self-help approach organising small farmers. Subsequently, in 1981, a group-based credit programme called Intensive Credit and a women's credit programme called Production Credit for Rural Women (PCRW) were launched. The Decentralisation Act (1982) recognised users' groups and, as a result, the Community Forestry Programme, which paved the way for what are now known as successful Forest Users Groups (FUG), was started.

The Eighth Five-Year Plan (1992-1997) put emphasis on partnership with NGOs, groups and local organisations. In the Plan, the group approach was adopted for agricultural extension and polycentric institutional arrangements involving water users associations in irrigation (Upadhyay, 1998). The new Cooperative Law (1992) gave space for people-initiated cooperatives in diverse sectors mainly allowing them to operate savings and credits which marked the turning point towards more successful cooperative practices than the old government-dominated and failing *Sajha* programme introduced in the 1950s.

The Ninth Five-Year Plan (1997-2002) further gave priority to collaborative works with NGOs, CBOs and other local organisations. The Local Self-Governance Act (1999) recognised community groups and NGOs as stakeholders, assigning LGUs a role to coordinate with them. The Tenth Five-Year Plan (2002-2007) continued the previous plans and strategised community (social) mobilisation programmes as the means to poverty alleviation and the attainment of the Millennium Development Goals (National Planning Commission [NPC], 2002). Moreover, NGOs were allowed to directly appeal for funding from foreign sources. During the last two decades, Nepal has devolved the management of several collective and public resources to the local level, such as community forestry, community schools, community irrigation, community hydropower, rural electrification, and community radios.

Similarly, under the NGOs, there are emerging rights-based groups, advancing the movement for ethnic and disadvantaged groups at an unprecedented level (Adhikari & Gellner, forthcoming). CBOs too have been powerful grassroots institutions. For example, during the time of civil war, when there was absence of any government agencies in most villages of Nepal, the CBOs were viewed as the one and only direct way to reach communities and to utilise development expenditure for local development (Nepali Times, 2005). Even today, NGOs and CBOs are important institutions to fill the vacuum created by the absence of elected local governments since 2002.

To give an overview of various organisations operating at local level, they can be presented using the typology of local institutions developed by Esman and Uphoff (1984). The typology is based on an opposition between the public and the private sectors, in between of which various intermediary organisations of a voluntary nature, such as CBOs and NGOs fall (Figure 1).

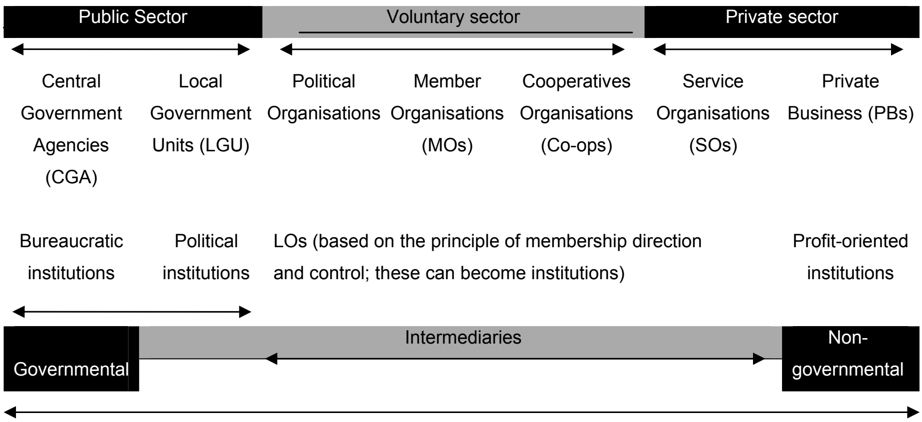



Figure 1: Typology of local institutions in Nepal. (Source: Adhikari, 2007)
(Adapted from Esman & Uphoff, 1984; Uphoff, 1986).

No reliable data are available about NGOs in Nepal. However, it is estimated that as many as 50,000 NGOs have been registered in the country[6]. Though not every NGO is registered with the Social Welfare Council (SWC), as it is voluntary, Figure 2 shows the increasing trend. For example, the number of NGOs in 1989 registered with the SWC was 222 which increased to over 37,539 in (July) 2013. The trend declined during the conflict period particularly between 2002 and 2006. *coup d'état* (Dixit, 2006) in 2005, the situation further worsened as the government attempted systematically to curb the freedom of organisations by banning some civil society associations and attempting to police NGOs through the imposition of a Code of Conduct 2005 (Kathmandu Post, 2005). However, the number steadily increased after 2006 as the peace process enabled the formation of new CBOs and NGOs.

6 This figure is an estimation as of October 2011 by the Kathmandu Insider, which has computed daily figures in order to come to this estimation (Retrieved March 25, 2015 from http://ktminsider.com/blog/2011/11/20/50000-ngos-in-nepal-and-growing/)

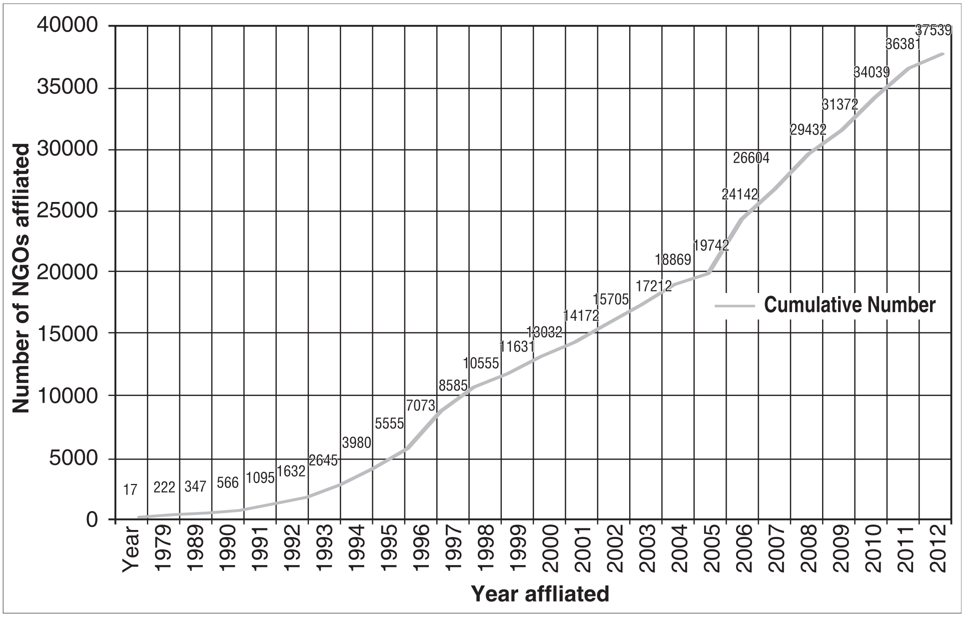



Figure 2: Growth of NGOs affiliated to SWC in Nepal between 1979 and 2013.
(Source: Social Welfare Council, http://www.swc.org.np/)
Note: Between 1999 and 2009, the figure is only tentative. The 2013 includes up to mid-July.

A broad categorisation based on the sector of operation of NGOs registered at the SWC between 1979 and 2010 in 10 groups shows that 62% of NGOs are community and rural development related while the remaining 9 categories are specialised in certain sectors equally relating to community development (Figure 3)[7]. It should be noted that even though almost all NGOs have something to do with the community development, very few are indeed active and renewed regularly.

As described already, the cooperative movement was started in the 1950s but only cooperative organisations that have emerged after the 1990s are running in a more resilient manner. The majority of them are initiated by the farmers as members and operate in rural areas. According to Cooperatives Department, 31,177 cooperatives were registered by mid-July 2014. The Department categorises these organisations into 16 groups of which savings and credit cooperatives are the largest (43%) followed by agricultural (26%), multipurpose (13%), and diary (6%) (Figure 4).

7 SWC has published NGO database as of mid-July 2013, but the sector-wise NGO data is available only as of mid-July 2010. (Retrieved March 03, 2015 from http://www.swc.org.np/allngo_list.php)

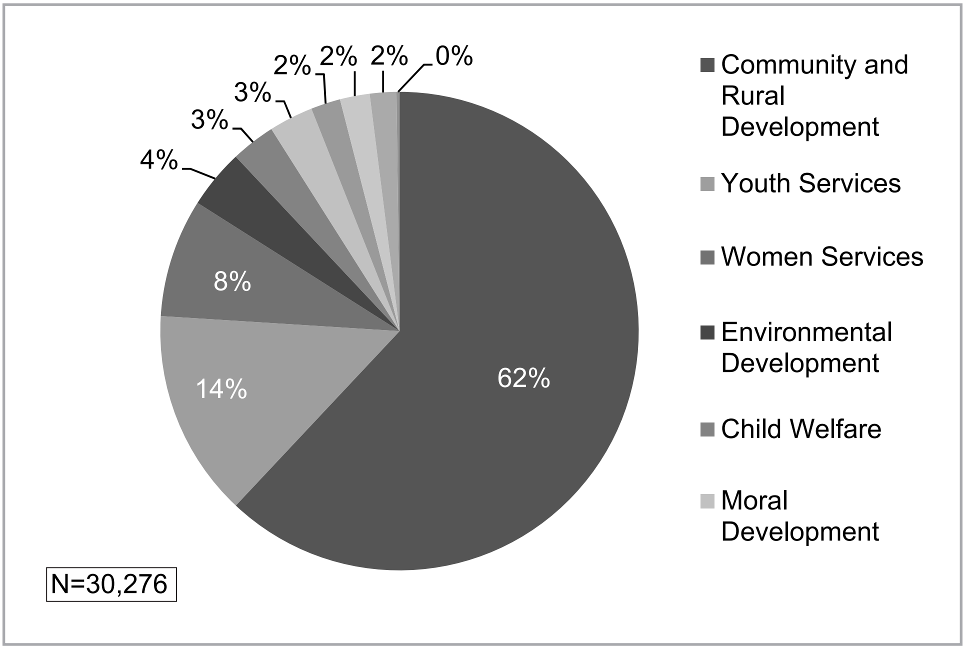



Figure 3: NGOs affiliated with SWC between 1979 and 2010 by type. (Source: SWC)

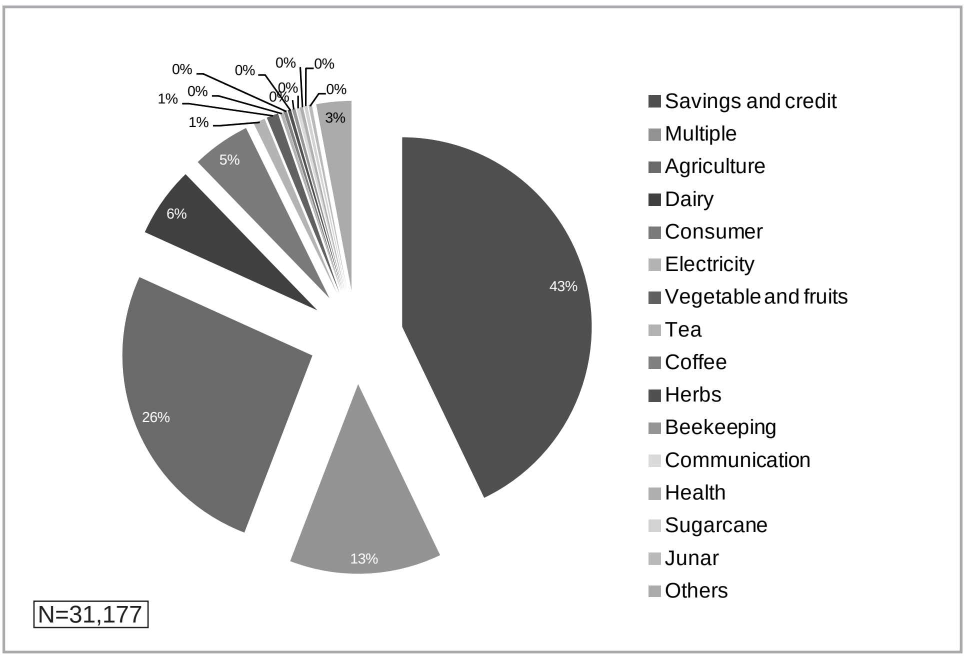



Figure 4: Cooperatives in Nepal by type (As of mid-July 2014).
(Source: Cooperatives Department)

Generally, CBOs are neither like NGOs nor are they like cooperatives, even though a few of them are registered as such. CBOs are very informal grassroots groups and are not normally registered. Only a few studies conducted in the past have attempted to map the size of the CBOs sector in Nepal (such as, Sah, 2003; Biggs et al., 2004; and Adhikari, 2005). The national survey conducted in 2004 (Adhikari, 2005) found that the 39 leading agencies that have participated in the survey have been responsible for the formation of 51,899 community-level groups, mobilising nearly one in four households in the country. The survey, built on figures from a previous study (Sah, 2003), revealed that if the overlapping of membership is not taken into account, four in five households in Nepal (based on 2001 census) would have participated in a development group of some kind. When the duplication ratio (i.e. one household participating in more than one CBO), which is 40.5% (ibid.), is taken into account, almost half of households were found to have participated in various groups at the village level. Figure 5 shows the percentage of households participating in CBOs by the type of mobilising agency as well as the percentage of households still not covered by them. The inner pie does not consider the duplication while the outer one does. It shows that the INGOs have induced the largest number of groups followed by the UN-supported government programmes, governmental or semi-governmental agencies, NGOs, and Grameen Bank replicators.

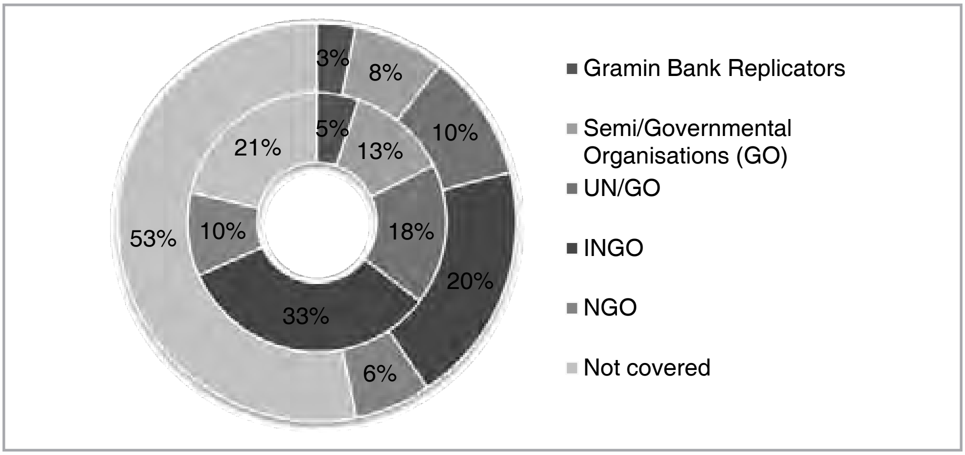



Figure 5: Share of socially mobilised household by types of agencies. (Source: Adhikari, 2007); Field survey 2004 and built on Shah, 2003). Note: Outer-duplication included, inner excluded

Biggs et al. (2004) estimated that the number of developmental groups at the grassroots level by dividing them into 10 sectors: micro savings and credit; agriculture; non-formal education; irrigation; natural resource management; infrastructure; drinking water; health and other multifunctional groups and other NGOs at micro level (Figure 6). They estimated that there are approximately 396,466 development groups formed by different agencies and projects. This figure may rise higher as many community-led management committees of public institutions such as schools and health posts, and several locally formed users groups, were not included. Overall, it can be inferred that more than half a million community groups have emerged by 2004, although only a small number of them have sustained over time. On average, this figure works out to be nearly a community group for every 11 households in the country.

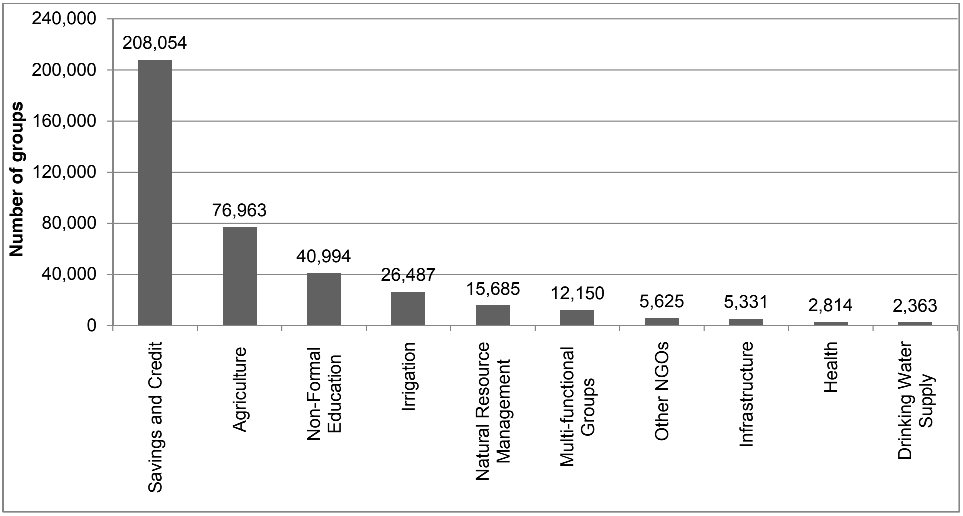



Figure 6: Overall preliminary estimate of the number of micro-level groups when divided in to 10 different sectors (2004). (Source: Built on Biggs et al., 2004).

Some sector-specific local groups have a secondary layer of organisation with federation ranging from the grassroots to the national level. These institutions have been very useful for bridging and linking relations, and advocating and pressing for the collective benefits on behalf of their affiliated members and groups. Some examples are: Federation of Community Forest Users Nepal (FECOFUN), National Federation of Water Users Association Nepal (NFWUAN), NGO Federation of Nepal, and Nepal Federation of Indigenous Nationalities (NEFIN).

In summary, there has been proliferation of local groups related to community development, and induced CBOs are by far the largest groups. Based on the empirical evidence and focusing on the CBOs, we further explore CDPs promoting CBOs, to what extent do the CBOs survive, and what are mobilising agencies' attempts on sustaining CBOs and their development activities.

# 4. Empirical results: Level of group sustainability and efforts

## 4.1 Components

Our survey involving leading agencies showed that CDP implemented by them involves forming and working with community groups. Table 2 presents a cross tabulation of major community development activities as practiced by 37 out of 39 leading agencies that participated in the survey of 2004 (Adhikari, 2005). In terms of practical application, the CDP components can be categorised as universal, mostly practised and sector-specific activities. Working with groups (existing or new) and aiming to 'empower' people are two universally practised components of CDPs in Nepal. Human resource development, and savings and credit are two components included in most CDPs. Similarly, most CDPs contain some kinds of support for micro-infrastructure development and credit support to the groups involved.

**Table 2:** Cross-tabulation of frequency of different components of CDPs (N=37 agencies).

| Programme components | Empow-erment | Group forming | HRD | Savings | Micro infrastructure | Revolving capital | Others: Sectoral |
|---|---|---|---|---|---|---|---|
| Empowerment | 37 | 35 | 34 | 33 | 24 | 21 | 18 |
| Group forming | 35 | 35 (+2) | 32 | 32 | 23 | 21 | 17 |
| HRD | 34 | 32 | 34 | 30 | 24 | 20 | 17 |
| Savings | 33 | 32 | 30 | 33 | 22 | 20 | 16 |
| Micro infrastructure | 24 | 23 | 24 | 22 | 24 | 16 | 14 |
| Revolving capital | 21 | 21 | 20 | 20 | 16 | 21 | 14 |
| Others-Sectoral | 18 | 17 | 17 | 16 | 14 | 14 | 18 |

### 4.2 Sustainability trend

Both of the studies that this paper is based on (Adhikari, 2005; Adhikari, 2007) were designed to capture the trends in groups' sustainability in different ways because the major reason behind the inducement of CBOs by development projects is to facilitate delivery and continuity of development-related activities. In the micro field study, which was conducted in 2004 and 2005 (Adhikari, 2007), the trend was mapped from the participating individual household's point of view categorising CBOs according to their number: total number formed or joined, existing, inactive, and defunct. Of the 285 cumulative number of CBOs joined so far by the members of the responding households (86 HHs), 239 (84%) were still in existence, 212 (74%) were functioning at various levels, 27 (9%) were inactive, and 46 (16%) were either left or defunct. Because many of the groups studied were still too young (5.5 years average age) and being supported by agencies, the survival rate of CBOs could be expected to decrease overtime.

The above analysis considered the activity of both members and groups by taking the cumulative numbers of CBOs joined by the household members. The groups' survivability was also mapped by taking the net number of groups. For this, the groups democratic functioning as well as its effectiveness level was identified[8]. Of the 127 groups studied 14 groups (11%) were either dissolved or defunct, and a further 12 (9.4%) were inactive. Hence, only 79.5% of the groups were functioning

[7] The indicators of Democratic Functioning and Effective Functioning of Groups are as follow:

A. Democratic functioning score was computed based on the meeting attendance and participation in decision-making process measured in five scales: 1. No meeting attendance in last 12-month as they were not organised. 2. Nearly one-fourth of the members attend but most of them do not participate in decision making process. 3. Almost half of the members attend but most of them do not participate in decision-making process. 4. Most of the members attend but only some involve actively in decision-making process. 5. Almost all members attend and involve actively in decision-making process.

B: Effective functioning also measured in five ordinal scales: Overall rating on the effectiveness of the groups: 1. Dead or disbanded, 2. Inactive, 3. Neither active nor inactive, 4. Active, and 5.Very active at various levels, but 7.9% of the total groups were operating at a very low level. As age might affect the survivable rate of the groups, further analysis of the functioning level of two years or older groups was attempted. It showed that 22% of the groups studied were either defunct or inactive, 10% were functioning at a low level, and another 22% were functioning at a moderate level. The rest (over two in five) of the groups were functioning at a relatively better level.

The analysis of the group survival rate in the study area showed that approximately three in four groups were surviving even though their functioning was at different levels. In an attempt to triangulate information and see the trend on a broader scale, the survey with leading agencies also asked a question about the level of functioning of groups promoted by them in the past. The analysis of the status of all groups formed within the previous 14 years (but support phased-out at the time of the survey) has shown an almost similar result: three in four groups were surviving; almost half of which were continuing at a normal level and the other half were growing in size, resource profiles, and activities. One in four groups was either non-existent or inactive. Since this was based on the self-reporting of the respective agency, the result should be taken cautiously due to bias, because it is highly likely that agencies tended to exaggerate their success and minimise their shortcomings.

The age effect was further checked in the data generated by the micro study through correlation analysis (Adhikari, 2007). The results showed a weak negative correlation between the age of the groups and the functioning score (Pearson $r=-.211$, $P=0.017$) suggesting the older the group, the smaller the functioning score. In order to see the extent of changes in the functioning level of all groups, group functioning during the project support or initial days was compared with that of the time of field study. The comparison of the effectiveness of the groups (paired-samples t-test) has shown a significant decrease in their effectiveness ($M = 73.68$, $SD = 16.4$) to ($M=44.76$, $SD = 26.71$, $t(126) = 12.30$ $P<0.000$). The ETA squared statistics (0.55) indicated the large effect size. This shows that normally groups function better prior to project's support being phased out or in the initial years even if they never had any project support.

### 4.3 Efforts at sustaining groups

As the sections on policy review above show, in the early days of rural development, agencies did not attempt to instigate CBOs. When they started forming CBOs, they were seen only as the vehicle for service delivery and lacked plans to make them independent and sustainable as institutions. There was, apparently, little thought given to the question: For how long would the external agencies continue to directly fund and facilitate such development efforts? The CBOs, on their side, assumed that they would continue their activities until they no longer received donor support. By the mid-1990s, it was realised that the prolonged presence of the agencies in the communities was leading to a situation of dependency. This was in no way in line with the premise of a self-sustaining and self-governing community.

When the problem of dependency was realised, it started to become a condition under the projects' rules that the agencies should withdraw from the community after a certain period of facilitation and implementation of the development programmes. This was based on the assumption that the local CBOs would have graduated and would be able to take charge of managing their development affairs through the induced organisations. Although many agencies still did not have an exit strategy (United Nations Development Programme [UNDP], 2004), some began to experiment with innovative ways of strengthening post-phased-out CBOs. The results found out through the agency survey regarding the post-phase out CBOs support activities are as presented in Table 3.

**Table 3:** Post phase-out agency activities (percentage of practicing agencies).

| | Back stopping | Local fund | Regis-tered | Feder-ated | Reserve fund | Others | Paying salary | Number of agen-cies |
|---|---|---|---|---|---|---|---|---|
| Backstopping | 84% | 73% | 62% | 54% | 43% | 41% | 32% | 37 |
| Local fund | 77% | 83% | 54% | 54% | 49% | 37% | 40% | 35 |
| Registered | 64% | 53% | 67% | 47% | 33% | 31% | 28% | 36 |
| Federated | 56% | 53% | 47% | 64% | 36% | 28% | 28% | 36 |
| Reserve fund | 44% | 47% | 33% | 36% | 56% | 19% | 25% | 36 |
| Others | 44% | 38% | 32% | 29% | 21% | 44% | 12% | 34 |
| Paying salary | 34% | 40% | 29% | 29% | 26% | 11% | 40% | 35 |

Follow-up of CBOs is the chief strategy that agencies adopt in the period after projects have been phased-out. Over four in five agencies (84%) have claimed that they had launched some sort of follow-up of the CBOs after the termination of their project. What ‘follow up’ means is very ambiguous and it is always easier said than done. Therefore, how meaningful this support is to CBOs is difficult to determine without further scrutiny. The second most-practised activity of the agencies is raising local funds. Most of the agencies (83%) tie their CDPs into micro savings and credit and raise some funds for future sustenance. This implies that conflation of savings and credit components in the CDPs is useful to keep people together for a sustained period of time in groups.

As shown in Table 4, two-thirds (67%) of the participating agencies claimed to have been working towards formalisation of CBOs by registering them with the government. There are limited options available in formalising CBOs through registration in Nepal. They can be registered as an NGO or as a cooperative, but in most cases, they are left unregistered. Creating a secondary tier (e.g. federation) of CBOs has become part of the strategy of agencies in strengthening the grassroots institutional development process. Nearly two thirds of the agencies (64%) participating in the survey claimed to have adopted this component in various ways.

Providing some seed/revolving fund and/or matching funds is also an activity aimed at helping the functioning of phased-out CBOs. The study shows that more than half (56%) of the responding projects were already using this practice. Similarly, two in five (40%) agencies was supporting phased-out CBOs with some portion of the salary of local staff at least for the first few years.

What types of support activities are more productive is not yet well understood. However, the recently emerging innovations of some agencies are very welcome initiatives. Nonetheless, if the past trends are any indication, it will be a long period before the best practices are replicated across the spectrum of development actors.

## 5. Discussion: Shrinking pathways of CBOS in Nepal

Despite recent efforts to build a support system with the CDP, some groups that were originally meant to be long-term remain inactive or are closed. Some people just leave groups that are functioning when they do not find them personally useful. The findings presented in previous section showed that newer groups function better than the older groups, and the level of effectiveness of the groups diminish substantially as they grow older. Even though, the analyses do not present temporal patterns of changes, the changes in group dynamics (mainly in four respects: membership, activities, participation and resources), differences in functioning level at two points in time, and trends in sustainability indicated a tendency that most induced groups go through a course, which I call a shrinking pathway, when they grow older, and when they are left on their own.

Even in some successful groups, frequent turnover in the membership is natural. Many successful groups studied were found to have changed from a multi-dimensional (having multiple and integrated functions) to a single (mostly confined to savings and credit) activity group. The substantial reduction of membership would mean that broad-based groups (covering almost all households of a given location or settlement with a common stake) were reduced to very small groups in terms of membership and activities. It was found that the process could go through many stages, but not necessarily following the same consecutive order. The time and process to go through this cycle may vary according to the level of group governance and social capital and level of institutional arrangement of the phased-out groups (Adhikari, 2007). In the absence of outside mediation and/or good internal governance practices, and local capabilities, some groups became fertile grounds for conflicts to emerge. In the failed groups studied, the tendency of elite capture of resources was most probable at the transition phase leading to the breakdown of the groups (Adhikari, 2007).

In life-cycle metaphoric terms, most successful groups may reach what Pretty (2003) calls the stage of ‘awareness interdependence’, in which groups acquire a worldview and value of groups that are irreversible. However, some groups in the present study that had crossed the ‘graduation’ level were still failing to institutionalise themselves (Adhikari, 1999; Rural Self-Reliance Development Centre [RSDC], 1998; Subedi, 1999). They seemed to follow what FAO (1999) calls the ‘over expansion phase’ of group development leading to ‘management crisis and retrenchment phase’ of their ‘S’ model. This is also consistent with the views of Greiner (cited in Lewis, 2001) in his life-cycle model that the crisis arises in transition from one stage to another, until the collaboration stage, threatening the very survival of the groups. Thus, some groups may even close after they are consolidated, as Avina (1993) notes in her life-cycle model for NGOs.

The shrinking pathways might not be applicable when extra efforts are made from time to time to keep the groups intact in size and activities, and when appropriate self-sustaining mechanisms and capacities with resources are fully developed. For example, CBOs managing natural resources such as FUGs are more resilient. Despite the nationalisation of forest management in the 1960s, the previous experience of customary collective actions in Nepal has been particularly an important asset, which, when combined with large, determined, and long-term external investment in developing local capacities, are proving worthy in averting a dismal shrinking pathway in the forestry sector in the mid hills of Nepal. Moreover, the existence of forest resources as a common property is a binding factor for all to cooperate. On the other hand, the 'tragedy of commons' is a well-known phenomenon of natural resource management (Hardin, 1968), and elite capture of resources is still commonplace in Nepal (Malla et al., 2003). Hence, the threat is not completely absent in this field too.

Generally, the group tendency to go through the shrinking pathways continues to exist as long as group sustainability continues to be an ignored dimension in Nepal. Present efforts being made by many Nepalese agencies are not likely to be sufficient to avert this pattern. There are deep problems. It begs some discussion about rooted problems and why the present policy and practices are not likely to be sufficient to avert the shrinking pathways that the induced CBOs are likely to follow in Nepal.

Despite the long history of rural development initiatives by government and external agencies in Nepal, the concept of sustainability is a relatively recent innovation in development discourse (Forest Action, 2003; Korten, 1990). The flagship IRDP in Nepal that existed between 1950s and 1990s largely entailed providing relief and incentives, thereby generating artificial participation. There was little real substance for, and slim chance of continuity of the programmes after cessation of external incentives; there was no clarity about local institution building; the programmes failed to ensure strong coordination among government agencies; and they were handed over to government, keeping the people at bay (Amatya, 1989).

The later programmes increasingly used the group-approach, inducing the formation of CBOs for the delivery of the programme. Until the late 1990s, there was little awareness on the part of the supporting agencies about the need for ensuring the sustainability of the programmes and groups. The studies that this paper is based on showed that there still exists a tendency among the mobilising agencies to put an emphasis on forming groups without any plans to sustain them. Often group formation is driven by the interests and politics of the agencies and donors rather than those of the communities concerned. Responding to the statement, “the agencies emphasise forming new groups, but fail to put a balanced view in institutionalising and sustaining them”, over 63% of the participating agencies admitted at least to some extent that there is such a tendency. Similarly, most of them also agreed that they are more accountable to donors than to the beneficiaries. The reason is clear: for the continuity of funding, agencies need to please the donors. Moreover, there is also a relatively new practice among some agencies to form community groups so to fake their experience and boost their profile to attract more substantial funding. So far, development agencies in Nepal have not formed a professional body, and set up standards of practice in order check the quality of work within the development industry.

Thanks to competition between agencies, and the inertia of bureaucracy, there is a tendency to set up new groups and ignore existing ones. This means that people end up participating in multiple groups and may lead to 'group fatigue' (Biggs et al., 2004). The results of these practices are conspicuous: a greater lack of coordination; a high degree of geographical as well as households overlapping; unhealthy competition among the agencies; exclusion or artificial participation through unsustainable incentive mechanisms; death of cooperative social institutions, elite capture of resources, etc., placing the beneficiaries in a disadvantageous position (Adhikari, 2007; UNDP, 2004).

The recent emphasis on project handover, too, is not genuine in the case of several agencies. Simply withdrawing supporting agencies from the communities does not offer a solution to the problem. In such cases, forcing the transfer of the overall management to the local community is a futile move from the beneficiary's point of view in that a huge amount of resources are completely used up during the project period leaving little or no for the future use. Similarly, the government policies encourage people to form groups through various programmes but are passive to the quality aspects, which explains the apparent lack of an enabling environment and support mechanism to the phased out groups. For example, due to the lack of an appropriate registration mechanism that suits to their informal nature and structure, groups are forced to formalise in order to fit into fixed registration structures such as NGOs or cooperatives (Adhikari, 1999; Upadhyay, 1998).

Another problem comes from the fact that the centre and local government agencies often compete with non-governmental development agencies, rather than acting as a monitor and coordinator. This results in discrimination between CBOs in accessing available State resources (Dahal, 2000; Paudyal, 2004). Furthermore, political instability and policy inconsistencies also create insecurity on the parts of CBOs. Frequent changes in policy – for example, adding new taxes onto the forest users' groups, and politically motivated whimsical decisions like the cancellation of BP Among the Poor Programme, the only programme having coverage in almost all districts in Nepal – have jeopardised the future of thousands of CBOs that are already established. The king's 'direct rule' in 2005 tried to dismantle the civil society sector because the latter refused to back the regime and stood firm on democracy. Similarly, the 10-year-old Maoist insurgency created several threats and challenges, such as: insecurity of resources owned by groups; orders to register with the so-called 'people's government'; scrutiny from the security forces; requests for donations, taxation, and forced labour from the Maoists; suspension of funding by major donors; absence of formal institutions including local government at the grassroots; and inability of government to channel resources at the grassroots (Singh, 2004). The sector also suffered as the conflict gave rise to the diversion of national development resources to meet growing military expenses (Adhikari, 2005; Subedi, 2006).

## 6. Conclusion

This paper attempts to revisit local and rural development policies and to recount the evolution of local organisations in Nepal, particularly the CBOs, which are induced and promoted by development agencies implementing CDPs. Based on a review of the literature and analysis of the empirical data, the rate and level of prevalence of CBOs were charted, along with their level of sustainability, and efforts made to sustain them.

The history of planned development in Nepal is not very long. Despite giving relief in the short run, many of the initial rural development initiatives failed to make an impact. They often disappeared without creating any local institutions as soon as donor funding came to an end. Changes in government policies in the 1980s paved the way for the emergence of organisations at the grassroots level taking a substantial stake in the local self-governance through self-help practices. This obviously brought a shift in the way rural development is implemented in Nepal, even though this did not put an end to the tendency of agencies, government or otherwise, to form groups with ephemeral incentives – well known as project syndromes – ignoring the sustainability of the organisations and continuity of their activities. Despite this, since the mid-1990s, some agencies and CBOs have taken some initiatives to make grassroots organisations and development activities sustainable. Standing the test of time, particularly through the Maoist conflict, many of the CBOs have proved their resilience even though a large number of them have either died or became defunct.

It seems that Nepal's real institutional strength lies at the grassroots and this should be linked, promoted and consolidated. The success of many CBOs in carrying out collective actions has a historical basis as they were once the norms of cooperation. If CBOs were the one and only mechanism that continued to function in rural Nepal right through the most difficult days of the civil war, then they must be seen as a part of affairs of nation-building from below. The government needs to promote the sustainability of CBOs and provide them with more rights, resources, and recognise them as an important part of local governance mechanisms and the local development policy process. Currently, there is a disproportionate debate taking place about the central and federal level of governance structures in order to prepare the constitution, yet they seems to have largely failed to account for these grassroots realities.

Since sustainability is still a new idea, further study is required to understand the situation, particularly as many previously formed CBOs have now reached a mature age. Furthermore, the present data and review presented does not discuss CBOs in terms of gender, ethnicity, regions and other important social factors. Additional research in to the effects and impacts of social factors are needed. The forms that CBOs take in Nepal are almost as heterogeneous as the country itself.

## References

Adhikari, K. P. (1999). Marchwar swabalamban karyakram: Ek eitihasik upalabdhi. [Marchwar Swabalamban Programme: A historical achievement]. *Swabalamban for Liberation from Deprivation, 1*(1), pp. 32-38.

Adhikari, K. P. (2005). *Status and challenges of induced community mobilisation in Nepal: A study from agency's perspectives.* Unpublished research report, Kathmandu: Rural Self-reliance Development Centre.

Adhikari, K. P. (2007). *Exploring the dynamics of social capital in the sustainability of induced CBOs in Nepal*. Unpublished doctoral dissertation, University of Reading, UK.

Adhikari, K.P. and Gellner, G.N. (forthcoming). New identity politics and the 2012 collapse of Nepal's constituent assembly: When the dominant becomes 'other'.

Adhikari, S. P. (2000). *Rural development in Nepal: Problems and prospects*. Kathmandu: Sajha Prakashan.

Amatya, S. L. (1989). The divergent approaches of IRDPs and problems of implementation in Nepal. *Contribution to Nepalese Studies (CNAS), 16*(1), pp. 43-54.

Anon., (2005, November 10). Controversial I/NGO codes enforced. *Kathmandu Post.*

Anon. (2005, January 21-27). Interview: Local groups can deliver service. *Nepali Times Weekly. 231.*

Avina, J. (1993). The evolutionary life-cycles of non-governmental development organizations. *Public Administration and Development. 13*, pp. 453-74.

Bhattachan, K. B. (2001). (I)NGOs and disadvantaged groups in Nepal. In: K.B. Bhattachan, D. R. Dahal, S. Rana, J. Gyawali, M. B. Basnet, et al., Eds. *NGO, civil society and government in Nepal.* Kathmandu: Sociology/Anthropology Central Department and Fedrich Ebert Stiftung.

Biggs, S. D., Gurung, S. M., and Messerschmidt, D. (2004). *An exploratory study of gender, social inclusion and empowerment in development groups in Nepal: Working from the positive (version ii).* Unpublished report. Kathmandu: National Planning Commission, Government of Nepal, The World Bank and DFID.

Blaikie, P. M., Cameron, J., and Seddon, D. (1979). *The struggle for basic needs in Nepal.* Paris: OECD Publishing.

Chambers, R. (1983). *Rural development: Putting the last first.* London: Longman.

Cooperative Department (2014). *Statistics of cooperative enterprises 2014.* [online]., Available at: *http://www.deoc.gov.np/downloadfile/Cooperative%20Statistics%202071_1418276512.pdf . Retrieved February 12, 2015*

Dahal, D. R. (2000). Grass roots governance in Nepal: Reinventing decentralization. *Sahabhagita.3&4* (2), pp. 33-47.

Dahal, G.R., & Adhikari, K.P. (2012). South Asia forest tenure assessment. *Environment and Climate Series 2011/3.* Kathmandu: HELVETAS/ Intercooperation Nepal, pp. 1-33.

Dahal, N (1997). A Review of Nepal's first conference on agriculture. *Water Nepal. 5*(2), pp. 149-164.

Devkota, P.L. (1994). Anthropological perspectives on grassroots development in Nepal. *Occasional Papers in Sociology and Anthropology,* 4, pp. 50-71.

Dixit, K. M. (2006, March). Two chairmen and a people. *Himal Southasia, 19*(2), pp. 16-24.

Esman, M., and Uphoff, N. (1984). *Local organizations: Intermediaries in rural development.* London: Cornell University Press.

FAO (1999). Small farmer group associations: Bringing the poor together. In: *Proceedings of an E-mail conference 24 September-11 November 1998*. [online]., Available at: http://www.fao.org/sd/PPdirect/ppfo0009.htm. Retrieved September 20, 2003.

FAO (2004). *Nepal agricultural policy and strategies for poverty alleviation and food security.* Rome: Food and Agriculture Organization.

Forest Action (2003). Editorial. *Livelihood and Forest, 2* (2).

Garforth, C. & Munro, M. (1995). *Rural people's organizations and agriculture development in the Upper North Thailand.* Reading: AERDD, The University of Reading.

Hardin, G. (1968). The tragedy of commons. *Science*. 162, pp. 1243-8.

Inlogos (2009). *Assessment of village development committee governance and the use of block grants.* Kathmandu: Ministry of Local Development and United Nations Development Programme.

Institute for International Cooperation, Japan International Cooperation Agency(2003). *Country study for Japan's official development assistance to the Kingdom of Nepal. Beyond Poverty and Conflict.* [online]. Available at: http://jica-ri.jica.go.jp/IFIC_and_JBICI-Studies/english/publications/reports/study/country/pdf/nep 02.pdfRetrieved February 14, 2014

Jha, C., Prasai, S., Hobley, M. & Bennett, L. (2009, May). *Citizen mobilisation in Nepal building on Nepal's tradition of social mobilisation to make local governance more inclusive and accountable.* [online]., Available at: http://www.gsdrc.org/docs/open/VA1.pdf . Retrieved February 14, 2014

Korten, D. (1990). *Getting to the 21st century: Voluntary action and the global agenda*. West Hartford, Conn: Kumarian Press.

Kshetry, D.B. (2013). *Overview of slavery in Nepal.* Pokhara: Parbati Kshetry.

Lama, M. S., Dhakal, S.L., & Rai, S. L. (2005). *Community based organizations (CBOs): Landscape, capacity assessment and strengthening strategy.* Kathmandu: Sagun

Lewis, D. (2001). *The management of non-governmental development organizations:* An introduction. London: Routledge.

Malla, Y. B., Neupane, H. R, & Branney, P. J. (2003). Why aren't poor people benefiting more from community forestry? *Journal of Forest and Livelihood, 3* (1), pp. 78-90.

Maskay, B. K. (1998). *Non-governmental organizations in development: Search for a new vision.* Kathmandu: Centre for Development and Government.

Mishra, C. (2001). New predicaments of "humanitarian" organizations. In: K.B. Bhattachan, D. R. Dahal, S. Rana, J. Gyawali, M. B. Basnet, et al., Eds., *NGO, civil society and government in Nepal.* Kathmandu: TU-FES. Kathmandu, Sociology/Anthropology Central Department and Fedrich Ebert Stiftung.

MoA (1958). *Krisi sammelanko report, 2015* [Report of Agriculture Conference 1958]. Kathmandu: Ministry of Agriculture, Government of Nepal.

Nlogos (2009). *Assessment of village development committee governance and the use of block grants.* Kathmandu: Ministry of Local Development, Government of Nepal and United Nations Development Programme.

NPC (2002). *Tenth Plan 2002-2007.* Kathmandu: National Planning Commission, Government of Nepal.

Panday, D. R. (1999). *Nepal's failed development: Reflections on mission and maladies.* Kathmandu: Nepal South Asia Centre.

Paudyal, D. P. (2004). *Sankatgrasta Nepal astitwoko khojima* [Nepal in crisis: In pursuit of an identity]. Kathmandu: Ratna Pustak Bhandar.

Pokharel, D., & Willet, A.B. (1996). History of an indigenous community management organization in Nepal. In: P. Blut, and D. Warren, Eds., *Indigenous Organizations and Development*. London: Intermediate Technology.

Pretty, J.N. (2003). Social capital and connectedness: Issues and implications for agriculture, rural development and natural resource management in ACP countries. *CAT Working Document Number 8032.*

Pyakurel, K. (1998). *Small farmers' group networks: A case study of small farmers cooperatives limited in Nepal*. (Report submitted to FAO). [online]. Available at: http://www.fao.org/sd/PPdirect/PPre0057.htm. Retrieved August 02, 2002.

Regmi, M.C. (1978) *Thatched huts and stucco palaces: Peasants and landlords in 19th-century Nepal.* New Delhi: Vikas.

Rural Self-Reliance Centre (1998). *Bipanatabata muktikolagi swabalamban [Swabalamban for liberation from deprivation]*. Kathmandu: Rural Self-Reliance Centre.

Sah, J. (Ed.). (2003). *A Study report:Social mobilization and its mapping in Nepal.* Kathmandu:South Asia Poverty Alleviation Programme, Local Governance Programme, Participatory District Development Programme, National Planning Commission, Government of Nepal and Social Mobilization Experimentation and Learning Centre/IAAS.

Shakya, K. M. (2008). Foreign aid, democracy and development: Personal experiences. In D. Gellner and Hachhethu, K., Eds., *Local democracy in South Asia microprocesses of democratization in Nepal and its neighbours, Volume 1,*. Delhi: Sage, pp. 258-278.

Sharma, G. N. (1990). The impact of education during the Rana period in Nepal. *Himalayan Research Bulletin, 10* (2&3), pp. 3-7.

Sharma, S., Bhattachan K. B., and Shrestha, R. P. (2001). *Institutional sustainability and impact of small farmer co-operative limited.* Unpublished study report. Kathmandu: GTZ and ADBN.

Shroff, S. (2007). *Back to the village dreams*. [online]. Available at: *http://www.boloji.com/index.cfm?md=Content&sd=Articles&ArticleID=3400. Retrieved February 16, 2014*.

Singh, K. (2004, February 20). Foreign aid or first aid: How to spend money when a war is going on. Nepali Times Weekly, 184

Subedi, K. (2006). 50 Arab Yetauta [50 billion rupees transferred]. Himal Khabar Patrika, 15 (22) Full Issue No. 166.

Subedi, N. R. (1999). *Village development program through social mobilization.* Kathmandu: PDDP.

SWC List *of NGOs affiliated with SWC.* [online]. Available at: *http://www.swc.org.np/.Retrieved February 12, 2014. Kathmandu: SWC.*

Tanner, P. (2001). Emerging methods in research participation and empowerment processes in Nepal. *Occasional Papers in Sociology and Anthropology,7,* pp. 147-179

Tatsumi, K. & Joshi, N.M (2010). *The roles of communities in rural development: potentials of community-based approach in Nepal.* Conference Paper: 4th Manila: Asian Rural Sociology Association (ARSA).

Thapa, P.B., & Rijal, M (2015, March 08). Local mess. *My Republica*

UNDP (2004). *Nepal national human development report 2004: Empowerment and poverty reduction.* UNDP, Kathmandu Nepal.

Upadhyay, S. K. (1998). *Regional expert group meeting on government-NGO collaboration in rural poverty alleviation.* Bangkok: United Nations Economic and Social Commission for Asia and Pacific (UNESCAP). [online]. Available at: *http://www.unescap.org/rural/doc/gov%5Fngo%5F1998/Nepal.PDF. Retrieved November 05, 2006 from*

Uphoff, N. (1986). *Local institutional development: An analytical sourcebook with cases*. West Hartford: Kumarian Press.

Uphoff, N. (1991[1985]). Fitting projects to people. In M. M. Cernea (Ed.). *Putting People First: Sociological Variables in Rural Development.* New York: Oxford University Press, pp. 359-395

Wehnert, U. and Shakya, R. (2001). *Transforming an unsustainable project into sustainable rural financial institutions: The case of the small farmers co-operatives ltd. (SFCLS) in Nepal.* Paper prepared for GTZ. University Cologne, Development Research Centre. [online]. Available at: *www.uni-koeln.de/ew-fak/aef/PDFnew/S-B12-%20Are%20SFCLs%20Viable%20Microfinance%20Organizations%20-U.pdf Retrieved April 27, 2003 from*

Wood, H.B. (1959). *Six years of educational progress in Nepal*. Kathmandu: Bureau of Publications, College of Education.

World Bank (1889). *Nepal social sector strategy review,volume II*. Washington, D.C.,: The World Bank.

Yadama, G. N., & Messerschmidt, D. (2002). Rise and fall of national service in Nepal: Politics of services in new democracies. In: Paper presented in the global conference IANYS, September 3-6. [online]. Available at: *http://www.clayss.educaciondigital.net/ianys/inform/sasia_eng.doc on 18/08/05 Retrieved August 05, 2005.*

12

# Gender, Energy and Poverty in Nepal: Perspectives from Human Development

Ishara Mahat

## Abstract
Access to rural energy in general, and biomass in particular, has significant impact on people's well-being. This is especially true for the life qualities of rural women in Nepal, as they are directly involved in production and management of household energy. Energy poverty involves deprivations on multiple fronts such as economic, social, cultural and ecological. Low access to energy services is one aspect of poverty, as energy choices of poor households are influenced by poverty. Energy poverty has multidimensional implications on human development, and particularly on women from rural areas. For instance, increased use of biomass limits the economic productivity and reproduction capacities of women, which, in turn, restricts their capabilities to access many socio-economic opportunities. The challenges are to identify alternative options that help to address both energy poverty as well as human poverty in order to increase the human capabilities (especially of women) and their freedom, improving the overall well-being of rural households. It is important to think about the type of fuel technologies and their delivery mechanisms that can possibly help to make a large-scale transition away from traditional biomass cooking to improve the well-being of women and their families in rural Nepal.

Key words: gender, energy, poverty, capabilities and freedom, Nepal

## 1. Introduction
Gender, energy, and poverty are inextricably linked and are associated with agricultural productivity, employment opportunity, environmental sustainability, and peoples' health conditions. Energy is essential to deliver adequate and quality living conditions, food, water, health care, education and employment opportunities (Najam & Cleveland, 2003). For instance, availability and accessibility of energy influence the process of food growing, cooking, lighting, heating and cooling. It especially influences poor people's lives as they spend much of their time and part of their economic resources in obtaining energy sources for basic needs (Akong, 2005). Yet, more than two billion people in the world are unable to access clean

and safe fuel and energy for their livelihoods; they rely on traditional biomass burning such as wood, crop residue and cow dung (Akong, 2005).

In Nepal, 86% of energy comes from biomass (CRT, 1999), the use of which often adversely affects the health and well-being of the people, especially girls and women. Fuel-wood has been the primary energy source in Nepal, and the main responsibility of collecting fuel wood falls predominantly on women. Evidence shows that women in rural Nepal spend a considerable amount of time (from two to up to twenty hours a week), often moving over difficult terrain, to collect fuel wood (Sinha 2001; Mahat, 2004). Many young girls are kept out of school to assist in firewood collection (Clancy, 2000). In many cases, women in rural areas of Nepal suffer from back pain, and face the risk of miscarriage and uterine prolapse, which are attributed to carrying heavy loads of firewood (Earth & Staphit, 2002; Haile, 1991; UNDP, 1997). Moreover, during firewood collection, some women also face threats of sexual harassment and rape, which is an issue that often goes unreported (Cecelski, 2000; UNDP, 1997).

As the houses in rural Nepal are poorly ventilated and firewood is being used as the main energy source for cooking and heating, the resulting indoor air pollution has created acute respiratory infection (ARI) for many, which is a serious health problem. A study in Nepal showed that the highest percentage of infant mortality due to acute respiratory infection (ARI) is associated with indoor air pollution (Pandey, 2003). This situation has indicated how energy and gender dynamics are closely associated with rural poverty in general, and human poverty in particular, affecting the well-being of people in rural Nepalese households (Ramani, 2004).

## 2. Capabilities approach of poverty

Poverty alleviation has been the main priority of Millennium Development Goal (MDG) in developing countries, including Nepal. However, it is ironic that the poverty reduction framework has often failed to incorporate the human dimensions of poverty despite the efforts that are in place to address human development (UNDP, 2006). Nobel laureate Amatya Sen (1999) argues that poverty is more than having low income and is closely connected with deprivation of basic capabilities, which diminishes the overall wellbeing of people, especially women. Sen claims that issues of social justice have created both income and gender inequalities, which directly affect people’s systems of livelihood elsewhere (Nussbaum, 2003; Robeyin, 2003). Disagreeing with economic growth as an indicator of life quality, Sen commends that growth alone does not reflect the deprivations of individuals which restrict their capabilities (Nussbaum, 2003). For instance, men and women do not enjoy equal benefits from development services such as education, which leads to the deprivation of their basic capabilities.

In this view it can be argued that women cannot contribute to fulfil the household’s needs required to uptake and maintain (or improve) family wellbeing unless they are free to engage in social and economic activities both inside and outside household environment (Sen, 1999). Hence, freedom of choice promotes gender equality and gender equality promotes household well-being. Household well-being bolsters economic productivity, leading to better livelihood of the family.

## 3. Relationship between energy poverty and human freedom

Energy is considered one of the means for poverty alleviation as it is an essential input for sustaining people's livelihoods (Clancy et al., 2000). Energy poverty reflects the low access to better energy services. However, the deprivations caused by energy poverty on human development are much more significant than the access to energy alone (Ramani, 2004; Modi et al., 2006). For instance, energy has equity dimensions as the richer households can afford higher quality fuel than the poorer households (Clancy et al., 2000; Cecelski, 2004). In Nepal, women from the poorer households suffer with an increased health burden as a result of spending more time collecting firewood. Such tasks restrict women's capabilities to utilise other economic and social initiatives and thereby adversely impact their well-being.

Women's time and labour are valuable for achieving the wellbeing of the entire family. Although a women's role in the production of energy and in the production of household income through small-scale household level enterprises are important, these enterprises are often undervalued in the social decision making system (Bhattachan, 2001; Cecelski, 1995; Skutsch, 1995). For instance, even though women are the main producers and managers of biomass energy in rural areas, they often are excluded from the decision-making processes for energy interventions such as the locating biogas plants (Cecelski, 2000b; Skutsch, 1996; Mark, 1995).

## 4. Conceptual model

Figure 1 presents the conceptual framework of this study and shows how the use of biomass energy causes multiple deprivations of the rural households affecting their wellbeing and agency freedom, thereby its lasting impact on human development.

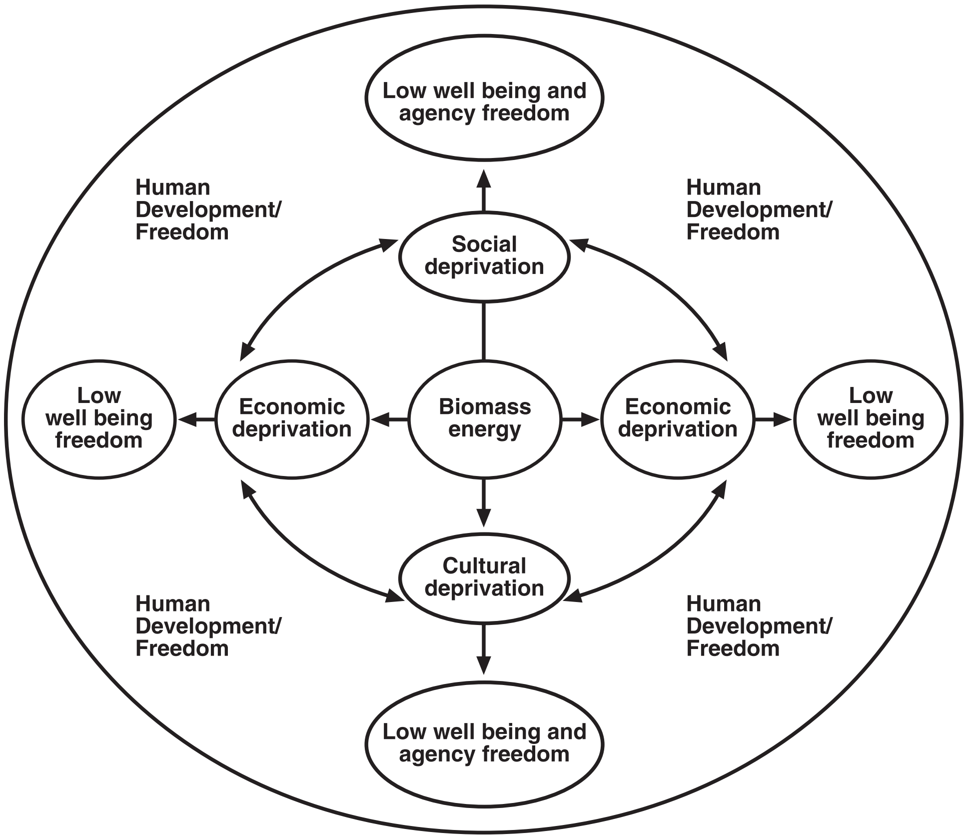



Figure 1: Conceptual model: Gender, energy and human development.

### 4.1 Social deprivation

As stated earlier, biomass is one of the major sources of cooking energy in rural areas, which is mainly managed by women. As the poorest households in rural areas have very little access to alternative fuels, they are compelled to use biomass as a major source of fuel causing numerous health problems as stated previously.

Burning traditional biomass over open fires or in inefficient stoves creates hazardous indoor air pollution which contributes to severe ill-health, and at times death, to those who are exposed to it (WHO, 2005; Barnes, 2005). The World Health Organization (WHO) estimates that 1.6 million deaths (2005 estimates) are associated with domestic chores, especially of women and children who are exposed to indoor air pollution while cooking and heating.

In addition, school aged girls often miss their school classes or are withdrawn from school to work at home; they are recruited to help their mothers in energy related activities, especially collecting and carrying firewood. These problems are considered a social deprivation, restricting women's choices, their productivity and health.

### 4.2 Economic deprivation

Absence of sufficient and quality energy hinders the growth and efficiency (UNDP, 2004) of economic production. It restricts the economic and social opportunities for rural households and fails to allow for new ventures and energy based enterprises (REN21, 2005).

For instance, when women use the majority of their time to fulfil the needs of acquiring biomass, it reduces the opportunities for them to be involved in economic activities (Skutsch, 1996; Cecelski, 2004; Mahat, 2004). This situation reduces the possibilities for household and community-level small-scale enterprises to grow and flourish.

### 4.3 Ecological deprivation

Using biomass for energy causes depletion of forest resources, which has a negative impact on its inhabitants as it contributes to the extinction of natural species (Najam & Cleveland, 2003) and contributes to global warming. Since forests are habitats for a large number of species, their degradation directly affects the loss of biodiversity and disturbs the natural ecosystem. Rural inhabitants in poor countries suffer the most due to environmental degradation, as their livelihoods depend ecological goods and services available from forests (e.g. generation of water, wood and non-wood forest products, fuel, recycling of nutrients, replenishment of soil fertility, prevention of erosion, carbon sequestration and storage, recreation, etc.) (Koziell & McNeil, 2002). If we analyse this complexity through a gender lens, women are more vulnerable to environmental hazards due to their closer exposure to risks and aforementioned reasons (Cecelski, 2004; Pearce, 2005).

### 4.4 Cultural deprivation

Culture refers to the collective identity of a group of people who follow a way of life, as defined by their choices. Depending on the nature of the society, culture also facilitates freedom of choice. Thus, cultural freedom protects not only the group but also the rights of every individual within it (Matilla and Sepilla, 2000). This concept can be linked with women in rural Nepal, who are dependent on forest systems as a survival strategy.

Given the existing patriarchal system in Nepal, and looking through a cultural lens, women and children, despite the energy related burden they have been bearing (Acharya, 1989; Bhattacharya, 2000), are allowed little input in decision-making regarding energy resources and related interventions. It restricts women’s ability to function well towards their livelihood and well-being (Rajavi, 1999; Rajavi, 1998).

## 5. Strategic model

Figure 2 shows a strategic model that helps to operationalise the concept of gender, energy and human development. It illustrates how better energy services (which are affordable, accessible and reliable) can help to alleviate the deprivations and thereby promote the wellbeing and agency of women for overall human development.

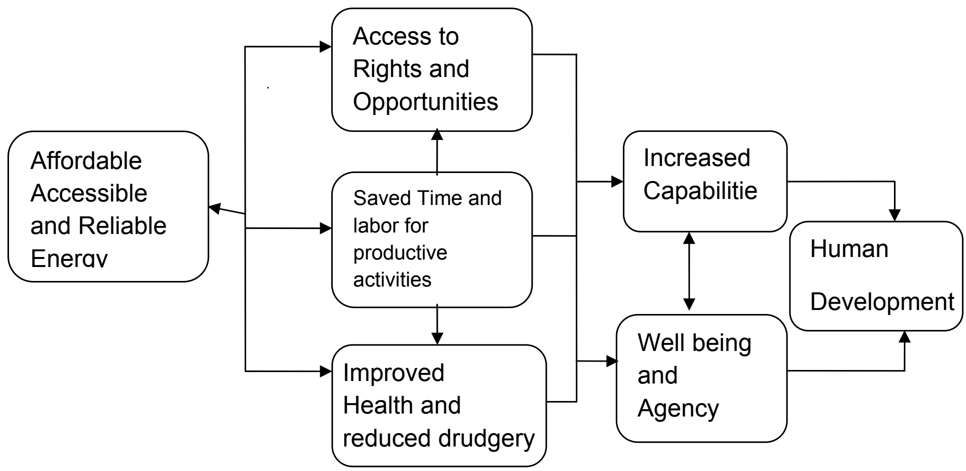



Figure 2: Strategic model: Gender, energy and human development

UNDP in its Millennium Development Goal (MDG) has emphasised the need for better energy services for improving the quality of life in rural settings. However, the challenge is to identify appropriate energy services including the use of modern fuels to replace traditional biomass energy sources which cause multiple deprivations that affect the overall well-being of rural households.

Using better energy alternatives such as improved biomass technology or biogas can help reduce acute respiratory ailments among young children and women which are caused by domestic air pollution; other health problems associated with the use of traditional energy may also be impacted.

Having access to better energy options, people in rural settings, especially women, are free (having more time and labour) to be involved in other economically productive activities such as energy based small enterprises; this increases the potential they have to improve the well-being of their families. Also, women and girls can pursue their right to self enhancement through education and employment opportunities. This ultimately helps the entire family.

As women become educated and employed, they are more capable of participating in decision-making processes within the household as well as at the community level. With the increase in capabilities through the freedom they enjoy, their overall human development (health, education, income status) will be improved as their family and personal agency is enhanced.

Also, when poor households have to rely less on firewood from the forest, not only for their own use, but also for the purpose of selling to make income for their living, there will be less pressure on forest resources. This will promote an ecological balance which better allows for sustained resources which are heavily relied upon by many rural households for their well-being.

# 6. Reflection on the case study

## 6.1 Research design

This research builds on data that was collected by the author in 2008 and is based on a logical theoretical framework that was built by rigorously synthesising evidence. The purpose of collecting new data was to obtain additional information in order to contribute to new knowledge on social and cultural deprivations related to biomass energy resources, biomass energy policies (national and regional levels) and to come up with appropriate policy strategies for better biomass energy options.

The fieldwork was undertaken in Kavre district of Nepal for nearly two months from July through September in 2008. Two Village Development Committees (VDCs), namely Mangaltar (27.35 km from the district headquarter) and Katunjebeshi (22.53 km from the district headquarter) were selected for field work. Participants were selected in order to accommodate the research needs as the key informants interviewed provided major contributions. At the village level, the participants were identified by discussions with some key informants such as local health workers, village heads and other village authorities; these individuals provided some general information on the socio-economic backgrounds of potential participants. Based on their information and through the personal observations made during field visits, the participants (mostly women) were selected for interviews. While selecting the participants, gender, ethnicity, and class were taken into account.

At the regional and national levels, the participants were representatives of different institutions and worked in energy related fields which included implementing agencies, donors, and government authorities at the top. Semi-structured interviews were conducted with policy makers at regional (district) and national levels and data triangulations were done to avoid possible biases.

One of the major limitations of this field research included the limited time availability of participants when responding to the questions, particularly because selected local women were always occupied with several household activities. In addition, it was a labourious period of the agricultural season and locating participants for research was a difficult task.

## 6.2 Analysis of findings

Since this research has highlighted human dimensions of energy deprivations, the following important issues related to biomass energy were analysed (sections 6.2.1 through 6.2.3).

### *6.2.1 Availability of biomass*

Firewood was found to be the major source of household energy, followed by agricultural residue and animal waste. There were no other options for household cooking due to the lack of other energy alternatives. Firewood was the main source of energy for the households. Thus, there was an excessive reliance on traditional sources of energy (Table 1).

Although it was observed during a field visit that the majority of the households in all communities visited used firewood for cooking, only a few households had installed the biogas system. These households utilising biogas could not fully rely on it to meet all of their energy needs and still required the use of firewood for ritual cooking and livestock feeding.

**Table 1:** Types of biomass used by rural households given as percentage of respondents

| Types of Fuel Wood Used | Percentage Quantity of Fuel Used |
|---|---|
| Fuel wood | 91 % |
| Agricultural residue | 7 % |
| Animal waste | 2 % |
| Total biomass used | 100 % |

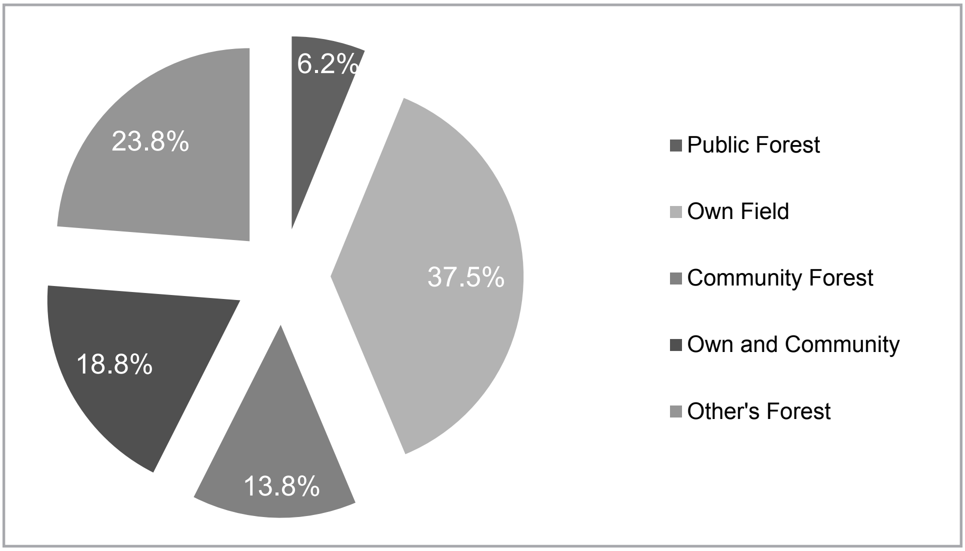
(Source: Personal observation, 2008)

Many households used agricultural residue such as corn and paddy sticks for preparing livestock feeding. Especially among the Brahmin community, women also used agricultural residue and animal dung for cooking their daily meals due to the lack of firewood; they had little time for collecting firewood in the absence of sharing workloads within the home.

During the field visit it was noted that local women had to travel up to 4 hours to collect a bunch of firewood from nearby forest areas (private forest). In total, they often would spend about 6 hours per day on this task. Collecting firewood from private forests was not an easy task as the general public lacked access to these resources. Sometimes women had to run, at times even breaking their legs, due to the fear of being caught and paying penalties. The majority of women collected fodder grasses around their own fields for livestock feeding; fodder was also used for cooking when they did not have time to go to the forest (Figure 3).

There was also a community forest in the local area; however, as the forest was protected, local people were only permitted to collect fallen branches and residue from the trees. They also purchased firewood once a year when the community forests were opened for cleaning. Every villager had access to the public forest (national); however, there was not enough firewood to meet the total energy demands of the local people.

Figure 3: Access to fire wood by rural households (percentage of respondents)




(Source: Personal observation, 2008)

### *6.2.2 Work load*

During field observations, it was noticed that the workload of women remained heavy, even with the availability of infrastructure such as road networks and electricity. The targeted villages in the research study were located in the middle hill areas of Nepal, and the geography and climate placed a huge work burden on women who needed to collect firewood to meet both cooking and heating needs. Since houses are made of mud and stone, living conditions were at times uncomfortably cold without the heating provided by burning firewood. Thus, in order to meet the multiple needs of the households, collecting and cooking with firewood involved a heavy work burden, especially for women.

Table 2 shows a representation of the gender roles in household energy management in two villages of Kavre.

**Table 2:** Gender roles in household energy management (percentage of respondents)

| | Who cuts down trees? | Who collects fire wood? | Who stores it? |
|---|---|---|---|
| Women | 35 | 65 | 71 |
| Men | 44 | 5 | 3 |
| Both | 21 | 30 | 26 |
| **Total** | **100** | **100** | **100** |

(Source: Personal observation, 2008)

Although some men in the Tamang community shared the task of acquiring fire wood, it was women who took on the major responsibility of collecting and managing firewood for cooking (Table 2). Men, especially from Brahmin community, were involved in cutting trees as women were considered not to be strong enough to complete the job.

Table 3 below presents the problems related to women's workload in collecting and cooking with firewood at household level.

**Table 3:** Problems in collecting and cooking with firewood (percentages of cases)

| Problems in Collecting Firewood | % of Cases | Problems in Cooking with Firewood | % of Cases |
|---|---|---|---|
| Long distance to walk | 86.2 | More smoke | 98.6 |
| No time to go to forest | 34.5 | Dirty utensils | 82.5 |
| Lack of firewood (long time to collect) | 48.3 | Dirty house | 57.3 |
| | | Hard to blow | 28.0 |
| Risky (falling down from trees, paying penalties) | 34.5 | Eye irritation | 26.6 |
| Costly to buy | 15.5 | Long time to cook | 4.2 |
| Other | 13.8 | High heat during summer | 2.8 |

(Source: Personal observation, 2008)

Psychologically, women were more worried about their daily work load related to the management of household energy systems. As stated earlier, women had to spend several hours a day to collect a bundle of firewood. Additionally, women were overwhelmingly concerned about the smoke caused by burning biomass, realising the negative health implications of this activity (Table 3).

The extra work needed to clean utensils, surfaces and houses caused by the smoke and associated particulates were one of the major problems for women in rural villages of Kavre. It took a considerable time for them when cleaning the houses, dishes and linens because they become dirty frequently while cooking with firewood and other biomass resources.

With the availability and accessibility of diesel mills and micro hydro mills in the villages, women's work-loads were reduced to some extent as they did not have to use their labour (human energy) to process agricultural products. As explained above, women were always occupied with household chores; they had very little time for other economic and social activities that could enable them to be empowered socially and economically.

*6.2.3 Health related problems*

It was observed that the majority of the women in the villages had eye and lung diseases, which were directly related to biomass cooking fuels (Table 4). As the houses were built in traditional ways having no proper ventilation, exhaust of the smoke was almost impossible. Thus smoke would spread inside the house causing different kinds of health and hygiene related problems. A woman in an interview expressed that, "we are used to the smoke even though we feel eye irritation and headaches so often, as we have no other options." The findings of this study also found similar results as other researchers, showing that domestic air pollution was found to be one of the major reasons for maternal and infant mortality in rural Nepal (Pandey, 1989). There were few households that used improved stoves installed with a chimney for smoke removal. However, the local women were not made aware of the technical problems related to chimney use and maintenance so many of them went back to using traditional stoves that they were more familiar with.

**Table 4:** Selected health problems in two villages (Percentage of Cases)

| Health Problems | Men | Women |
|---|---|---|
| Eye problems | 35 | 73.0 |
| Lung disease | 21 | 41.0 |
| Asthma | - | 13.5 |
| Uterus Prolapsed | - | 49.5 |

(Source: Personal observation, 2008)

There were a few women who mentioned their prolapsed uterus as a health condition a result of carrying heavy loads of firewood. However, this problem was reported to be combined with other household chores which added to their overall workload. Especially in rural areas, women go to the fields while pregnant and return to the fields or forests within a month post-partum, and thus problems of uterus prolapse was observed due to the heavy work load during and after childbirth. This problem was not often identified by the women themselves as they were unaware of the causes of their problem. In many cases, women remained quiet without expressing this problem on their own as it was a sensitive topic. However, it was indirectly noticed that the majority of women in the past had suffered from this problem. Such situations were explored through indirect conversation. A woman expressed that, "we never knew that a prolapsed uterus was caused by heavy workloads, and we always feel shy to talk about this problem."

## 7. Wellbeing and agency freedom

Wellbeing and agency freedom are related with the life qualities of people. Agency freedom is defined as the freedom to act and accomplish a common good for all. It is related with the collective effort people make to achieve a common well-being. Rural women hardly enjoy agency freedom in their attempts to enhance their wellbeing as they are already stocked with wellbeing freedom.

For instance, people must be free to achieve and obtain basic education, basic housing, basic health and quality foods. In rural areas of Nepal, people, especially women, are deprived of such wellbeing. The female children are allowed to go to school only if they finish housework; they often drop out from school if they have to travel relatively long distances from the villages to reach school. It was reported that only a few girls from wealthier households had gone to the adjacent villages to continue their higher secondary education, and the completion of college education by rural women was very rare. These issues are also related to the household energy system as women often get overloaded with energy related work. Women often refuse to re-cook even if there is not enough food left for them; they often remain hungry the entire day while expending the same energy needed for household chores. This has caused numerous health problems such as ulcers and gastric problems. One female respondent mentioned that, "our elders especially our father-in-law and brother-in laws eat first and we women eat later all the leftovers. We do not care if we have enough or not." Women expressed that they have very little time and opportunity for education and health care and are often incapable of participating in other economic and social activities.

Women have little power to decide on issues related to their own lives or if they want to participate in the activities outside the home. It was observed in the villages that women rarely participated in the village level meetings organised for different activities such as rural energy programs, road building programs and other programs. Although women were the active contributors in constructing micro-hydro canals as well as raising and mobilising funds through savings, their participation in community and village level decision-making was nominal. Mostly men were the decision-makers at the village level. A woman mentioned that "we do not have time to participate in such meetings and we also have little understanding of the subjects matter." On the other hand, some other women mentioned that "we are not encouraged by the family members to participate in such meetings." There was a mix of ideas and thoughts about their role in the participation in these activities. However, it was observed that at the village level, women actively participated in community forestry programs and helped to manage and preserve the forest. They participated in village level meetings and shared their ideas with male members involved in the forest committees. However, women have little time and few opportunities to participate in other economic and social activities that could enable them to be empowered economically as well as socially. In some cases, women were involved in cash crops and livestock production at a personal level and were able to generate some income for themselves. However, they still used the income for the welfare of their family, although such incomes helped their economic empowerment and raised their self-esteem for the wellbeing of the whole family. In one interview, a woman reported the circumstances of women, stating that "our life is around the forest and the house, no matter whatever technologies are there. We cannot be free from firewood and fodder, and free from our house. Our work is waiting for us, who will let us go for enjoying meetings and trainings."

## 8. Equity versus efficiency

Using biomass for cooking has many implications for equity. For instance, only a few wealthy households use quality fuels such as modern combusted biomass (biogas) for cooking, while the poorer household rely on low quality biomass fuel such as agricultural residue and animal dung. A woman in an interview reported that, "there are few biogas plants in this village for many years but it is no use for us as we cannot afford it."

While alternative technologies can have potential for reducing the drudgery, and increasing the income of a household, they have not been able to reach a larger section of society. For instance, only 5% of the households have access to solar lighting technologies. Similarly, in each village only a few households were able to install biogas systems, while the majority are unable to afford this technology, even with subsidies. Many households lack the feasibility of installing biogas plants in the absence of adequate cattle and labour supply. This situation has created even more inequalities in the villages where there are large socio-economic gaps existing even within relatively small communities. Until the technologies are designed for low income families and subsidies are appropriately channelled, such technologies will remain out of reach for the majority of the poor. A woman in an interview mentioned that, "we cook with biogas, but if it goes wrong, sometimes we do not know how to fix it. And there are no men around the house, so we better use the firewood." The Improved Cooking Stoves (ICS) program and the Biogas program, without a package (e.g. monitoring the socio-economic impact, effectiveness of stoves, and ensuring the proper use of a chimney, etc.), such programs have been less effective and adoptable by many rural women, especially in the hilly areas of Nepal.

In addition, alternative energy technologies (AETs) like solar power and micro-hydro power have only been used for basic lighting; no other technologies have been explored that could work to utilise local resources, including women's knowledge and the numerous skills of local producers. AETs have a large potential to initiate home based enterprises such as dairy production and handicrafts in which women can gain access, empowering them both socially as well as economically.

## 9. Conclusion

In the absence of clean energy resources in the rural areas of Nepal, the rural households are heavily relying on the biomass energy as a sole source of cooking fuel. The heavy reliance on biomass energy is not only a problem for women, limiting their economic productivity and reproduction capacities, but it also limits the opportunities for socio-economic advancement of rural households. This has a significant impact on rural poverty, impacting the quality of life for rural women as they are the direct victims of energy problems in rural areas.

It is unlikely that the poorer households in rural areas of Nepal will be able to shift to better fuels in the near future due to their inability to afford better energy price. Even though there has been an increased effort to bring the modern energy services to the poor, the emphasis is on electricity and not on cooking fuels. Women's drudgery related to household energy management remains unaddressed, until there is an intervention focussing especially on women's workload, and in dealing with indoor air pollution. Energy planning without its integration with social indicators such as women's empowerment and poverty reduction has had little impact on the overall development of the family and community. There have been efforts to address household energy issues by focussing on energy policy aimed at increasing the coverage of biogas plants and integrating micro-hydro systems for household energy in the long-term. Given the poor socio-economic conditions of the rural households, even the subsidised plants are unreachable to the poorest section of society.

In order to address the cooking related problems, there is a critical need for interventions which reduce the high level of indoor air pollution; for example, the use of Improved Cooking Stoves (ICS) could address this problem. However, development and building of ICS is not the end for solving targeted problems; there is also a need to for the integration of training individuals on the construction of ICS and chimney related problems for the end users. In addition, there is a need for sustainable harvesting of firewood from forest land in order to ensure its continuous supply to meet basic household energy needs. Also, it is important to introduce multipurpose, quick growing tree species in farmland areas as a way to rapidly reforest areas. It is important to think about the type of fuel technologies and their delivery mechanisms, which may possibly help to induce a large-scale transition away from traditional biomass cooking for the majority of the poor. Managing biomass energy for cooking has a significant impact on women's workload and their health, which can hinder their capabilities and opportunities for participating in economic and other social activities. This has restricted their freedom both for achieving their own wellbeing as well as their family and community as a whole.

## References

Acharya, M. (2001). Women and the economy: The key issues, in Manandhar, K. L. and Bhattchan, B.K., Eds. *Gender and Democracy in Nepal.* Kathmandu: Central Department of Home Science, Women's studies Program, Tribhuvan University, pp. 19-52

Agrawal, B. Humphries, B. & Robeyins, I. (2003) Exploring the challenges and work of Amartya Sen: Ideas and work, *Feminist Economics*, 9, pp. 3-12.

Akong, C. N. (2005) Energizing poverty reduction: Assessing the nexus of energy and poverty in poverty reduction strategy papers: Emerging findings and discussions on Sub-Saharan Africa. New York: United Nations.

Batliwala, S. & Reddy, A.K.N (1996). Energy for women and women for energy: A proposal for women's energy entrepreneurship. *ENERGIA News,* 1:1.

Barnes, D. F.(2000) *Energy and poverty: Strategies for assisting the rural and urban poor,* Washington, D.C.: South Asia, Energy Sector Unit, World Bank.

Bhattachan, B.K. (2001). Sociological perspectives on gender issues in changing Nepalese society. In Manandhar, K.L. & Bhattchan, B.K., Eds. *Gender and democracy in Nepal.* Kathmandu: Central Department of Home Science, Women's Studies Program, Tribhuvan University, pp. 76-94.

Cecelski, E. (2004). Re-thinking gender and energy: Old and new directions, Energy,

Environment and Development (EED), *Discussion paper*. ENERGIA/EASE.

Cecelski, E. (2000a). Energy and poverty reduction: The role of women as a target group,

ENERGIA, IN: *Paper presentation at the Debate on Sustainable Energy in Danish Development Assistance, Copenhagen: Landstingssalen, Christiansborg*.

Cecelski, E. (2000b). *Role of women in sustainable energy development*. Colorado: NREL.

Cecelski, E. (1995). From Rio to Beijing: Engendering the energy debate', *Energy Policy*, 23(6), pp. 561-575.

Clancy, J., Skutsch, M., & Batchelor, S. (2003). *The Gender-Energy-Poverty nexus:*

*Finding the energy to address gender concerns in development.* London: DFID [project CNTR998521].

CRT (1999). *Desk study on women's energy needs and some fuel-cooking systems in Nepal,* Kathmandu: Centre for Rural Technology.

ESMAP (1999) *Household energy strategies for urban India: The case of Hyderabad.*

Washington: ESMAP.

GNESD (2007) *Reaching the millennium development goals and beyond: Access to modern forms of energy as a prerequisite.* Rome: Global Network on Energy for Sustainable Development (GNESD).

Haile, F. (1991) *Women fuel wood carriers in Addis Ababa and the Peri-Urban forest.* Geneva: International Labor Organization, (ILO).

Jackson C. & Jones, P. (2003) Rethinking gender poverty and work. Development and Change, 30, pp. 557-583.

Kelkar, G. (1995) ‘Gender analysis tools’, *Wood Energy News,* 10 (2).

King, E. M. & Alderman H. (2001). Education. Brief No. 6. In: Quisumbing, A. R., & R. S. Meinzen-Dick, Eds. *2020 focus 6: Empowering women to achieve food security*. Washington, D.C., International Food Policy Research Institute (IFPRI). [online]. Available at: *http://www.ifpri.org/2020/focus/focus06.htm.*

Knight, J. & Kingdon, G.G. (2007). *Subjective well-being: poverty vs. income poverty and capabilities poverty,* Journal of Development Studies, 42 (7).

Koziell, I. & McNeill, C.I. (2002) Building on hidden opportunities to achieve the Millennium Development Goals: Poverty reduction through conservation and sustainable use of biodiversity. *In Opinion paper in World Summit on Sustainable Development.* Rome: International Institute for Environment and Development

Krznaric, R. (2007) How change happens: Interdisciplinary perspectives for human Development. *Research Report*. Washington, D.C.: Oxfam.

Marks, I. (1995) Women and energy resource management, UNIFEM Perspective. *Natural Resources Forum, Vol. 20* (2), pp. 145-152.

Mattila, V.A. & Seppälä P. (2000) Navigating culture: A road map to culture and Development. Helsinki: Ministry for Foreign Affairs, Department for International Development Cooperation.

Modi, V., S. McDade, D. Lallement, & J. Saghir (2006) Energy and the Millennium Development Goals. New York: Energy Sector Management Assistance Programme, United Nations Development Programme, UN Millennium Project, and World Bank.

McKinley, T. *(2006) One Pager #26*, , Brasilia: International Poverty Centre IPC.

Nussbaum, C.M. (2003). Capabilities as fundamental entitlements: Sen and social justice. *Feminists Economics*, Vol. 30, pp. 33-59.

OECD (2002). Poverty-Environment-Gender Linkages. Off-Print of the *DAC Journal 2001,* 2 (4) Paris: OECD.

Pearce, D. (2005) *Investing on environmental wealth for poverty reduction*. New York: UNDP.

Pearce, D. (2005) *Managing environmental wealth for poverty reduction, poverty and environment partnership: MDG7 Initiative - Economics.* New York: UNDP

Pettit, P. (2001) Symposium on Amartya Sen’s philosophy: Capability and freedom: A defence of Sen. *Economics and Philosophy,* Vol. 17, pp. 1-20.

Reddy A. K. N. (2000) Energy and social issues. In World *Energy Assessment.* New York: UNDP. ISBN 92-1-126-126-0.

Ramani, K.V. (2004) *Energy for sustainable development: Challenges for Asia and the Pacific and lessons from UNDP projects in the region*. New York: UNDP

Rajavi, S. (1999) Gendered poverty and well-being: Introduction. *Development and Change* 30, pp. 405-433.

Rajavi, S. (1998) Gendered poverty and social change: An issues paper. *UNRISD Discussion Paper 94.* Geneva: UNRISD.

REN21 Renewable Energy Policy Network, (2005). *Energy for development: The potential role of renewable energy in meeting the Millennium Development Goals.* Washington, DC: Worldwatch Institute.

Robeyins I. (2003) Sen's capability approach and gender equality: Selecting relevant Capabilities. *Feminist Economics 9* (2 – 3), pp. 61 – 92.

Saith R. & White, R.B. (1999). Gender sensitivity of well-being indicators. Development And Change. 30, pp. 465-497.

Sen, A. (1999a) *Development as freedom*, Oxford University, UK.

13

# Operational Readiness: Links to Sherpas' Peak Performance in Tourist Mountain-Guiding

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## Abstract
This scoping study is focused on defining performance excellence and operational readiness for Sherpa mountain-guiding for improved tourist safety in Nepal. Based on applied research with Olympic athletes, an internationally-tested, operational-readiness assessment tool has been developed for evaluating gold-medal performers' in any given high-risk occupation. With a preliminary framework established, an additional objective was to confirm the capacity for a more comprehensive investigation into operational readiness. The risks and challenges of high-altitude (HA) mountain-guiding expeditions over 7,000 meters were categorised. Mental readiness was identified as an important influence in HA-guiding in this preliminary evaluation. Of the three major readiness factors rated by mountaineering experts—physical, technical, mental—mental readiness was the one that showed the greatest perceived contribution to successful performance. Vocabulary, examples and scenarios were gathered to adapt the operational-readiness 'interview guide'. Potential 'watch items' were detected which included unprepared tourists, environmental pollution, a female-guiding trend and human-resource issues related to training, morale and mentoring. Demographics and scheduling of HA Nepali climbers were openly shared by important mountaineering stakeholders to lend confidence for future logistics. The important components needed for conducting a full-scale Operational Readiness Assessment of exceptional Nepali HA mountain-expedition guides were established for a future evaluation. This research aligns with the sustainability plans in Nepal to advance tourism-development through building human-resource capacity, quality and performance.

## 1. Introduction

### 1.1 Overview
Tragedy came again to Mount Everest on April 18, 2014 as BBC reported an avalanche near Everest Base Camp that claimed the lives of 16 Nepali Sherpa guides and supporters. Since climbers have been challenging Everest, over 200 have died (Adventure Stats, 2015). The majority of deaths have been attributed to falls, ice collapse, altitude sickness and avalanches. Despite the danger, the allure of summiting the Himalayas is never without risk.

Safety is a major focus of the trekking and climbing industry in Nepal. The business is dominated by guides raised in the mountain and hill regions—most notably the Sherpa tribe. These natives reside in the Himalayan region and are famous throughout the world for their mountaineering skills. They specialise in demanding, high-risk endeavours that deal with altitude, avalanches, extreme weather and human stamina. Tensing Norgay was the legendary Sherpa who accompanied Sir Edmund Hillary on the first successful Everest summit in 1953.

Other popular activities that draw tourists to Nepal include rock-climbing, white river rafting, kayaking, canyoning and paragliding. However, it is mountaineering that has been the most attractive activity for international tourists (Government of Nepal, 2013). Reaching an altitude of 8,848 meters, Mount Everest is the world's highest peak and is considered the Mecca by climbers.

Nepal has been officially open to international tourism since 1951. Sustaining this industry has become its top priority. However, despite six decades of promotion, Nepal still ranks low (112$^{th}$ position over 140 countries) in the World Economic Forum's Travel and Tourism Competitiveness Index (Gandip, 2013). The United Nations (UN) categorised Nepal as a 'least developed country' exhibiting some of the lowest socioeconomic and human development indicators of poverty, economic vulnerability and human resources weaknesses (UN-OHRLLS, 2015). Nepal must work smarter to be successful in leveraging the global tourism market. Further efforts that aggressively brand its natural beauty, humble and friendly people, and famous Sherpa-climbers would highlight Nepal as a premier tourist destination.

The UN has emphasised tourism development in low-income countries as a means of reducing poverty (UNDP, 2011). Similarly, government and major funding organisations have focused on promoting this industry with the goal of creating greater economic stability. For example, International Development Research Centre (IDRC) is a Canadian Crown corporation which has a goal of assisting developing countries access resources and services to strengthen policies that address local problems (IDRC, 2015).

The University of Ottawa has conducted extensive studies focusing on a new discipline entitled 'operational readiness'. It links applied research with Olympic athletes to high-risk occupations, like policing, air traffic control and surgery (McDonald, 2006; 1993; Nav Canada, 1997; McDonald et al, 1995 respectively). These studies—focusing on high-performing professionals—have identified the important balance of technical, physical and mental readiness to performance excellence and resiliency. Specifically, mental readiness skills have been found to be a major contributor to peak performance.

High-risk occupations share common day-to-day issues that influence safety, productivity and morale. Could capturing the 'operational readiness' of world-renowned Sherpa mountain-guides translate into an investment in a safer and more satisfying tourist-experience in the growing world-wide activity of mountaineering in Nepal? A Canadian-Nepali partnership would be needed to foster this new research. A resulting profile of excellence in mountain-guiding techniques would provide a unique contribution to the shared interest for environmentally-friendly, viable, activity-based tourism in Nepal, Canada and other mountainous regions of the world.

### 1.2 Goals of the study

This preliminary study was focused on defining performance excellence and operational readiness for Sherpa mountain-guiding in Nepal.

The objectives were to

a. become localised and acclimatised in Nepal and with the guiding community;
b. define the expectation for performance excellence; and
c. assess the need for mental readiness among Sherpa mountain-guides.

With an established framework in place, the question has arisen as to whether to pursue a more comprehensive investigation of the operational readiness of exceptional Nepali mountain-guides. This study will hopefully produce an answer and result in the support of the Nepali mountaineering stakeholders. Thus, a final objective was to

d. identify the practical implications (‘the fit’) and confirm the capacity for an Operational Readiness Assessment using an adapted internationally-tested, standardised tool applied to Sherpa mountain-guiding in Nepal.

### 1.3 Nepali mountaineering stakeholders

The Ministry of Culture, Tourism and Civil Aviation in collaboration with influential tourism bodies in Nepal—Nepal Tourism Board (NTB), Nepal Association of Tours and Travel Agents (NATTA), Trekking Agencies’ Association of Nepal (TAAN), and Hotel Association of Nepal (HAN)—have adopted the government of Nepal National Tourism Strategies.The vision from 2014 to 2023 (Government of Nepal, 2013) underscores that:

> *“Tourism is valued as the major contributor to a sustainable Nepal economy, having developed as a safe, exciting and unique destination through conservation and promotion, leading to equitable distribution of tourism benefits and greater harmony in society.”*

These key stakeholders govern to make mountain-climbing and trekking tourism more lucrative for Nepal (Government of Nepal, 2015). The role of these agencies is to contribute to sustainability by: implementing international standards, promoting environmentally-sensitive mountain tourism, training Nepali mountaineer workers, protecting cultural heritage, maintaining web-based communications, generating employment opportunities for locals, lobbying government, and reviewing policies related to mountaineering in Nepal. They are also represented on the Union Internationale des Association d’Alpinisme (UIAA) who in October, 2013 approved six new (climbable) peaks over 26,000 feet/8,000 meters—for a new world total of 14 peaks.

With this impressive breadth of governance, any proposed enhancements to mountain-guiding in Nepal would need to include these tourism leaders.

### *1.2.3 Potential benefits*

a. Lay groundwork to better understand the performance and operational readiness of Sherpa mountain guides.

b. Support objectives of the Nepalese government and leading national tourism and mountaineering organisations to improve tourism human-resource capacity.

c. Establish Nepali-Canadian partnerships for further future collaborations.

## 2. Background

**2.1 Gaps in economic sustainability and tourism in Nepal**

The UN has engaged in innovative new methods to identify post-2015 Millennium Development Goals (MDG). These MDG targets aim at reducing poverty, generating employment and creating economic development (Shishkin, 2014). However, achieving the 2015-MDG deadline has become a serious challenge for Nepal.

The Nepali tourism sector is facing many quality destination challenges (Federation of Nepalese Chambers of Commerce and Industry, 2015) including:

- accommodation and service quality;
- food safety and hygiene;
- human resource shortage and productivity;
- immigration procedures and entry-visa requirements;
- poor infrastructure, purchasing power and pricing;
- environment overcrowding and degradation; and
- security constraints due to poor communication channels.

The Nepalese tourism policy 2065 mentions the provision for: tourist-travel safety and crisis management; expansion of the tourist police force; and improved search-and-rescue teams (Federation of Nepalese Chambers of Commerce and Industry, 2015). However, no specific tools are developed to monitor these indicators of quality tourism services.

Current research recommends incorporating an aggressive complement of domestic policies and the promotion of a desirable country image of providing quality, innovative and attractive tourism services to national and international visitors (Dupeyras & MacCallum, 2013). The Nepalese Ministry plans to establish and monitor indicators of tourism success for:

- tourism performance and impacts;
- tourism gross domestic product and per-capita earning;
- average length of stay from inbound tourists;
- export of tourism services; and
- occupancy in hotels and homestays.

To sustain the tourism market, Nepal must maintain its international competitiveness to increase domestic and global market shares to generate income, jobs, gender equality and wealth creation. Proposed work is focused on developing tools for monitoring service quality on the frontline. Existing systems can only partially generate these measures.

**2.2 Operational Readiness Assessment for high-risk occupations**

Operational Readiness is the ability to effectively prepare to perform with excellence in challenging situations. This requires an appropriate balance of technical, physical and mental readiness specific to the activity. Often it is the level of mental readiness that determines success when placed in high-performance situations. An Operational Readiness Assessment tool (see Box 1) has been developed for evaluating‘gold-medal performers’ in high-performance occupations.

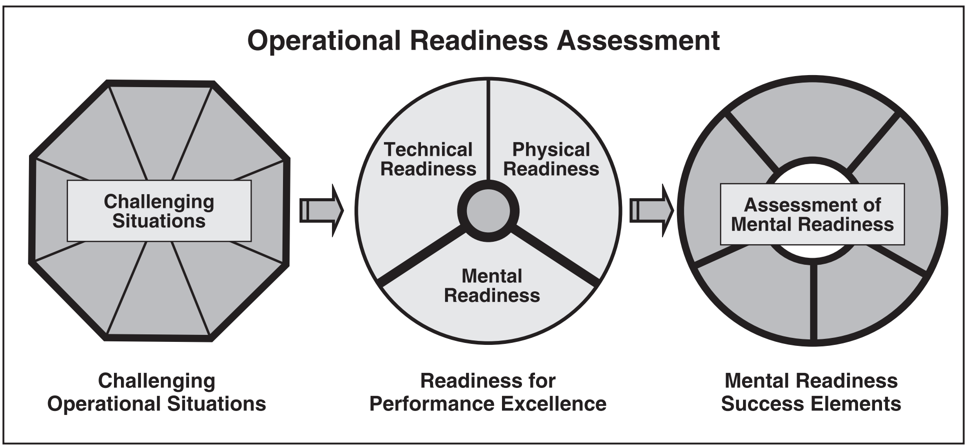


Figure 1: Three stages of an Operational Readiness Assessment (Source: McDonald, 2006)

This internationally-tested standard could be adapted for measuring and assessing the operational readiness of exceptional Nepali mountain-guides. A full-scale, investigative process with a sample-group of ‘excellent’ mountain-guide would consist of three parts:

- defining and classifying challenging-situations in mountain-guiding under seven categories used in previous high-performance occupation research (McDonald, 2006);

- determining the relative importance mental readiness has played—compared to physical and technical readiness—when these mountain guides successfully performed with excellence;

- assessing the quality and quantity of mental readiness skills among these 'excellent' mountain-guides based on a known mental readiness model—Orlick's Wheel of Excellence—which provided a framework for measuring success skills, blocks and influential factors during these mountain-guides' best and dissapointing performances in challenging situations (Orlick, 2003).

University of Ottawa studies on "operational readiness in high-risk occupations" expose effective practices of peak performers that impact their overall readiness. Landmark research with exceptional surgeons (McDonald, et al., 1995; McDonald & Orlick, 1994) and police (McDonald, 2006), where standards of excellence have serious life and death consequences, found that mental preparedness strategies paralleled those of elite athletes.

In 2003, Burke and Orlick investigated the mental strategies employed by successful Mount Everest climbers. The researchers determined that climbers employed mental skills in three distinct phases: the preparation, the ascent and the descent. The research found that the climbers believed that a positive mindset and effective focus was a vital part of their climbing success. There is now a need to go beyond the climber and investigate the Nepali mountain-climbing guide given that risk is exponentially greater when responsible for others.

# 3. Methodology

## 3.1 Descriptive Analysis

### *3.1.1 Subjects*

Over a two-year period, subjects included:

- <u>Mountaineering leaders</u> such as Nepali and foreign mountain-climbers, expedition guides, members of the Sherpa climbing-community, and high- and low-altitude supporters.

- <u>Nepali tourism association executive and staff</u> from NTB, NMA, UIAA, NMG and NCAO.

- <u>Business owners</u> from Nepali mountain trekking and expedition companies, local mountaineer retail-shops and hotel management.

- <u>Academics and government officials</u> from the Open University of Nepal Initiative, Nepalese Ministry of Culture, Tourism and Civil Aviation, Nepalese Ministry of Education and Nepalese Embassy in Ottawa, Canada.

- <u>Others</u> such as homestay families, foreign trekkers and climbers, and local merchants.

### *3.1.2 Instruments*

Instruments used to collect this preliminary data included:

- A presentation entitled *Gold-Medal Mountain-Guiding in Nepal: Performance Excellence and Mental Readiness* with Powerpoint;
- *An Operational Readiness Interview Guide;*
- Note-taking and/or tape-recording to document and capture qualitative and quantitative data.

### 3.2 Exploratory procedures

Two independent site-visits to Nepal were completed by the principle investigator (PI) (McDonald, 2011; McDonald, 2013). They produced various opportunities to explore an initial framework and assess the capacity for a comprehensive study of elite mountain-guides. Included in this scoping study were group sessions, consultations, interviews, and observations after several direct immersions in Nepali culture. This exploration involved a qualitative and quantitative collection of data.

### *3.2.1 Group Sessions*

Two group sessions consisting of a workshop and focus group (pictures below) were held to define performance excellence and mental readiness for mountain-guiding in Nepal, and to gauge the 'buy-in' for a future full-scale Operational Readiness Assessment.

Picture 1: Workshop, Nepal Tourism Board Office, 2011


Picture 2: Focus Group, Nepal Mountaineering Association Office, 2013

• **Workshop:** A workshop group-session was held at the Nepal Tourism Board (NTB) Office in Kathmandu, Nepal on October 14, 2011. In attendance were 32 individuals representing: NTB staff, mountain trekking and climbing companies, Nepali mountain-climbing guides and members of the Sherpa community. A ppt-presentation was provided followed by an open discussion on excellence, operational readiness and proposed 'Gold-Medal Mountain-Guiding' in Nepal research.

Ideas and main points before, during and after the session were documented then grouped by themes. Topics included: mountain-climbing versus trekking guides; prevalence of English-speaking guides; logistics (e.g., equipment, transportation, food); learned versus natural abilities in guiding; and basic guiding vocabulary. Contact information on 'exceptional' Sherpa guides was also collected in confidence. Scrutiny from the varied experts in tourism, summiting, trekking, expeditions, business and the Sherpa-culture was an invaluable first-step in defining the scope.

- **Focus Group:** A focus group-session was held at the Nepal Mountaineering Association (NMA) Office in Kathmandu, Nepal on November 25, 2013. There were eight NMA board members and staff in attendance representing mountain-climbing, business, local and international associations, and the Sherpa guiding community. Similar to the workshop, there was an overview followed by a discussion and careful examination of the 'operational readiness' concept.

  Data collection included: verification of stakeholder involvement and buy-in; need and fit of the Operational Readiness Assessment for Nepali mountain-climbing guides; cross-cutting themes such as female guiding and environment impacts; and the logistics for contacting referred mountain-guides and high-altitude supporters. In addition, participants submitted a written sheet detailing the importance of readiness in mountain-guiding and their personal contact information.

### *3.2.2 Consultations, forum and interviews*

Consultations ranged from one to three hours in length with note-taking or tape-recording to capture ideas, themes and relevant information. Generally, a 10-30 minute briefing was provided followed by a series of guided open-ended questions. The intention was to explore related content, needs and willingness to support further research on operational readiness of Nepali mountain-guides.

- **Consultation with the Open University of Nepal Initiative Steering Committee:** In Ottawa, Canada from August 8-10, 2011. A proposal on 'Gold-Medal Mountain-Guiding' in Nepal was reviewed by steering committee members of the Open University of Nepal Initiative. On August 10, 2011, a letter of invitation was issued by the Ministry of Education for the PI to be an invited speaker at the Open University of Nepal Forum, organised by the Non-Resident Nepali Association in October, 2011. It also highlighted that this research was "important for professionalising tourism industry and promoting economic development… and… transferring knowledge between professions." They reinforced their interest to collaborate, share academics and advance a long-term working relationship.

- **Open University of Nepal Initiative Forum:** On October 11, 2011, an Open University of Nepal Forum was held in Kathmandu as a global meeting of Non-Resident Nepali. The lead partnership for the Open University of Nepal Initiative was Athabasca University of Canada. The research-concept for assessing operational readiness in mountain-guiding was presented by the PI and publically recognised within the Local Contextualisation in Research portion of the forum.

- **Consultations with expedition companies:** On September 2, 2013 (prior to arriving for the second site-visit in Kathmandu), the Nepal Mountaineering Association (NMA) President sent a letter of welcome.

> *"[I am] strongly supporting an assessment of high-performing Sherpa mountain-guides… using an international-tested tool. Therefore, NMA would provide its strong support… and encourage the social-network and local-level support from Canada that this will bring to Nepal during the field work."*

Once in Kathmandu, NMA endorsement continued in coordinating meetings with numerous climbing and trekking company owners—Asian Trek, Alpine Trekking and Expedition Service, First Environmental Trekking and Sherpa Trekking. They all generously shared operational details for expeditions, organisational-structure in guiding, logistics for meeting 'exceptional' mountain-guides and support for future research.

- **Consultation with Nepalese Ministry official:** A private briefing with the Joint Secretary of the Ministry of Culture, Tourism and Civil Aviation took place on November 25, 2013 with Judy McDonald (PI, University of Ottawa) accompanied by the Executive Director of the Nepalese First Environmental Trekking. The Joint Secretary stated in his follow-up letter of December 2, 2013:

  > *"This reinforcement of high-standard in climbing-leadership will directly serve in elevating mountaineering and promoting Nepali tourism. Therefore, I would like to request to all for necessary cooperation."*

- **Consultations with tourism business experts:** Opportunities were taken to discuss the impact of mountain-guiding both locally and internationally with six successful entrepreneurs living in Kathmandu—an international Nepali businessman, two local hotel-restaurant managers and three foreign climbing-leaders.

- **Trial interviews with Nepali mountain-guides:** A total of three confidential, anonymous, in-depth, trial interviews were conducted with Sherpa mountain-climbing guides during the second site-visit in November, 2013. Guiding vocabulary and scenarios were collected and tested for adaptability in the standardised guided-interview. One of the interviewees was female allowing a different gender-perspective.

It was also a realistic opportunity to examine the feasibility and comprehension of an English-speaking interviewer with native Nepali mountain-guides.

#### *3.2.3 Cultural immersion: Participation and observation*

The model used for this research requires a foreign researcher to become localised and acclimatised in Nepal. Operational Readiness Assessments are by nature applied to high-risk occupations expected to perform with excellence. Investigating such professionals—like surgeons, police and air traffic controllers—requires an invitation into their 'inner-culture'. Research with Nepali mountain-guides requires adaptation to not only Nepali language, customs and specialised mountaineering terminology, but also high-altitude. Participation in a mountain-trek and several homestays were chosen by the PI to gain cultural sensitivity and awareness—for a total of 40 days in Nepal.

- **Everest Base Camp trek:** Trekking to Everest Base Camp (EBC) was selected as a destination since EBC may eventually be a location of choice to meet top Sherpa mountain-guides. A trekking group of 12 foreign trekkers (including the PI) set out on October 18, 2011 for Lukla accompanied by a Nepali guiding team—one lead-guide (Sirdar), three additional guides and four porters/supporters. Ultimately, after 13 days, the excursion was complete with all 12 trekkers having safely reached EBC.

- **Homestay-experience #1:** This first homestay-experience for the PI took place over an eight-day period in Kathmandu from October 10 to 17, 2011 just prior to the EBC trek. The homestay-family included parents, one adult daughter in post-secondary school and an adult son overseas at university. This immersion aided in acclimatising to the altitude, culture, food and neighbourhood—all within the safety and comfort of a family setting. It provided participation in daily 4:00 a.m.-walks, full meals at 8:00 a.m., water-purification practices, regular power-outages, preparation of Nepali meals and days filled with rural-community sounds and activities. The kindness of Nepali people was unmistakable. And the head of the family shared his extensive trekking and climbing experiences.

- **Homestay-experience #2:** A second visit to Kathmandu by the PI was for 19 days from November 10 to 28, 2013 at a different homestay. This family home provided interaction with two children—six and 12 years of age. Such an environment accelerated insight into fundamental lifestyle-skills such as: rudimentary Nepali language, table manners (for eating with your hands), and favourite things to do, eat, play, etc. Dealing with practical situations (like power-outage) meant becoming familiar with many back-up systems and prioritising daily activities.

# 4. Results and discussion

These results are a compilation of all exploratory procedures used in collecting this preliminary data for understanding performance excellence and mental readiness of mountain-guides in Nepal.

### 4.1 Cultural immersion: Localisation and acclimatisation

Working with elite, high-risk occupations requires going well beyond a review of research and related documents. An intensive cultural immersion and invitation into their ‘inner-circle’ were critical to:

- being respectful and knowledgeable of local customs;

- understanding fundamental operational-procedures;

- becoming familiar with official (and unofficial) guiding-terminology; and

- establishing an open dialogue with all levels within the mountain-guiding community.

### *4.1.1 Local customs*

Both homestay experiences (McDonald, 2013; McDonald, 2011) permitted extensive familiarity with Nepali customs, foods and flavours such as gundruk vatmas (dried leafy greens with fried soya bean), ghee (cow and buffalo fat), jira-masala (a spice mixture) and various curry.
Observations relevant for research included:

- Daily power-outages are a norm in Nepal where life continues having to regularly switch to a back-up system or do without.

- Resourcefulness and support of local commerce were prevalent with simple marketplaces, portable herbal salt-tea stations and meagre home-grown produce stands.

- English spoken in Nepal varies and requires familiarity and acuity with the Nepali-accent to comprehend.

- Organic solutions were common practice for gaining quick energy, replenishing fluids and finding remedies in the mountains. For example: roasted corn-powder (satu) in water, roasted gram beans (chana) and milk fat (ghee) to give energy; garlic soup to thin blood at high-altitude; Nepali (chiya) tea to replace fluid; no alcohol consumption to prevent dehydration and altitude-sickness; steady servings of Nepali vegetarian staples of lentils (daal), rice (bhat), vegetables curry (tarkari) and pickles (aachar).

### *4.1.2 Everest Base Camp mountain-experience*

As a novice trekker (ordinarily living at about 1,000 feet above sea level), reaching Everest Base Camp (EBC) in Nepal at 17,650 feet / 5,380 meters was a destination with risks. Each trekker was responsible for carrying a daypack and repacking a single duffle-bag of personal supplies each morning which was then taken by the porters. The experience of physically trekking to and from EBC over 13 days was an effective way to observe low-altitude Nepali guides surrounded by their native mountain peaks. It was effortless for them to name and point to Chooyu, Gokyo Peak, Pumori, Everest, Nuptse, Lhotse, Island Peak and Amadablam. Or similarly, to list the villages enroute—Lukla, Phakding, Namche Bazaar, Tengboche, Pheriche, Lobuche, Kala Pattar, GorakShep, Dingboche and Manjo.

Nepali innovation, patience and stamina in rural areas were commonly observed from using open solar-cooking apparatuses, washing laundry in icy streams to drying yak-dung for fuel. The same resourcefulness was noticed among the guides. While regular daily power-outages occur in Nepal, all guides had a working cell phone while trekking.

Unpredictable group dynamics are to be expected with foreigners trying to cope with daily trekking-challenges. Everyone deals with fatigue, altitude, unfamiliar daily events and cultural adaptations in their own way. To make meals more familiar, efforts were made in teahouses to serve North-American-style food to accommodate the tourist-palette [e.g., macaroni and yak-cheese (somar)]. Guides frequently offered to carry the packs for anyone struggling to keep up.

Many lessons had to be learned for trekking in the Himalayas. For example, high-altitude (although EBC is considered 'low-altitude' in the expedition-world) has a known impact on sleep and therefore a hiker's health and performance. Just as jet-lag is complex, high-altitude conditions require unconventional preparations to ensure quality sleep, appropriate rest habits and remedies for fatigue (McDonald, 2015).

While still a struggle, as a first attempt at this challenging activity (for a novice trekker), it was a triumph. Altitude precautions, cultural preparation, attention to each step, and effective rest habits improved the chances for success during the trek. These were significant components for an inexperienced high-altitude trekker's (HA-trekker's) overall readiness and performance. Critical lessons were learned should EBC be chosen to conducted future interviews.

#### *4.1.3 Sherpa mountain-guide history*

Candid 2013 interviews with Nepali and foreign business-leaders personalised and pieced together the many historical events that developed mountaineering in Nepal. Beginning in the 1920s, British expeditions hired Sherpa mountain people for their unique stamina in high-altitudes to carry supplies and navigate across steep terrain. The book Tigers of the Snow (Neale, 2002) was sourced as describing these new economic opportunities for the Sherpa people and their efforts to escape poverty. Many lives were lost before 40 years of HA research to understand how to properly acclimatise. The Norgay-Hillary expedition in 1953 made climbing famous in being the first to summit Everest. In the sixties, the hippies arrived to "chill-out, get high and have fun living." By 1965, travelling the Himalayas began with the arrival of American armies and foreign interests in camping. From 1968 to 1972, geography of Nepal was detailed by the Swiss. The Nepalese Mountaineering Association was formed in the 1970s to look after the well-being of mountain workers. In 1980, the French reached Annapurna and were the first to cross borders.

Nepali climbing legends continue. *Touching my Father's Soul* (Norgay, 2001) is an insider's story by the son of famed mountaineering father Tenzing Norgay who tells little known stories of his father's historic climb. Also disclosed was his own ascent during the May 1996 climbing-disaster, his family honour, personal discovery and the spiritual life of the Sherpas. Sherpa pray to the Buddhas often in the mountains and in the ice-falls for wisdom and blessing. Norgay explains the importance of "mental ability and strength to allow our minds to be changed in the direction of complete awareness"—known as 'tsin-lap'.

For HA mountain-climbers, Everest is the Asian markers in achieving the seven peaks in seven continents [i.e., as well as summiting: McKinley (Alaska), North

America; Aconcagua (Argentina), South America; Elbrus, Russia; Kilimanjaro, Africa; Carsterisz, Australia].

As mountaineering grew in popularity so did issues with ecology. The construction of teahouses encouraged local employment. Ironically, since democracy in 1992 and the increase in business-mindedness, the natural skills in guiding have diminished.

#### *4.1.4 Official (and unofficial) mountaineering vocabulary*

During group sessions, consultations and interviews, special consideration was given to collect basic mountain-guiding acronyms and colloquial language to adapt the Interview Guide. As examples: 'high-altitude supporters", or HAS, is now preferred rather than 'porters' for those climbing over 7,000 meters; crevasses are categories as A (convex), B (concave) and C (circular); and to minimise misunderstandings on expeditions, an 'agreement' is what you (the company) promise to give (to the client).

#### *4.1.5 Common operational issues in high-risk-occupations*

McDonald (2006) identified common day-to-day operational issues shared by high-risk workplaces related to safety, productivity and morale. Many of these same issues were raised during the group sessions and consultations.

- **Scarce resource issues** to schedule time for training. After government royalties, less than a quarter of climbing-fees go to the company for equipment and food—leaving little for training. For those in remote areas, communication and the completion of desired certification may not be possible.

- **Human-resource drain** with a limited number of experienced, veteran-guides available to mentor a young, inexperienced workforce. International-guides are being brought into Nepal to meet the demand for quality manpower.

- **High stress** from elevated accountability, a demanding work-schedule, increased fatigue from a lack of downtime together with extensive overtime and absence of regular family-life. "The guide is the face and reputation of the company and Nepal." A seasoned Sherpa-guide explained, "[Foreign] leaders believe guides are paid to summit. They don't think Sherpa has family and children and should take more risks. They are very difficult to convince."

- **Feeling of being misunderstood and undervalued** as frontline-staff in the field, away from administration and wanting more or better equipment. Guiding in Nepal offers no pension. Guides depend on extra allowances (seasonal only) and subsidy from other work. The ratio of freelance to staff ranges from 50:50 to 60:40. Guiding remains a pride for mountain-people.

- **Inconsistent performance and productivity** from a lack of proper preparation techniques in facing critical situations. The guiding-world is very competitive with better infrastructure, education and finances in nearby places—such as Tibet, India and Pakistan. A Nepali businessman explained that, "focus needs to be on quality manpower and internalising guiding for Nepal. Switzerland is also a small country but is the best at many things."

- **Insufficient knowledge-transfer** mechanisms to instill operational savvy and confidence. There can be extreme controversy in reading and anticipating risk. A senior guide reported,

  > "*From Camp 3 to 4, I was monitoring [group] speed and strength to reach the summit. We could reach the summit but coming down [would be] disastrous. I recommended it was safest to go down. Clients said, 'I don't care about my life!' I replied, 'If you go up, we don't go!' "*

Addressing these same issues is part of the safety and crisis management goal of the Federation of Nepalese Chambers of Commerce and Industry (2015).

## 4.2 Expectations for performance excellence

Many more tourists participate in trekking then climbing-expeditions. However, the challenges and extrapolations from expeditions to trekking would be far superior. Consistently, HA-expedition climbs (over 7,000 meters) with significant life and death conditions were recommended as more beneficial to study. There is also the potential to simplify lessons-learned for low-altitude activities. For these reasons, this exploration was focused solely on HA-expedition guides.

Performance excellence was defined by understanding the level of risk, 'excellence' in mountain-expedition guiding and challenging situations. What dictated a 'successful' and 'disappointing' performance was also defined.

### *4.2.1 Level of risk*

Similar to other elite performers, Sherpa guides show extraordinary respect for their surroundings—in this case, the great Himalayas. One guide reflected that "every mountain has its own degree of difficulty—technical but not HA; HA but not technical; or navigation difficulty with challenging people."

Mountaineering activities in Nepal are categorised as trekking, peak-climbing and HA expedition-climbing as follows:

- **Trekking** operates from 4,000 to 5000 meters where the guides need no special training but may be certified by the Ministry of Culture, Tourism and Civil Aviation.

- **Peak-climbing** is from 5,000 to 7,000 meters where a group needs at least one guide certified with the NMA Basic course. There are 38 peaks under 6,500 meters ranked as 'A' or 'B' difficulty.

- **High-altitude expedition-climbing** is recognised by the Nepali government as climbs over 7,000 meters (to 8,848 meters) and also ranked as 'A' or 'B'. Guiding qualifications for expeditions are similar to peak-climbing but require more practical experience—usually through peak-climbs. Nepali climbs can differ from other countries since 'expeditions' are organised with many Sherpa-guides versus individual climbs with only one Sherpa-guide.

#### *4.2.2 'Excellent' mountain-expedition guides*

It was surprising to learn that within the international climbing-scene, Sherpa-guides are not considered the best climbers—seemingly contradictory to the general premise that they are "the best in the world." However, in a subsequent interview on home-soil (April 29, 2014), an elite Canadian military climber said it best:

> *"There is some truth that Sherpa-guides are not the most technically-qualified, but you really want them to get you and your supplies up the mountain. You don't necessarily use Sherpa for a technical wall like the Kangasalan-face. Sherpa have commitment to their clients… They think differently. I would rather climb with a Sherpa than another Canadian, Italian or anyone else. They will 'haul your -ss down the mountain [whether you suffer] from weather, freezing, altitude, exhaustion… The others will keep on going to reach the top. That separates Sherpa from others. Being a mountain-guide is a privilege and they are dedicated to you."*

Similarly in *Tigers of the Snow* (Neale, 2002), it was the Sherpas—not the Europeans—who were acknowledged as the most responsible climbers. This well researched narrative reports on the 1934 German-climb gone wrong in the West Himalayan peak of Nanga Parbat.

Today, the superior high-standards and dedication of Nepali guides are still recognised. A respected foreign climbing-leader shared that:

> *"The Nepalese would laugh at 'Search and Rescue' on the mountain… especially from 'low-landers' in helicopters. If it is on the mountain, the Sherpa-guide gets you down!"*

Over the course of this initial exploration, the question was asked, "What is an 'excellent' mountain-climbing guide?"
Mountaineering experts answered that an 'excellent mountain-climbing guide' is:

- physically fit and strong; can lift (i.e., strong climbers can carry 50 kg at 8,000 m); have summited various mountains (Everest summits being one measure);

- a good climbers trained in all weather; can tie knots; good at high-altitude—can walk over 8,000m;

- a good leaders (with Sherpa staff and clients), well respected, empathetic, supportive during difficult times with a sense of humour;
- friendly to customers with an understanding of the psychology of tourists/ clients;
- a good negotiator, convincing communicator in English with clients; explains things;
- well organised; plans ahead; asks lots of questions about logistics; knows the value of money and supplies; can judge food-fuel supplies;
- able to handle the politics of service agencies and other companies;
- mentally focused, ready, serious and can stay focused;
- intellectual, knowledgeable and environmentally-sensitive; able to make the right decisions at the right times;
- willing to help, work and be dedicated; and
- shows commitment and courage.

#### *4.2.3 Challenging situations*

Performance excellence is derived by understanding the level of risk and how ‘excellent’ mountain-expedition guides operate ‘successfully’ in ‘challenging situations’.

The following challenges for mountain-expedition guides were compiled from the data collected using categories from a generic template (McDonald, 2006).

**Table 1:** Challenges for mountain-expedition guides.

| Challenging-situation category | Challenging situations for mountain-expedition guides |
|---|---|
| Heightened risk | the 8 mountains (plus 6 new ones) over 8,000 meters (e.g., Everest, Macalu, Kanchengunga, Dalageri) • environmental conditions [e.g., cloudiness, heavy snow, rock-falls, ice-falls, landslides, crevasses 'A'] • cold, high winds, wind-chill (can increase 2$^0$C in 5 minutes) and frostbite problems • technical mountains (e.g., Amadablan, Janu N-face, Lhotse, Macalu) • hard to break trail • at 'high-altitude' everyone is increasingly stressed • physical health risks (e.g., headaches, vomiting) |
| Complex situations | multi-tasking and distractions (e.g. taking photos with potential lapses in safety) • hobbyist who is not fit nor technical but has sponsors with high expectations • food problems • potential that Sherpa climbers will revolt or not cooperate • what and how many supplies to bring (e.g., technical materials, first aid, food) • can't go up or down, yet lack food • tent blew away—now six in one tent |
| High-risk customers | low-budget clients—demanding without paying for services (e.g., want heaters in tent, no sugar for ginger tea, food complaints) • arrogant clients • complaining that others got to the top but they did not • thinking only about reaching the top and not about the danger • clients fighting together • unprepared clients thinking it's "a holiday" • claims to "loves mountains" but, gives no time to train • clients who don't tell you the truth (e.g., headaches, vomiting) • rude clients • stubborn/short-term thinking clients • disoriented customers pressuring guides to complete the climb in bad conditions • under-qualified clients desiring to summit (e.g., inadequate physical training, inadequate technical training) • customers who misunderstand/under-estimate their contribution (i.e., Everest is a 'full service' climb versus a technical 'alpine-style' where customers must pull their weight) |

| | |
|---|---|
| Coaching/Teaching others | higher demands for training (e.g., need-for-skiing debate) • motivational and generational differences between guides • more complicated with a trainee • sense of responsibility with trainee • communication with non-NMA members in remote areas |
| First-of-its-kind, exceptional results, and unfamiliar situations | climbs to set a record (not just to summit) are now a norm (e.g., first with one-foot, all-female team, blind, backwards, fastest time) • any situation which a guide has not experienced |
| Special relationship pressures | climbs with a relative, a friend, a child • clients with challenges desiring to summit (e.g., physical disabilities, children, elderly) • those climbing for religious reasons (visiting a 'holy mountain') |

These categories of challenging-situations demonstrate the need for performance excellence in unique and specialised challenges faced by mountain-guides such as ice-falls, food problems, untrained clients, climbs to set a record or clients with disabilities.

#### *4.2.4 Successful performances*

This is a 'challenging situation' that a mountain-climbing guide judged to be one of his or her best efforts. Nepali mountaineering-guides' examples of successful performances included:

- "The expedition 'topped-out.' When you get to the top then everyone is happy no matter what happened earlier—everything is now all right."
- "Did not summit but happy customer. It is considered successful when you had no control such as weather or getting sick."
- "Safe climb and good budgeting of office money."
- "Good tips and no accidents."

A foreigner-leader defined an 'excellent' climb as: *"A climb completed within the individual's/party's competency-level and a high ethical-standard. Climbing is the art of moving safely in potentially dangerous places."*

#### *4.2.5 Disappointing performances*

This is a 'challenging' situation that a mountain-climbing guide judged to be disappointing or less than his or her best efforts. Nepali mountaineering-guides' examples of 'disappointing' performances included:

- "Unsuccessful summit. Not necessarily a failure but some companies (usually new ones) believe 'any means possible to get to the top.' If a

Sirdar has that pressure, then rock-falls and weather are very stressful."

- "Customer is back and upset. It can be related to nationality."
- "Not summit due to issues inside control (e.g., rope not fixed on time; did not account for enough food, tents, oxygen, fuel)."
- "Not summit due to issues outside control." (e.g., weather, physically unable, cold and cannot move, frostbite danger, too late, no light to see).
- "Lied that they got to the top but did not."
- "Clients agree to give money then do not pay."
- "Having to be rescued" was described by a foreign-climber and leader as the ultimate embarrassment.

Success or disappointment is not always willingly shared. A foreign-leader recounted asking a Nepali guide, "How was the climb?" His response was, "Those who wanted to complete did." (Subtly translated: "Mind your own business.") In reality, 90% finished and 10% were unhappy. The guide had to follow-up and smooth things out with the 10%.
An elite Canadian military climber emphasised that, "how you handle failure is very important to succeeding."

### 4.3 Need for mental readiness

The need for mental readiness was explored in expedition-guiding by defining overall readiness; the weight of mental readiness compared to physical and technical readiness; and noting if any proven mental-readiness indicators emerged in conversation.

#### *4.3.1 Overall readiness*

Within the Operational Readiness Assessment model, overall readiness for peak performance depends on three components: physical (ability), technical (know-how) and mental (skills). 'Readiness' in mountain-expedition guiding was defined as:

- **Physical readiness:** healthy and physically fit; can lift; able to climb and endure weather.
- **Technically readiness:** has knowledge and application of equipment, ropes and pitons, weather, communication, first-aid and altitude-sickness; can organise supplies and transportation.
- **Mental readiness:** is dedicated, confident and clear-headed; shows leadership (democratic and autocratic); able to concentrate, refocus and evaluate decisions.

#### *4.3.2 Importance of mental readiness*

Quantitative results were collected that illustrated the need for mental readiness relative to physical and technical readiness. A sample of eight experienced Nepali high-altitude mountain-expedition guides independently answered the question:

> *"When you perform at your best, how much do you believe your overall performance depends on your physical, technical and mental readiness? What percentage would you allot to each to add up to 100%?"*

In mountain-expedition guiding (see Figure 3), mental readiness was said to contribute 37% [standard deviation (SD) at 4.90], while physical was 33% (SD at 6.92), and technical 30% (SD at 5.45). Mental readiness seems to play a major role in the success of dealing with challenging situations. This finding supports results found with high-achievers in policing, surgery and sport (McDonald, 2006; McDonald et al, 1995; Orlick & Partington, 1988). Even with a modest interpretation, mental readiness must be judged equally as important as physical and technical readiness.

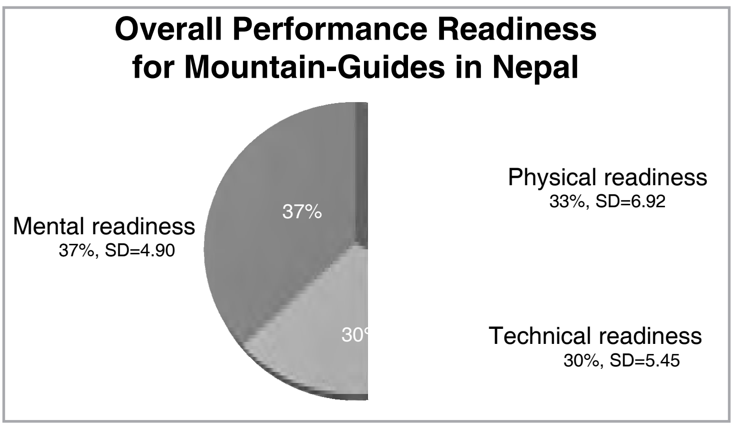


Figure 2: Measures of mental, physical and technical readiness combined for overall performance readiness for mountain-guiding.

#### *4.3.3 Indication of mental-readiness skills*

In Orlick's Wheel of Excellence (2003), seven critical mental skills are identified as: commitment, self-belief, positive imagery, mental preparation, full focus, distraction control and constructive evaluation. While time did not permit probing into these skills, some were detailed in group sessions and interviews.

- **Positive imagery** or visualisation was described as being frequently employed before and during climbs to plan the route, as well as to re-evaluate when things had gone wrong. Mountain-guides placed a high emphasis on visualisation. They were animated in motioning their rehearsal of the path taken up the mountain.

  Similarly, research on mental preparation of surgeons (McDonald et al., 1995; McDonald & Orlick, 1994) discovered that positive imagery was a common practice either before or after surgery. It was used by 73% of surgeons for rehearsing in preparation and by 27% for recalling and evaluating performance details. Imagery was also used in coping with negative consequences.

Future interviews would be necessary with a larger number of Sherpa-guides to verify and expand on these initial findings of using positive imagery during difficult climbs.

- **Self-belief** or confidence is frequently challenged in Nepal. A Nepali climber commented that while "all porters are unskilled, those from India and Pakistan are perceived to be more confident than those who have Nepal as their homeland." The recommendation from a Nepali hotel-manager was for native Nepali "to leverage confidence from: the natural beauty; the humble, kind and friendly people; and the fame of Sherpa-climbers in the world."

  A foreign-climber's perception of "confidence on a mountain" was: "being at home in the snow and standing relaxed in an exposed position on the mountain."

- **Commitment** was brought up numerous times by climbers and business-owners as an outstanding and desirable trait of Nepali guides. "You appreciate the total responsibility when someone dies in your arms (both literally and figuratively)."

  It would be interesting to determine if mountain-guides also employ similar mental-skills in preparation, ascent and descent as found in Burke and Orlick's work (2003) with individual climbers. Clearly, this is an area where a full Operational Readiness Assessment of elite guides would be beneficial.

## 4.4 Practical implications ('fit') for an Operational Readiness Assessment

Group sessions, consultations, immersions and observations allowed for preliminary exploration of performance excellence and mental readiness of mountain-expedition guiding in Nepal. An additional objective was to determine the feasibility for a full-scale study in operational readiness. Numerous measures were explored to see if there was a 'fit' in applying the Operational Readiness Assessment—an internationally-tested, standardised tool—to mountain-expedition guiding in Nepal.

### *4.4.1 Confidentiality and trust*

A Nepali businessman emphasised that "referrals are an earned privilege. There are so many NGOs, Nepali do not want to talk anymore." It was only through demonstrated confidentiality, earned trust and reputation that valued information was shared. By the end of the second site-visit (during one-on-one consultations and interviews), names of 'excellent' guides were willingly provided.

Various published documents were also provided by NMA that listed all registered mountain-climbing guides. NMA agreed to assist in the future with names and contact information. Historical record-keeping of successful Mount Everest ascents tends to be the measuring stick for guides (i.e., how many times, unusual conditions/ clients, etc.). All climbers who summit Everest are annually published after having registered their achievement with Ms. Elizabeth Howley in Kathmandu. Together these resources are essential for future contacting and in-depth interviewing to be possible.

The clear recommendation was to pursue further research and to expect their support.

### *4.4.2 Adaptation of the interview guide*

This scoping study provided the necessary vocabulary, examples and scenarios required to adapt the Interview Guide to a specific Mountain-Expedition Guide Interview for a comprehensive assessment. For such an investigation, it would be important to determine what critical subject-groups to isolate (e.g., Sherpa/non-Sherpa, low-/high-risk expeditions, gender, years-experience, client income, etc.). The in-depth interviews would be with identified 'excellent' mountain-expedition guides who are respected by their peers and agencies, and representative of the various critical subject-groups. Elite performers are acutely aware of issues; have a range of effective options for resolving and coping; and are extremely articulate, honest and frank (once anonymity and trust are established). These individuals are a unique group with very unique qualities in an interview setting.

### *4.4.3. Subjects*

This exploration verified that the focus should be on 'climbing' versus 'trekking' guides for mountain-expeditions over 7,000 meters. An expedition-team of six to seven climbers consists of: 1 (foreigner) Leader, 1 Leisure Tourism Officer (government), 1 Sirdar (Chief of Sherpa administrative decision-maker), 1 HA Sirdar-Guide, 4 Assistant-Guides/HA-Supporters. Mountain-guides for future research would focus on those in HA, frontline operations (i.e., HA Sirdar-Guides, Assistant-Guides and HA Supporters). Based on previous research protocol, they would need to be active within the past year as a mountain-climbing guide. Given the need to speak effectively with clients, it was confirmed that they must speak English.

The NMA estimated that there are approximately 700 serious Nepali expedition climbers/guides in Nepal (i.e., 400 registered with NMA plus another 300 non-NMA members). Therefore, the top five-percentile of mountain-guides would be a sample of approximately 35 guides. Several opportunities for group gatherings were identified before and after the Spring and Fall expedition-seasons. Everest Base Camp was also identified as a challenging but logistically feasible location to interview top guides.

### *4.4.4 Dominant cross-cutting themes*

Six major cross-cutting themes and issues were detected in the mountain-guiding occupation. The following themes merit further consideration:

- **Unprepared tourists:** Tourists who arrive thinking, "It's a holiday" and are unprepared. They do not consciously understand hypothermia or wind-chill. They figure, "How bad is it?" They believe Sherpa can/should drag them up and down.

- **Long-term environmental impact:** The accumulation of garbage from mountain-expeditions has now become regulated to gain back control.

- **Female guiding trend:** Guiding is slowly trending with females in Nepal. There are now numerous NMA board members and climbers.

- **Generational differences:** Older guides began working as soon as they were old enough to carry supplies. They had no education and no choice—they guided to survive. Many of today's Nepali guides are registered, qualified and want to be guides.

- **Socio-economic issues:** Lack of education, alcohol-use and unemployment exist among many Nepali mountain-climbers.

- **Families of guides:** How do the families of Sherpa-guides prepare and cope?

#### *4.4.5 Potential collaborative partners*
It is essential when working with elite performers that strong collaborative partners are in place to ensure future project completion and long-term success. This preliminary work has generated overwhelming support and the recommendation to pursue further research. The following stakeholders demonstrated and extended their support within their regulations:

- Nepalese Ministry of Culture, Tourism and Civil Aviation;
- Nepal Tourism Board;
- Nepal Mountaineering Association;
- Companies: Asian Trekking, Alpine Trekking and Expedition Service, First Environmental Trekking Ltd., Sherpa Trekking;
- Open University of Nepal Initiative (in partnership with Athabasca University, Canada);
- Embassy of Nepal, Ottawa, Canada; and
- Canada Foundation for Nepal.

## 5. Conclusions
The following conclusions were drawn from an integration of the findings from this scoping study of Sherpa mountain-expedition guiding in Nepal:

### 5.1 Categorisation of risks and challenges
HA expedition-guides, with climbs of over 7,000 meters, are subject to the greatest levels of risk in Nepal mountaineering. The challenges they face have been compiled into six distinct categories: 1) Heightened risk; 2) Complex situations; 3) High-risk customers; 4) Coaching/Teaching others; 4) First-of-its-kind, 5) Exceptional results

and unfamiliar situations; and 6) Special-relationship pressures. This profiles the range of risks and challenges managed by HA expedition-guides.

### 5.2 Definition of performance excellence in high-altitude guiding

Excellence in HA-guiding was articulated as a comprehensive list of physical, technical and mental competencies. 'Success' and 'disappointment' are measured heavily by the clients' final interpretation. Realistically, summiting is a struggle of internal and external pressures where only some are within a guide's control. Sherpa guides remain distinguished from other climbing-guides in the world for their ability to manage these pressures at high-altitudes.

### 5.3 Importance of mental readiness

Mental readiness seems to be an important influence on HA-guide's performance from this early evaluation. Of the three major readiness factors rated by mountaineering experts—physical, technical, mental—it was the factor that showed the greatest perceived contribution to success.

### 5.4 Confirmation of 'the fit' for an Operational Readiness Assessment

Important components for conducting an Operational Readiness Assessment in a high-risk occupation were met. Significant vocabulary, examples and scenarios were gathered to adapt the Interview Guide. Numerous conditions and expectations were identified to confirm the need for performance excellence for expedition-guides. Mental readiness appears to play a major role in the success of an expedition. Some of the known predictors of mental readiness emerged as being significant for guiding (i.e., positive imagery, self-belief and commitment). Demographics and the schedules of HA-climbers in Nepal were openly shared to lend confidence for future interviewing-logistics. It was confirmed that the Operational Readiness Assessment tool could be adapted. As such, this internationally-tested standard for evaluating 'gold-medal performers' could be used for a full assessment of elite Nepali mountain-expedition guides.

### 5.5 Identification of 'watch items' (emerging issues)

There are instances that indicate potential problems or changes in the future. For example, more and more tourists are arriving unprepared simply thinking, "It's a holiday." They don't understand the implications of hypothermia or wind-chill. "How bad can it be?" … "Can't the Sherpa drag me up and down?"

A second prominent issue is the impact of environmental-pollution given rise to an annual Eco-Everest Expedition—a regular clean-up of Everest.

Other repeating themes included: female-guiding trend, generational differences among guides, socio-economic issues (e.g., lack of education, alcohol-use and unemployment), and need for coping strategies for families of guides. Various human-resource issues, common to high-risk occupations, were also found to be prevalent in mountain-guiding. These issues included: scarce training resources, human-resource drain, high stress, low morale, inconsistent performance and insufficient mentoring.

### 5.6 Alignment with human-resource development and sustainability

This exploration detailed and categorised the high standards and mental readiness demanded of world-renowned Sherpa-guides. This work supports the objectives of the Nepalese Ministry of Culture, Tourism and Civil Aviation and leading national tourism and mountaineering organisations—specifically, the need to address current shortcomings in tourism by improving tourism human-resource capacity. Qualitative and quantitative performance details were highlighted for use by training organisations, local rescue-operators in mountaineering, policy-makers advising authorities and promoters of mountaineering in Nepal.

### 5.7 Importance of stakeholders

The collaboration and 'buy-in' of mountaineering stakeholders were vital in collecting new data to advance the operational readiness of Sherpa mountain-guides. Their input and influence in industry, university and government will ultimately lead to improving the quality of mountain-guiding and tourism in Nepal as a way to strengthen economic sustainability.

## 6. Recommendations

### 6.1 Short-term: Create immediate awareness at multiple levels

This preliminary study has generated attention to mental readiness and its links to performance excellence in high-altitude expedition guiding. Immediate opportunities to promote this awareness include:

- Recognition events (e.g., annual, world-wide Everest summiteer ceremonies)
- Nepal Mountaineering Association training courses (e.g., Basic, Advanced, High-Mountain Rescue, International Mountain-Guiding and Aspirant Guide)
- Features on mountaineering stakeholder websites
- E-learning tools (e.g., Open University of Nepal Initiative)
- Ministry meetings and forums

### 6.2 Long-term: Conduct a comprehensive research study

The capacity for a more comprehensive investigation of the operational readiness of exceptional Nepali high-altitude expedition-guides was confirmed by establishing this preliminary framework. Based on applied research with high-risk occupations, an internationally-tested, operational-readiness assessment tool may now be used to answer the question:

> *"How do Nepali high-altitude climbing-guides perform their best in challenging expeditions? How do they prepare to be ready-on-demand, manage distracting situations, stay focused and develop coping strategies?"*

The anticipated benefits of a comprehensive study would be to:

- brand Nepal Sherpa-guiding by establishing a 'gold-medal' standard for climbing-leadership and operational readiness of Nepali mountain-guides;
- advance safety and risk management in Nepali mountain-climbing through mentoring by 'excellent' guides;
- strengthen performance, increasing productivity and improving morale of Nepali guiding services;
- enhance the tourist experience on the largest mountains in the world—the Himalayas; and
- build Nepali-Canadian partnerships for further collaborations on mental readiness and resiliency for mountain-guiding. For example, an elite Canadian climber—who survived after falling into a crevasse on a solo expedition—asked

  > *"How do some people 'tough the void,' don't give up and go so deep inside, while others give up and die?"*

**6.3 Practical resources: Create measureable tourism-indicators and tools**
By adapting the layout from previous tools from operational-readiness research on high-risk occupations, new resources for Nepali mountain-guiding can be created such as:

- *'Gold-Medal'* Mountain-Guiding document profiling excellence in Sherpa mountain-guiding (branding Nepal as the first!).
- *Performance Assessment* (user-friendly, two-page form) to measure indicators of operational readiness.
- Service-delivery best practices from exceptional frontline Nepali guiding-leaders.
- *Training Enhancements* with new content on physical, technical and mental readiness.
- Handouts to distribute and educate future policy and training professionals.
- Human-resource improvements by integrating mental-readiness principles into recruitment, selection and retention in the mountain-guiding industry.
- Tourist-marketing update through validating Nepal's high-standards of excellence for mountain-guiding.

## References

Adventure Stats (2015). *Everest fatalities*.[online], Available at: *http://www.adventurestats.com/tables/everestfatilities.shtml.*

BBC News, (2014, June 19). Everest avalanche kills at least 12 Sherpa guides. *BBC News.* [online] Available at: *http://www.bbc.com/news/world-asia-27075638.*

Burke S. & Orlick, T., (2003). Mental strategies of elite Mount Everest climbers. *Journal of Excellence, 8,* pp. 42-58.

Dupeyras, A. & MacCallum, N., (2013, February). Indicators for Measuring Competitiveness in Tourism: A Guidance Document. OECD Tourism Papers, OECD Publishing, pp 65. [online]. Available at: *http://www.oecd.org/cfe/tourism/Indicators%20for%20Measuring%20Competitiveness%20in%20Tourism.pdf.*

Federation of Nepalese Chambers of Commerce and Industry, (2015). *Government policies and acts: Tourism policy 1995* [Unofficial Translation]. [online]. Available at: *http://www.fncci.org/tourism.php.*

Gandip, K., (2013). *Environmental management and sustainable tourism development in the Annapurna Region, Nepal (Thesis).* Nepal: Centria University of Applied Sciences, pp. 63. Available at: *https://www.theseus.fi/bitstream/handle/10024/61730/GANDIP%20KC%20THESIS.pdf?sequence=1*.

Government of Nepal, (2015). *Ministry of Culture, Tourism and Civil Aviation: Tourism Associations.* [online]. Available at: *http://www.tourism.gov.np/menu.php?p=15&page=Tourism Associations*.

Government of Nepal, (2013). *The national tourism strategy plan for Nepal—2014-2023*. Kathmandu: Ministry of Culture, Tourism and Civil Aviation. [online]. Available at: *http://cooperation.unwto.org/news/2014-05-27/national-tourism-strategy-plan-nepal*.

International Development Research Centre—IDRC (2015). *Funding*. Available at: *http://www.idrc.ca/EN/Funding/Pages/default.aspx.*

McDonald, J. (2015). *The science of sleep*. New York, NY: Time Books.

McDonald, J. (2013, November 10-28). Site visit #2. On-site field work. [Unpublished notes].

McDonald, J. (2011, October 10-30). *Site visit #1*. On-site field work. [Unpublished notes].

McDonald, J. (2006). *Gold medal policing: Mental readiness and performance excellence*. New York, NY: Sloan Associate Press.

McDonald, J. (1993). Mental readiness training for air traffic control trainees. In: *Monthly course manual for air traffic control trainees in Canada from 1994-1999.* Cornwall: Transport Canada.

McDonald, J. & Orlick, T. (1994). Excellence in surgery: Psychological considerations. *Performance Enhancement, 2,* 13-32.

McDonald J., Orlick T. & Letts M. (1995). Mental readiness in surgeons and its links to performance excellence in surgery. *Journal of Pediatrics Orthopaedics*, 15, 691-697.

Nav Canada, (1997). *Situational awareness module: Train the trainers.* Cornwall, ON: Nav Canada Training Institute.

Neale, J., (2002).Tigers of the snow: How one fateful climb made the Sherpas mountaineering legends. New York, NY: Macmillan Press.

Norgay, J. T. (2001). *Touching my father's soul.* San Francisco, CA: Harperone.

Orlick, T. (2003). *Wheel of excellence.* [online]. Available at: *http://www.zoneofexcellence.com/Articles/ wheel.htm, Oct.*

Orlick, T. & Partington, J. (1988). Mental links to excellence. *The Sport Psychologist, 2*, pp. 105-130.

Rosen, J. (2012, May 7). Michael Phelps and his high-altitude sleeping chamber. *The Baltimore Sun.*

Shishkin, M. (2014, December 4). Point of view: The Millennium Development Goals as global governance. *Swissinfo.ca*.[online]. Available at: *http://www.swissinfo.ch/eng/the-millennium-development-goals-as-global-governance/41152038?ns_mchannel=ps&ns_campaign=DSA&ns_source=adw&ns_linkname=_cat:swissinfo.ch&gclid=CIqg5sKQzsQCFVU2gQodGBkAzw.*

UNDP (2011).Tourism and poverty reduction strategies in the integrated framework for least developed countries. *Discussion Paper*.Geneva: UNDP, Trade and Human Development Unit.

UN-OHRLLS (2015). *UN Office of the High Representative for the least developed countries* [online]. Available at: *http://unohrlls.org/about-ldcs*.

# Theme IV:

## Health and Sustainable Livelihoods

14

# Social Determinants of Health in Nepal: A Neglected Paradigm

Govinda P. Dahal and Madhusudan Subedi

## Abstract

While health equity issues related to universal access to health care services remain crucial, social determinants of health (SDH) and their distribution have emerged to the forefront of the policy agenda for reducing health inequalities, especially after the reinforcement given by the World Health Organization's Commission on Social Determinants of Health in 2008. In this paper, the theoretical background of SDH, current health issues in Nepal and transitional policy development are discussed. The review of Nepal's policy development over the last half a century still suggests a gloomy scenario when we consider the current status of population health in Nepal. For the first time, the key SDH applicable to Nepal are identified, and their links to current disease burdens are explored and synthesised. The synthesis of facts shows that the origin of the burden of diseases, disabilities and premature deaths are primarily due to living conditions. Despite this fact, the majority of people in Nepal are not aware of this evidence or workable solutions to reduce the burden of diseases. The key recommendations to address the SDH include: raising public awareness of this issue; developing political will; and effectively implementing health policies and programmes through coordination and actions between relevant Ministries and local communities.

## 1. Introduction

> *Healthy life is an outcome of sustainable development, as well as a powerful and undervalued means of achieving it. We need to see health both as a precious asset in itself, and as a means of stimulating economic growth and reducing poverty - Dr. Gro Harlem Brundtland (http://www.who.int/wssd/en/).*

The above statement by Gro Harlem Brundtland, Director-General Emeritus of the World Health Organization (WHO) indicates that health – "as a state of complete physical, mental and social wellbeing and not merely an absence of disease or infirmity" (WHO, 1946) – is both a resource for, as well as an outcome of, sustainable development. As good health is a major resource for social, economic and personal development, it is an important dimension to the quality of life. Health as an ingredient of human capital is a vital element in achieving sustainable livelihoods; hence good health and sustainable livelihoods are interconnected as they are mutually reinforcing elements. Our everyday interactions with political, economic, social, cultural, ecological, behavioural and biological environments help to determine our health (Dahal, 2000). Lack of proper optimisation of these factors means that ill-health is more or less inevitable (WHO/HWC & CPHA, 1986).

Until recently, it was believed that access to quality healthcare services and life style choices were the primary factors that shape health outcomes (Mikkonen, et al., 2010). However, we have come to learn now that medical treatment or life style choices are only valuable components, but are not the primary factors. According to WHO's Commission on Social Determinants of Health, the prime factors that really shape our health are the living conditions into which we are born, grow, live, work and age (WHO, 2008). These conditions have come to be known as the 'social determinants of health' (SDH):

> *"Our health is shaped by how income and wealth is distributed, whether or not we are employed, and if so, the working conditions we experience. Furthermore, our well-being is also determined by the health and social services we receive, and our ability to obtain quality education, food and housing, among other factors. And contrary to the assumption that citizens have personal control over these factors, in most cases these living conditions are (for better or worse) imposed upon us by the quality of the communities, housing situations, our work settings, health and social service agencies, and educational institutions with which we interact" (adapted from Mikkonen & Raphael, 2010:p7-8).*

It is clear from the above excerpt that SDH are those factors that directly influence our health and well-being. The indisputable evidence based on hundreds of studies and decades of research findings from all over the world has proven that, more than any other factors, it is the social injustice resultant from social structures and power relationships that is detrimental on a grand scale (Mikkonen et al., 2010; WHO, 2008). New studies also claim that during the last 20 years, health equity gaps (differences in health that are unnecessary, avoidable, unfair and unjust) within and between countries appear to be widening more than ever before, no matter whether the country is developed or developing (Dahlgren & Whitehead, 1992; Marmot & Wilkinson, 1999; Tarlov 1999; Braveman & Gruskin, 2002; Mackenbach, 2005; Wilkinson, 2005; Marmot, 2005; WHO, 2008). For instance, the majority of people in low and middle-income countries and one-in-five in high income countries face rampant health inequality (Yazbeck, 2009; Labonte et al., 2005; Wade, 2004; Cornia, 2001).

Considering the extent to which health inequalities are occurring even in Europe's most affluent countries where substantial improvements in health care systems have taken place for decades, one can easily imagine the degree of severity in the situation of health equity in low income countries where health care systems are still fragile and national economies and development budgets are solely relying on external sources and donors. The poorest of the poor and/or socially marginalised groups, especially from remote rural areas of third world countries are suffering the most (Yazbeck, 2009; WHO, 2008).

Despite huge efforts and investments to improve population health over many decades and having remarkable development in biomedicine, the stunning picture of health inequity demonstrates systemic problems in health policies within and between countries. Given the earlier failures resulting in differentiated health outcomes, addressing SDH is becoming a global and national agenda as a means to reduce health equity gaps, presumably in a generation (Schrecker & Taler, 2013; WHO, 2008). However, in many low and middle income countries (e.g. Nepal), where health problems are enormous, there is still little understanding of SDH and a lack of prioritisation of issues to reduce the associated structural barriers. This article attempts to explore and discuss SDH in Nepal linking it to the context of disease burden, health policies and practices.

This paper aims to describe the existing scenarios and theoretical concepts of SDH in association with Nepal's current health related issues, policy development and their changing patterns over time. This paper also aims to identify SDH that can be applicable to Nepal's context, which in turn, will be helpful in narrowing down the health equity gaps across the country. Understanding the gaps and associated factors are crucial pre-requisites in promoting sustainable livelihoods. In analysing social determinants of health, it should be clear whether the author is focusing on only social determinants of health such as how these factors shape health outcomes in general; or the distribution of social determinants of health such as how the inequitable distribution of these determinants comes to cause health inequalities. This paper focuses more on the former case.

The paper begins with some of the international commitments to take action on SDH, followed by presentation on Nepal's position on health status internationally, and in South Asia. The paper also discusses Nepal's current health problems and their changing scenarios, historical background, a logic model and some important conceptualisations of SDH to layout the theoretical foundation, and identification of SDH that are applicable to Nepal with their brief explanations.

## 2. Methodology

This article is based on review of literature from published peer reviewed journal articles and web-based literature. In addition, grey literature - such as books, book chapters, government reports, and conference proceedings relevant to this chapter were reviewed. Many health experts and government officials were contacted for relevant grey literature. Furthermore, a main database that was used for literature search was 'Google Scholar', and the search was guided by a list of key words and names of key health institutions, authors and some of the relevant references that were identified from recently published articles and reports. All relevant literature which were accessible online were downloaded and screened. Only articles deemed relevant were reviewed. The results were synthesised mainly using a rapid review technique.

To review the level and trend of relevant health outcomes, a number of indicators highlighted by the WHO 2013 (Table 1) and the Institute for Health Metrics and Evaluation (IHME), 2013 (Table 2) were considered. Among health indicators, the life expectancy at birth is considered as a standard to measure overall health status of people in a given country. For example, in 2010, people of Sierra Leone and Japan had respectively, the lowest (45 years) and the highest (83 years) average life expectancy at birth. The former indicates the poorest health while the latter indicates the strongest health. In the given circumstances, some people can live longer with an absolutely healthy life, while some survive for relatively long periods but with illnesses and some die prematurely. The experiences of disease burden, the number of years lost due to ill-health, and disability or early death ultimately influence the overall longevity of people. To adjust such experiences while estimating longevity the estimation of health-adjusted life expectancy has been the most common approach used recently. To estimate health-adjusted life expectancy at birth, as used in this paper, the estimation of disability-adjusted life years (DALY) is needed and can be calculated by combining both mortality (average years of life lost-YLL) and morbidity (years lived with disability-YLD) experience into a single common metric. To estimate DALY, a standard statistics of life expectancy is needed. In this paper DALYs are used to indicate the health or premature death status of Nepalese, explaining the step-by-step calculation and procedure used is beyond the scope of this paper but for more details of this method see Horton (2012).

## 3. National and international commitments

On October 2011, the representatives of WHO member states came together in Rio de Janeiro and every national authority reiterated their determination "to take action on SDH through the three overarching recommendations: to improve daily living conditions [of people]; to tackle the inequitable distribution of power, money and resources; and to measure and understand the problem and assess the impact of action" (WHO, 2011:p1).

The WHO (2011: p1) also reaffirmed that:

> *“Health inequities within and between countries are politically, socially and economically unacceptable, as well as unfair and largely avoidable, and that the promotion of health equity is essential to sustainable development and to a better quality of life and well-being for all, which in turn can contribute to peace and security.”*

In May 2013, the 66th Assembly of WHO was held in Geneva where delegates and representatives from 188 out of 194 member states attended. They restated the pressing need to take action on reducing health inequities across the member states by implementing the 2011 Rio Political Declaration on Social Determinants of Health to: identify social determinants which cause health inequalities; address health inequalities and achieve good health; enjoy good health as a fundamental right; adopt better governance for health and development; promote participation in policy-making and implementation; further reorient the health sector towards reducing health inequities; strengthen global governance and collaboration;

monitor progress and increase accountability; and call for global action (WHO, 2013). Nepal has also vowed to commit to the implementation of these declarations (WHO, 2013b).

## 4. An overview of population health situation in Nepal: Positioning in the globe and in South Asia

Health inequalities in Nepal are widespread and manifested through numerous health indicators such as life expectancy, infant mortality, adolescent fertility and level of stunted children. Table 1 shows Nepal's health status in the globe and in South Asia based on these health indicators. Although Nepal has experienced complex political turmoil along with relatively weak economic growth over the past few decades, it has been progressing well in its population health outcomes (NPC/UNCTN, 2013). For example, life expectancy at birth has increased from 38 years in 1960 to 68 years in 2011. The infant mortality rate also declined steadily from around 200 per 1,000 live births in 1960 to 39 per 1,000 live births in 2011 (WHO, 2013). The under-five mortality rate and maternal mortality ratio also followed a similar trend. For example, the maternal mortality ratio of 770 per 100,000 live births in 1990 decreased to be 360 and 170 respectively in 2000 and 2010 (Ministry of Health (MoH), 2011).

**Table 1:** Nepal's ranking on selected health indicators in the world and in South Asia

| Indicators | Status | Relative Ranking (1 is best) among WHO member states and SAARC* countries | |
|---|---|---|---|
| Life expectancy at birth (both sexes) 2011 | 68 years | 128th of 194 WHO member states | 4th of 7 South Asian nations |
| Infant mortality rate (per 1,000 live births) 2011 | 39.0 | 140th of 194 WHO member states | 4th of 7 South Asian nations |
| Adolescent fertility rate (per 1,000 girls ages 15-19 years) (2005-2010) | 81.0 | 118th of 147 WHO member states | 6th of 6** South Asian nations |
| Stunted Children <5 (%) (2005-2012) | 40.5 | 92nd of 114 WHO member states | 4th of 7 South Asian nations |

(Source: WHO, 2013)

*SAARC (South Asian Association of Regional Cooperation) comprises Nepal, India, Bhutan, Bangladesh, Pakistan, Maldives, Sri Lanka and Afghanistan. As Afghanistan was recently added to this network, is not included in this ranking

** Bangladesh has no data reported for adolescent fertility rates of girls aged 15-19.

Overall, in recent years, South Asia has made good progress in reducing mortality and prolonging life (WHO, 2013). Although most South Asian countries have succeeded in decreasing the intensity of communicable diseases, with the exception of HIV/AIDS, communicable disease have still remained the top drivers of premature deaths and disabilities (Table 2).

**Table 2:** Ranking of general life expectancy and the health adjusted life expectancy at birth in South Asia between 1990 and 2010

| Countries | Life expectancy at birth (Years) | | | | Health adjusted life expectancy at birth (Years) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | Rank | 2010 | Rank | 1990 | Rank | 2010 | Rank |
| 1. Sri Lanka | 73.3 | 1 | 75.5 | 2 | 62.1 | 1 | 65.3 | 2 |
| 2. Maldives | 65.1 | 2 | 78.8 | 1 | 55.7 | 2 | 68.0 | 1 |
| 3. Pakistan | 62.3 | 3 | 65.7 | 6 | 53.3 | 3 | 56.5 | 5 |
| 4. Bangladesh | 58.9 | 4 | 69.0 | 5 | 49.2 | 7 | 58.4 | 6 |
| 5. Bhutan | 58.8 | 5 | 69.4 | 3 | 50.0 | 4 | 59.7 | 3 |
| **6. Nepal** | **58.8** | **6** | **69.2** | **4** | **49.8** | **5** | **58.8** | **4** |
| 7. India | 58.3 | 7 | 65.2 | 7 | 49.8 | 6 | 56.2 | 7 |

*Note: Although life expectancy at birth in Nepal in 2010 seems slightly higher than in 2011 (Table 1), the two sources are influenced by different calculation techniques. Source: IHME, 2013.*

As other South Asian neighbours, Nepal is improving its population health indicators over time. For example, life expectancy at birth in Nepal in 1990 was ranked 6th, which moved up to a rank of 4th in 2010 (Table 2). Similarly, the health adjusted life expectancy at birth moved up to 4th in 2010 from its 5th rank in 1990. Despite these improvements, Nepali people are dying 14.3 years earlier (IHME, 2013) than their potential capacity of surviving, which may be due to the current burden of diseases (Table 3).

## 5. The real health problems in Nepal that cause premature deaths and disabilities

It is important to understand the diseases that cause ill health among Nepalese and lead them to die prematurely. Robust scientific evidence shows that there are 168 causes of ill health, disability and premature deaths in Nepal (IHME, 2013) including both communicable and noncommunicable diseases. Table 3 shows some of the most common causes that contribute to ill-health and premature deaths in Nepal.

**Table 3:** Top 20 causes of premature deaths and disabilities in 1990 and 2010 in Nepal by types

| Mean rank | (a) Top 20 diseases in 1990 | (b) Top 20 diseases in 2010 | (c) Change in rank from 1990 to 2010 |
|---|---|---|---|
| 1 | Lower respiratory infection *** | Lower respiratory infection*** | No change |
| 2 | Diarrheal disease*** | Diarrheal disease*** | No change |
| 3 | Neo-natal encephalopathy*** | Neo-natal encephalopathy*** | No change |
| 4 | Pre-term birth complications*** | Chronic Obstructive Pulmonary Disease (COPD)** | 6 to 4 |
| 5 | Tuberculosis*** | Low back pain** | 11 to 5 |
| 6 | Chronic Obstructive Pulmonary Disease (COPD)** | Tuberculosis*** | 5 to 6 |
| 7 | Congenital anomalies** | Pre-term birth complications *** | 4 to 7 |
| 8 | Protein energy malnutrition*** | Ischemic heart disease** | 19 to 8 |
| 9 | Tetanus*** | Iron deficiency anaemia*** | 10 to 9 |
| 10 | Iron deficiency anaemia*** | Self-harm* | 18 to 10 |
| 11 | Low back pain** | Road injury* | 15 to 11 |
| 12 | Neo-natal sepsis*** | Neo-natal sepsis*** | No change |
| 13 | Syphilis*** | Stroke** | Emerged |
| 14 | Mechanical Forces* | HIV/AIDS*** | Emerged |
| 15 | Road injury* | Major depressive disorder** | Emerged |
| 16 | Measles*** | Asthma** | 20 to 16 |
| 17 | Maternal disorders*** | Diabetes** | Emerged |
| 18 | Self-harm* | Migraine** | Emerged |
| 19 | Ischemic heart disease** | Anxiety disorder** | Emerged |
| 20 | Asthma** | Congenital anomalies** | 7 to 20 |

Note: *** Communicable, maternal, neonatal, and nutritional disorder; ** Noncommunicable; *Injury

(Source: IHME, 2013) †Although evidences from IHME, 2013 cannot be free from limitations.

In Nepal, respiratory disease is the number one cause of premature deaths and disabilities, especially infecting the lower respiratory system in the human body such as the trachea (windpipe), airways and lungs (Gostin et al., 2003). Similarly, diarrheal disease is the second leading cause of death among children under five years of age, which can be caused by a host of viral, bacterial or parasitic organisms, most of which are spread by faeces-contaminated water (WHO, 2015). Neonatal complication, the third leading cause of death in Nepal, is a clinically defined syndrome of disturbed neurological function in infants which manifests by difficulty with initiating and maintaining respiration, depression of tone and reflexes, sub-normal level of consciousness, and often seizures (Nelson et al., 1991).

Similarly, as people age and tend exercise less, bone strength and muscle elasticity and tone tend to decrease loosing fluid and flexibility that lead to nerve or muscle irritation or bone lesions which cause musculoskeletal disorders (e.g. lower back pain) (NIH, 2014). Tuberculosis, which typically affects the lungs and also other parts of the body, is another cause of premature death. Similarly, as shown in the Table 3, pre-term birth complications (before 37 completed weeks of gestation); cardio-vascular disease (any abnormal condition characterised by dysfunction of the heart and blood vessels); iron deficiency anaemia (low red blood cell or haemoglobin levels); psychological disorder (a syndrome characterised by clinically significant disturbance in an individual's cognition, emotion regulation or behaviour that reflects a dysfunction in the psychological, biological or developmental processes underlying mental functioning); injury (road injury including bicycle, motorcycle, motor vehicle, pedestrian injury, falls, drowning, burns, and self-harm); HIV/AIDS (a disease of the human immune system caused by infection with human immunodeficiency virus); diabetes (metabolic diseases in which a person has high blood sugar); and migraine (a chronic neurological disorder characterised by recurrent moderate to severe headaches) are other leading causes of death and disabilities in Nepal.

Table 4 shows some of the top risk factors (in order of higher to lower effect) that Nepali people faced in 2010. Each of these factors was associated with developing diseases that caused premature death.

**Table 4:** Risk factors contributing to the causes of premature deaths and disabilities in Nepal

| | |
|---|---|
| 1. | Dietary risk |
| 2. | Household air pollution |
| 3. | High blood pressure |
| 4. | Tobacco smoking /chewing |
| 5. | Ambient (outdoor) particulate matter pollution |
| 6. | High fasting plasma glucose |
| 7. | Alcohol use |
| 8. | Underweight during childhood |
| 9. | Physical inactivity |
| 10. | Occupational risk |
| 11. | Sub-optimal breast-feeding |
| 12. | Sanitation |

(Source: IHME, 2013)

Dietary risk has been the number one risk factor for premature deaths (Table 4) in Nepal. Dietary risk generally refers to dietary deficiencies or failure to assess the risks (Box 2) as well as being unable to consume a minimum number of servings from one or more food groups represented in the Food Guide Pyramid (Fig. 1) and follow the Dietary Guidelines (Box 1); this leads to impaired or endangered health status (The National Academy of Sciences, 2002). Nepal also published Food-Based Dietary Guidelines in 2004 (FAO, 2004) which highlights seven directions to "(1) eat a variety of foods every day, (2) eat four times a day, (3) encourage eating traditional and festival foods, (4) consuming livestock products (fish, meat, milk, eggs) everyday, (5) encourage eating locally available dark green, yellow and other vegetables and fruits, (6) use iodized salt and (7) use fats/oil in moderation" (FAO, 2004). Despite this publication, the food-based dietary guidelines are vague and not clear enough to apply them in daily life.

Household air pollution is the second leading risk factor, contributing to developing acute respiratory infections among children and chronic obstructive pulmonary disease and lung cancer in adults in Nepal. According to the NDHS, 2011, over 80% of Nepal's population live in rural areas (GoN, 2012). Almost all of them depend on their traditional indoor stoves using solid and biomass fuels (e.g. firewood, dung, and agricultural residues) and coal for cooking and heating (GoN, 2012; MoH, 2011). This cooking and heating technique results in high levels of indoor pollution containing small particles, carbon monoxide and excessive levels of particulates (WHO, 2014). Tobacco smoking and ambient (outdoor) particulate matter pollution are further causes contributing to problems related to respiratory complications (WHO, 2014). Likewise, people who are economically well-off and have sedentary lifestyle or who are physically inactive are increasingly developing high blood pressure, high fasting plasma glucose (diabetes) and other risk factors as outlined in Table 4, which adds further risks.

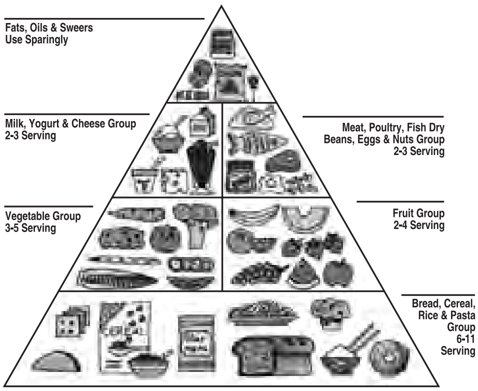


Figure 1: Pyramid guide for food choice

**Box 1: The dietary guidelines for Americans**

- Let the Pyramid guide your food choices.
- Choose a variety of grains daily, especially whole grains.
- Choose a variety of fruits and vegetables daily.
- Keep foods safe to eat CHOOSE SENSIBLY.
- Choose a diet that is low in saturated fat and cholesterol and moderate in total fat.
- Choose beverages and foods to moderate your intake of sugars.
- Choose and prepare foods with less salt.
- If you drink alcoholic beverages, do so in moderation.

*(Source: USDA/HHS, 2000) from The National Academy of Sciences, 2002.*

**Box 2: Dietary risk assessment indicators**

- Inadequate/Inappropriate nutrient intake
- Failure to meet dietary guidelines (Box 1)
- Vegan diets
- Highly restrictive diets
- Other dietary risk
- Inappropriate infant feeding
- Early introduction of solid foods
- Feeding cow's milk during first 12 months
- No dependable source of iron for full-term
- Infants at 6 months of age or later
- Improper dilution of formula
- Feeding other foods low in essential nutrients
- Lack of sanitation in preparation/ handling of nursing bottles
- Infrequent breastfeeding as sole source of nutrients
- Inappropriate use of nursing bottles
- Excessive caffeine intake (breastfeeding
- woman)
- Inadequate diet
- Inappropriate or excessive intake of dietary
- Supplements including vitamins, minerals, and herbal remedies
- In adequate vitamin/mineral supplementation
- Inappropriate feeding practices for children

*Source: Food and Nutrition on Service (FNS, 1998) from The National Academy of Sciences (2002)*

## 6. Changing pattern of health problems over time in Nepal

Understanding the changing patterns of diseases is crucial for identifying the intensity and effect of each disease over time. Table 3 presents the top 20 diseases responsible for premature deaths and disabilities in 1990 and 2010 in Nepal. The last column of Table 3 presents the changing trends of diseases according to their impact (ranking) in 2010 compared to 1990 and also displays some newly emerging illnesses, majority of which are related to noncommunicable (chronic) diseases and psychological disorders.

Accounting for only the top 20 among 168 causes of illnesses between 1990 and 2010 in Nepal, the disease burden in 1990 was dominated by communicable, maternal, neo-natal and nutritional disorders (60%), followed by non-communicable disease (25%) and injuries (15%). However, this trend in 2010 shifted to be dominated by non-communicable diseases (50%) followed by communicable, maternal, neo-natal and nutritional disorders (40%), and injury (10%) (although top three causes of mortality and morbidity in 2010 were still from communicable diseases). The burden from non-communicable causes comes especially from musculoskeletal disorders (e.g. low back pain), ischemic heart disease, stroke, asthma, diabetes, migraine, anxiety disorders, major depressive disorders and congenital anomalies.

## 7. Social determinants of health to address the burden of diseases

In order to address the issues related to the burden of diseases, we have to first identify the root cause(s) of these diseases. Theoretical evidence (Figure 2) (Tarlov, 1999; Keon & Pepin, 2009) clearly shows that the origin of these health problems facing Nepal have very little to do with access to quality healthcare services, albeit healthcare services are very important for treatment of diseases; they are primarily related to the range of socio-economic and environmental conditions in which people live and interact (Marmot, 2005).

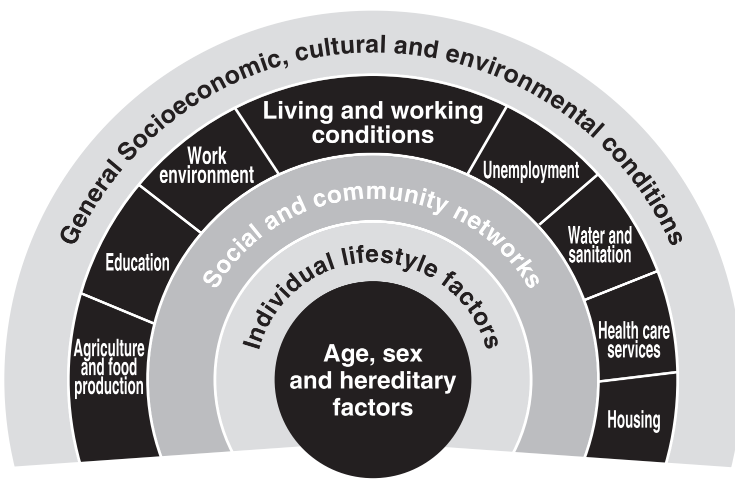


Figure 2: The determinants of health as set out by Dahlgren and Whitehead (1992)

Dahlgren and Whitehead's (1992) social health framework, commonly known as 'multi-level rainbow model', supports this idea (Figure 2). According to this model, there are five levels where different factors contribute to (the origination of) disease(s) which impact our health. They are:

*1. Biological factors:* This includes any biological factors such as age, sex and heredity.

*2. Individual life style factors:* (micro-level) that refers to our individual behaviours such as diet, substance abuse, sexual behaviour, physical activity, which can have positive or negative impacts on our health. If our behaviour is linked to smoking, drug and alcohol misuse, poor diet and lack of physical activities, the origin of diseases such as respiratory infections, diarrhoea, or diabetes may begin.

*3.Social and community networks (meso-level):* refers to family (e.g. parents, wife, children, and siblings), friends, and the wider social circles around us. The quality of social and community networks are a protective factor to promote health, but if the healthy and joyful relationship between these networks cannot be maintained, this leads to psychological stress by which health complications begin.

*4.Living and working conditions (macro-level):* refers to accessibility of welfare services, such as the national or local health system, education, social services (especially public), transport, leisure facilities, training and employment, housing and amenities. It also includes facilities like running water and sanitation, and having access to essential goods like food, clothing and fuel. If any imbalance in these living and working conditions is experienced, they negatively impact our health and a range of health problems can originate.

*5. General socio-economic, cultural and environmental conditions (macro-level):* refers to factors such as wages, disposable income, availability of work, taxation, and prices; fuel, transport, food, clothing, and health policies etc., that impact health and wellbeing. Furthermore, these general conditions can directly affect government spending capacity, and in turn have a direct influence on health and social policy priorities. These factors related to our living conditions of where we are born, grow, live, work, and age are considered determinants of health.

Tarlov (1999) has quantified the extent our health can be determined by different factors of SDH. He believes that genes and associated biology, as well as health behaviours, account for about 25% of the impact. The remaining three layers of determinants are: social characteristics (e.g. discrimination, gender, culture), physical or total ecology (e.g. where people live) and the social structural element beyond the remit of public policy such as social and community aspects of health services or medical care (e.g. access to quality health care and having or not having insurance); altogether these account for about 75% of the impact on our health. A report by the Canadian Senate in 2009 also stated that 75% of the factors that influence population health are not related to any healthcare delivery system (Keon & Pepin, 2009). This evidence affirms that our living conditions alone are responsible for creating 75% of our health problems. This also confirms the previous assumption that clinical care alone can fix all of our health problems was inaccurate; indeed, advanced clinical systems can only provide treatments for these diseases that are created by the interactions of different factors from our living conditions (see WHO, 2010a, Social Determinants of Health Discussion Paper 1 for details).

Whitehead (1992) showed that there may be measurable differences in health experiences and health outcomes between different population groups according to age, disability, ethnicity, gender, and socio-economic status. If these differences occur, then health inequalities are likely to exist. These inequalities can be either avoidable or unavoidable. For example, the difference in mobility between an 80 year old grandfather and his 20 year old grandson attributable to the 'biological health determinant' may not be possible to change. When a health outcome is unavoidable and is called 'health inequality'. Similarly, there are measurable differences in opportunity for disparate population groups which results in unequal health status. For example, infant mortality rates between people from different social classes of Nepal such as Newar, Brahmin, Dalit and Janjati are different (MoH, 2012). This measurable difference in infant mortality rates is avoidable and can be judged to be ethically unfair and unjust (Whitehead, 1992: WHO, 2008). Such 'health inequalities' are called 'health inequity' (Gwatkin, 2002). This health inequity results from social structures and power relationships establishing barriers to health equality (Mikkonen et al., 2010; WHO, 2008). Nepal is not an exception. This suggests that identifying SDH applicable to Nepalese context would allow us to pinpoint the gaps to improve the SDH factors affecting health and thereby allow us to address them. Doing this can enhance the better health of Nepalese people which ultimately promotes sustainable livelihoods.

## 8. Social determinants of health: a neglected paradigm in Nepal's health policies

Since 1965, the Government of Nepal has been continuously trying to improve the health of its people and has been working in collaboration with national and international communities. In 1986, world health leaders attended the first international conference called "Ottawa Charter for Health Promotion" in Ottawa, Canada which emphasised collectively the influence of contextual factors on health (WHO, 1986). Nepal also agreed on the decisions but could not implement this concept in the Seventh Development Plan (1985-1990). This plan was the first of its kind in the history of Nepal, in which a comprehensive set of policies focussing on population-health, agriculture, forestry, urbanisation, manpower and employment, education, women empowerment, as well as community development were established (MoHP, 2012). Subsequently, the government of Nepal introduced a comprehensive National Health Policy (NHP) in 1991 aiming to enable its citizens to live more healthy lives by improving their overall health conditions. This policy adopted a primary health care approach and aimed to extend health services, including modern medical facilities and trained health care providers, to address both preventive and curative services to the rural and remote areas of Nepal. A year after this policy was implemented, Dahlgren and Whitehead (1992) from WHO, Regional Office for Europe published a report highlighting the importance of social determinants on people's health. Nepal's Eighth Development Plan (1992-

1997) was introduced in the same year which gave continuity to the health policy priorities of 1991 (NPC, 1992). Until that time, there was no clear awareness about the concept of social determinants of health in Nepal.

Over time, fairly comprehensive frameworks of health policies, strategies and plans have been formulated. In 1997, the second Long-term Health Plan (1997-2017) and the Ninth Development Plan (1997-2002) were formulated. They followed the strategic analysis to operationalise the second long term health plan (2002-03), the medium term expenditure framework, Nepal Health Sector Program Implementation Plan (2003-2007), the Tenth Development Plan (2002-2007), and the Nepal Health Sector Program - I (2004-10). Later, along with the interim constitution 2007, a three-year National Plan was introduced. Since 2010, Nepal Health Sector Programme-II (NHSP-II; 2010-2015) has been in operation (Ministry of Health and Population, 2010). Now Nepal is in the process of preparing NHSP-III for 2015-20. However, thus far the Nepal government and other stakeholders working in population health sectors have not integrated the concept of social determinants of health into health policies in a meaningful way. This situation also hampers several public/population health institutions (e.g. Institute of Medicine or Academy of Sciences) as they lack a foundation of scientific literature in Nepal's context to refer to in order to develop a comprehensive public health curriculum which embraces SDH for Bachelors and Masters degrees. Otherwise, this prevents awareness and training of the next generation of those working in the health care system. In this context, Shrestha and Pathak (2012) state that, "the new health policy should be broad enough to include issues not only of the health sector but also of population and nutrition .... and should cover the SDH" (p 24). However, until now it can be argued that social determinants of health have still been neglected in Nepal's health policies and programs.

## 9. Identifying social determinants of health in Nepal

A variety of conceptualisations of SDH have been developed over time in the international arena (Table 5). Social context of a nation or society is the most important feature for identifying SDH applicable to that nation or society.

**Table 5:** Various conceptualisations of the social determinants of health

| Ottawa Charter (1986) | Dahlgren and Whitehead (1992) | Health Canada (1998) | World Health Organization (WHO, 2003) | Center for Disease Control USA (CDC, 2005) |
|---|---|---|---|---|
| - Peace<br>- Shelter<br>- Education<br>- Food<br>- Income<br>- Stable ecosystem<br>- Sustainable resources<br>- Social justice<br>- Equity | - Agriculture and food production<br>- Education<br>- Work environment<br>- Unemployment<br>- Water and sanitation<br>- Health care services<br>- Housing | - Income and social status<br>- Social support network<br>- Education<br>- Employment and working conditions<br>- Physical and social environments<br>- Healthy child development<br>- Health services<br>- Gender<br>- Culture | - Social gradient<br>- Stress<br>- Early life<br>- Social exclusion<br>- Work<br>- Unemployment<br>- Social support<br>- Addiction<br>- Food Transport | - Socio-economic status<br>- Transportation<br>- Housing<br>- Access to services<br>- Discrimination by social grouping<br>- Social and environmental stressor |

Source: Bryant et al. (2010):p3

SDH not only concentrates on how these determinants shape health outcomes in general, but also focuses on how the inequitable distribution of these determinants causes health inequalities (Bryant et al., 2010); this scope is the most important factor to inform policies for sustainable population health outcomes, which is one of the fundamental characteristics of sustainable livelihoods. In Nepal, no SDH have been identified yet. However, considering Nepal's commitments to take action on SDH (following recommendations from the World Health Organization) as a means of reducing health inequity, identifying social determinants of health applicable to the context of Nepal is important. This paper, for the first time, contributes to this endeavour, focusing on how social determinants shape health outcomes considering the conceptualisations of SDH given in Table 6 as a basis. The concept of social gradient and double burden of diseases are important for understanding Nepal's current context in connection to SDH.

## 10. Social gradient and triple burden of diseases in Nepal

The concept of leading healthy lives is easy for some, but difficult for many, is known as the 'social gradient in health' that runs from top to bottom of the socio-economic spectrum (WHO, 2014). This means, the lower the socio-economic position, the more inferior the health status. Normally, people with such poor health status in high income countries tend to be suffering from the burden of noncommunicable diseases, but in low income countries it is expected to suffer from the burden of communicable diseases. However, Nepal, even being characterised as a low-income country, is suffering from the triple burden of diseases: (i) communicable, (ii) noncommunicable (MoHP, 2011), and (iii) injury-violence and disaster. Box 3 presents a simple story of the complex set of factors/conditions that determine the burden of diseases in Nepal.

**Box 3:** A scenario of living conditions that determine the burden of diseases

| (a) A scenario of a poor rural 11-year illiterate girl | (b) A scenario of a rich and college graduate urban 35-year woman |
|---|---|
| **Q:** Why is Shanti in the health post?<br><br>**A:** Because she has a bad infection in her foot.<br><br>**Q:** But why does she have an infection?<br><br>**A.** Because she has a big cut on her foot and it has got infected.<br><br>**Q:** But why does she have a big cut on her foot?<br>**A.** Because whist trying to collect firewood by chopping a log, her hand accidently slipped and her rusted axe jabbed into her bare foot.<br><br>**Q:** But why she was collecting firewood at such an early age?<br><br>**A.** Because as the first child among her 5 siblings and being from a poor family she has the responsibility to help her parents to provide for the family. She has a daily routine to go to forest with other villagers to collect firewood in the morning and looking after her siblings during the day.<br><br>**Q:** But why don't her parents send her to school?<br><br>**A.** Because her parents are so poor and living in a miserable condition. They are not even able to sufficiently feed their kids despite their hard work. Sending her to school is out of the question.<br><br>**Q:** But why are her parents so poor?<br><br>**A.** Because they only have a small plot of land, which is not enough to grow adequate food and vegetables to feed the family even for 3 months in a year. They are uneducated and have to work hard for daily wages just to feed the family.<br><br>**Q:** But why? | **Q:** Why is Sonu in the hospital?<br><br>**A:** Because she is suffering from type-2 diabetes and high blood pressure.<br><br>**Q:** But why does she have diabetes and blood pressure?<br><br>**A.** Because she is overweight and under lots of stress.<br><br>**Q:** But why?<br><br>**A.** Because she does desk work, she does not have regular designated meal times, but when she eats, she has a very heavy meal and does not do any exercise.<br><br>**Q:** But why?<br><br>**A.** Because she thinks that living the good life is only based on eating high calorie delicious food and staying with sedentary life style.<br><br>**Q:** But why does she think so?<br><br>**A.** Because she has grown-up in such an environment where most members of society perceive that spending money on expensive food (e.g. alcoholic beverage, meat and sweets) and having a relaxed life will lead them to be prestigious and are envied.<br><br>**Q:** But why?<br><br>**A.** Because money is thought to be the key to prosperity, and citizens are often not educated about healthy lifestyles as a part of prosperous life.<br><br>**Q:** But why? |

*Note: This story is based on the discussions with key health researchers, and policy makers in Kathmandu during February 1-16, 2014 and also personal observations of author in rural villages of more than 50 out of 75 districts in Nepal.*

The conceptual framework developed by Brunner and Marmot (2006) on social determinants of health and the pathways to well-being or illness is adapted (modified from the original) to apply it to the Nepalese context. Figure 3 shows a process of pathways which starts from social structure and ends at well-being, morbidity and/or mortality. It is clear from the figure that social structure influences the living and working conditions of people which shapes one's health and well-being, operating through the social environment, economic, psychological, material and behavioural pathways. Genetics, early life and cultural factors strongly influence health in all stages of life (Figure 3).

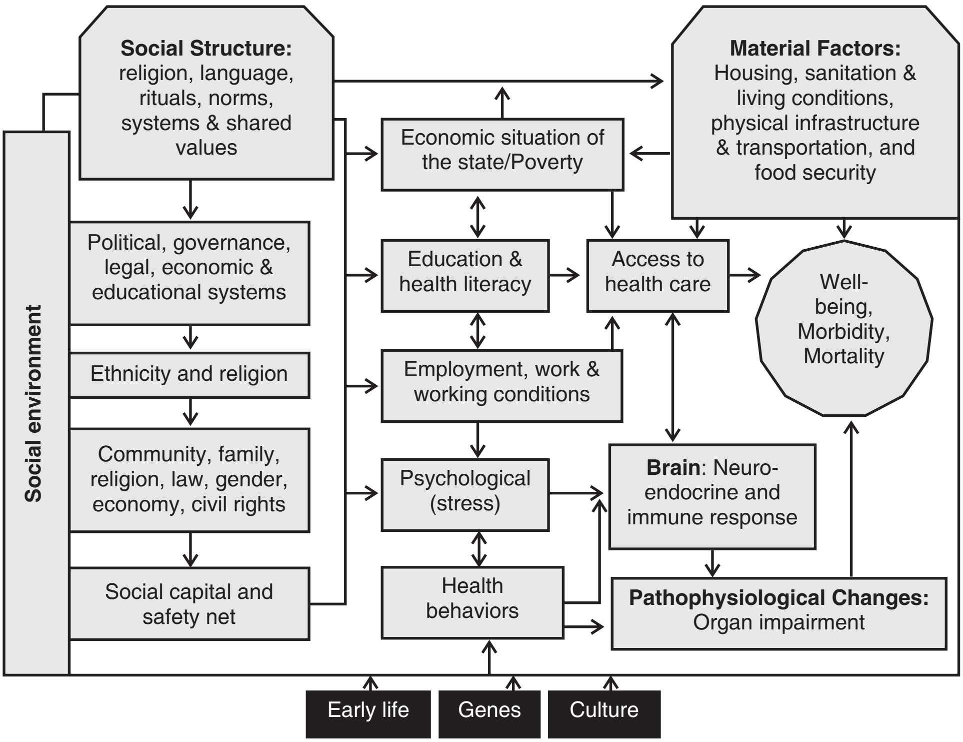


Figure 3: Social determinants of health and pathways to health and well-being adapted from Brunner and Marmot (2006) p.9.

## 11. Social determinants of health that are directly applicable to Nepal

Considering all of this evidence and conceptualisations of SDH related to the particular context of Nepal, the following thirteen SDH are applicable to the nation (Table 6).

**Table 6:** Key social determinants of health that are directly applicable to Nepal

| | |
|---|---|
| 1. Politics, policy and governance | 8. Poor housing, sanitation and living conditions |
| 2. Poverty | 9. Physical infrastructure and transportation |
| 3. Education and health literacy | 10. Food security |
| 4. Employment and working conditions | 11. Early life and childhood development |
| 5. Gender | 12. Stress |
| 6. Ethnicity, religion and culture | 13. Access to health care and seeking behaviour |
| 7. Social capital and safety net | |

Below the key social determinants of health are briefly summarised as they apply to Nepal.

**11.1 Key determinant: Politics, policy and governance**

Politics, policy and governance are interlinked. For better or worse, they play a critical role in health affairs, ranging from disease prevention to health care reforms as well as the implementation of intervention programs aimed at reducing inequalities (WHO, 2011a). Public policy that emerge from good politics and effective governance systems positively affect housing, education, income, access to food, the availability and quality of health care; all of these create the environment in which we live (Harvard School of Public Health, 2011). Adopting appropriate laws and policies and ensuring their effective implementation is necessary in addressing existing as well as emerging health issues aiming to improve overall population health.

In Nepal, a long transition period and general political instability has affected the overall governance system, making it difficult to reduce or eliminate policy gaps in the public health arena. Nepal is working towards a peace process after a decade-long armed conflict, and was supposed to promulgate a new constitution in 2010. However, the Constitution Assembly elected in 2008 failed to make this constitution in time. Political trust and understanding between and within parties remains fragile; the current state of governance is poor; the rule of law and civil order are weak; corruption, crime and impunity are widespread and progressively on the rise; and citizen-safety has become weaker (NPC/UNCTN, 2013). These scenarios have negatively affected the well-being of Nepalese people, specifically in regard to their contribution to the social determinants of health.

**11.2 Key determinant: Poverty**

Poverty is often defined in absolute terms of income or consumption. For example, by most standards, individual earning less than US$ 1.25 a day are regarded as ‘absolute poor’. The United Nations defines absolute poverty as a “condition characterised by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education, and information. Poverty depends not only on income but also on access to social services" (United Nations, 1995: Chapter II, paragraph 19). Poor and marginalised groups tend to have a higher risk of social exclusion, illness and disability, which in turn affect household savings, learning ability and productivity; this also often leads to a poor quality of life, thereby perpetuating or even increasing poverty (WHO, 2014).

Nepal, with a human development index of 0.463, and ranked at 157 out of 187 countries (UNDP, 2013), is one of the poorest countries in South Asia. This is the situation in spite of the fact that Nepal has been working to alleviate poverty since 1956 and to eradicate extreme poverty and hunger since 2000 (GoN/NPC/UNDP, 2010). Despite political instability, ineffective policies and inefficient governance, Nepal has made some progress in reducing poverty (NPC/UNCTN, 2013). For example, in 1990, one-third (33.5%) of people in Nepal were living with an income of less than one US dollar a day; and 42% of people were living below the national poverty line. Through the Millennium Development Goals (MDG), Nepal targeted to reduce these percentages by half their amount by 2015. The Nepal MDGs Progress Report (2013) shows that by 2013, the first target had already been met, dropping the proportion to 16.4%. The second target is also close to its goal, as the proportion of those living below poverty line in 2013 is 23.82%.

Although poverty at the national level seems to be declining, over 2.7 million people still live in abject poverty (NPC/UNCTN, 2013). Again, one fourth of poverty reduction in Nepal comes from remittances sent by Nepali labourers, but its sustainability is still doubtful. In the case that the flow of current remittances was cut off, the incidence of poverty in Nepal would double. However, Nepal has no additional plan(s) for creating jobs or a sustainable economic base and has no concrete plan for reducing income disparities in the near future (NPC/UNCTN, 2013). Table 7 presents the distribution of wealth in Nepal based on wealth quintile, and Gini Coefficient, which refers to the wealth distribution (0 being an equal distribution and 1 being totally unequal distribution). The Table clearly shows the unequal distribution of wealth across the country.

**Table 7:** Distribution of wealth in Nepal by residence, ecological zones, and regions

| | Wealth quintiles | | | | | Gini | |
|---|---|---|---|---|---|---|---|
| **Residence** | Lowest | Second | Middle | Fourth | Highest | Coefficient | N |
| Urban | 3.7 | 3.3 | 7.8 | 23.6 | 62.3 | 0.12 | 6338 |
| Rural | 22.6 | 22.5 | 21.8 | 19.5 | 13.6 | 0.22 | 41785 |
| **Ecological zones** | | | | | | | |
| Mountain | 41.4 | 30.7 | 19.8 | 7.7 | 0.5 | 0.18 | 3358 |
| Hill | 31.9 | 21.1 | 14.6 | 12.5 | 19.9 | 0.28 | 19501 |
| Plain (Terai) | 8.0 | 17.8 | 24.2 | 27.4 | 22.7 | 0.21 | 25264 |
| **Development regions** | | | | | | | |
| Eastern | 16.2 | 18.9 | 20.3 | 23.8 | 20.9 | 0.21 | 11481 |
| Central | 13.7 | 18.8 | 20.7 | 20.7 | 26.1 | 0.24 | 16011 |
| Western | 14.8 | 21.4 | 20.7 | 22.0 | 21.0 | 0.22 | 9895 |
| Mid-western | 41.5 | 20.1 | 16.3 | 12.1 | 10.0 | 0.24 | 5911 |
| Far-western | 34.5 | 23.7 | 19.5 | 14.3 | 7.9 | 0.20 | 4826 |

(Source: MoHP, New ERA, & ICF International Inc, 2012) (Table 2.6)

The widespread poverty and unequal wealth distribution in Nepal lead many people towards more hardship for survival. This misery compels them to face poor physical health and chronic psychological stresses. Evidence shows that poor people have limited options and their poor coping abilities for dealing with stress further leads to vulnerability and diseases through biological pathways by weakening the hormonal and immune systems (Mikkonen & Raphael, 2010). This scenario proves that poverty and its distribution is one of the most important social determinants of health for Nepal.

### 11.3 Key determinant: Education and health literacy

Associations between education, morbidity and mortality are not new. Education opens the door for understanding different pathways to better health, equips people with problem solving skills and improves one's ability to access and understand information that helps them to stay healthy (Higgins et al., 2008). According to Higgins (ibid), the level of education is highly correlated with income, employment and social status in a society, which help educated people to move up their socio-economic ladder and generally live with better health. However, if people are not educated, they miss such privileges. Education can affect health in different ways at different stages of their life cycle. Evidence also indicates that higher levels of education have been shown to have greater impact on healthy behaviour, and also on mental health outcomes in younger age groups and physical functioning in older age groups (ibid).

In Nepal, a large section of the population is still illiterate. A large fraction of those literate are still uneducated. Among the educated ones, a significant proportion of them are still without a high school diploma. Therefore, a relatively small portion of people in Nepal have achieved higher education. If we divide the educational attainment by gender, the outcomes clearly favour males. For example, the overall illiteracy rate (aged 5 and above) in Nepal is 34.1% in 2011. Among the 65.9% literate people, 75.1% are males and 57.4% are females (Central Bureau of Statistics (CBS), 2012). If we consider the adult literacy rate (15 year and older), the fraction of literate people is much smaller, at just 56.5%, with wider gender differences (71.6 % of males, and 44.5 % of females). However, if we review the history of net primary enrolment rate for last 23 years, the recent achievement shows an encouraging outcome: 64% in 1990 to 95.3% in 2013 with almost equal gender parity (NPC/UNCTN, 2013).

Experience from Canada shows that people with low literacy skills are more likely to be unemployed and poor, to suffer from ill health, and to die earlier than their counterparts with a higher level of education (Mikkonen & Raphael, 2010). This finding is equally applicable to Nepal. Evidence from Nepal itself shows that the nutritional status of children of educated mothers was far better than the nutritional status of children of uneducated mothers (Dahal, 1999). Furthermore, recent evidence from the Nepal Demographic Health Survey 2011 (MoH, 2011) and the Nepal MDG Progress Report 2013 (NPC/UNCTN, 2013) consistently confirmed this finding. In addition, educated married males in Nepal were more likely to adopt permanent family planning methods to limit their family size and to promote their wives' health and well-being compared to their uneducated male counterparts (Dahal et al., 2008; Dahal, 2008).

Nonetheless, being literate does not always mean to be health literate. It is because health literacy is not just the ability to read and write but also to encompass a much wider spectrum to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate decisions and to have the ability to apply these skills to promote their health and well-being (AHRQ, 2011). Even educated people with low health literacy cannot fall under the category of health literate; this concept, to a large extent, reflects Nepal's current situation [see Box 3(b)]. Therefore, education and health literacy are important social determinants of health for Nepal.

### 11.4 Key determinant: Employment and working conditions

Studies have shown that employment and better working conditions are associated with better socio-economic status and better health. Thus, unemployed or underemployed people tend to have inferior health because of their lower income and stress associated with their deprivation (ILO, 2013). In Nepal, about 400,000 youth enter into the labour market every year (NPC/UNCTN, 2013). Since Nepal has little scope of employment other than in agriculture and some service sectors, about 300,000 youth of different age groups emigrate to different countries in search of employment (ibid).

On the positive side, this migrant labour force remits money home and contributes to the reduction of family poverty, helps with the education of their children and siblings, and adds to the sustainability of the national economy (NPC/UNCTN, 2013). On the negative side, many of these semi-skilled labour migrants are compelled to face life-threatening working conditions when seeking employment. They also often face discrimination by their employers. A range of unfavourable working conditions cost many lives of labour migrants (The Guardian, September 25, 2013). The economic and psychological impact of this death toll on their dependents and family members is catastrophic and irreparable.

These tragic events have not deterred the youth, who are the main forces behind the productivity of the agricultural sector (which accounts 35% of GDP) from migrating to foreign land every day. This draining of the country's productive labour force has been weakening Nepal's agricultural sector (NPC/UNCTN, 2013). Other sources of employment sectors in Nepal, such as the service sector, tourism and manufacturing, have relatively limited contribution to employment and the national economy.

In addition, a large proportion of youth are unemployed in the country and are facing difficulty for survival with no other options for life chances. As a result, they face prolonged stress linking to health risks. Evidence from a range of countries shows that even after allowing other factors, unemployed people (given there is no other source of income) and their families suffer substantially more with increased risk of premature deaths and disabilities (Wilkinson & Marmot, 2003). Therefore, employment and working conditions are significant social determinants of health.

### 11.5 Key determinant: Gender

One's sex, classified as either a male, female, or intersex, is biologically determined at birth. However, the gender roles of a 'man' or a 'woman' are both personally and socially defined; these classifications are determined by social norms, called gender. Gender norms can be quite different from one culture to another (Nobelius, 2004). A growing body of evidence on the social determinants of health shows that health outcomes are not attributable to biology (Wilkinson & Marmot, 2003). The WHO (2010) recognises gender as an important determinant of health because of two main reasons: firstly, "gender inequality leads to health risks for women and girls globally; and secondly, addressing gender norms and roles leads to a better understanding of how the social construction of identity and unbalanced power relations between men and women affect the risks, health-seeking behaviour and health outcomes of men and women in different ages and social groups" (Men et al., 2011; Dahal, 2008).

Global trends show that women generally live longer than men. However, due to mixed effects of social and biological factors, women may experience more adverse health impacts than men as only women have the biological capacity to give birth and, as a mother, they carry more responsibilities for raising children and taking care of household works. Similarly, many of them suffer socially because they are female and also a member of a minority, disadvantaged or marginalised group (Dahal et al., 2007). Although the status of women in Nepal is improving substantially compared to the previous decades, women still face multiple facets of discrimination (MoH, 2011; NPC/UNCTN, 2013). For example, giving birth to male children is associated with family pride in most families across all social groups in Nepal, and limiting child birth only starts after having at least two sons in the family regardless of the number of daughters they already have (Dahal et al., 2008; Dahal, 2008). Compared to boys, girls in the family have a lower social status; get less opportunity for nutritious foods and quality education; and face early marriage and the burden of heavy responsibility of domestic and agricultural work, especially in marital households and, give child birth at a young age (NPC/UNCTN, 2013). Similarly, women have been given less opportunity to be involved in decision making processes, whether the decision is related to the family or nation (Basnet & Adhikari, 2007). The unequal and unfair treatment of women are the sources of prolonged stresses on them, and that of the developing risk factors for different diseases, disabilities and premature deaths (Table 4).

### 11.6 Key determinant: Ethnicity, religion and culture

Differences in health in terms of both morbidity and mortality across ethnic groups and religions due to their specific culture have been reported elsewhere (Rogers, 1992; Stewart et al., 1999; Gupta et al., 1995; Sheldon & Parker, 1992). This situation arises when the socio-economic inequalities exist between and within different ethnic, religious and cultural groups. In Nepal, widespread poverty and deprivation, inequality in wealth distribution, education and employment, gender discrimination and conflicts over the ethnic identity agenda are major contributing factors for developing stresses, diseases, disabilities and premature deaths (Table 4). There are differences in health outcomes based on the layers of categories of caste, religion and culture (Bennett & Dahal, 2006).

### 11.7 Key determinant: Social capital and social safety net

Social capital generally refers to the set of norms, networks, and organisations through which people gain access to power and resources, thereby decision making and policy formulation occurs (World Bank 1997, p78; Coleman 1993). So, social capital is embodied in social organisation, which facilitates coordination and cooperation for the mutual benefit of the group members (Putnam 1993; World Bank 1997, p78). Similarly, the social safety net refers to a range of programs that are implemented by such social or public institutions to protect citizens from transitions during large life changes, such as having and raising children, attaining education and employment trainings (Mikkonen & Raphael, 2010). Likewise, people may face unexpected life events, such as having an accident, becoming unemployed, developing a physical or mental illness or disability that can affect health. Such circumstances threaten health and ruin peace increasing the conditions of economic insecurity and aggravating psychological stress, which are all important aspects of social determinants of health.

In Nepal, apart from some limited provisions of old-age, disability allowances and travel allowance to pregnant women who get admission to health facilities for delivery (as well as some other small incentives) (GoN, MoHP, 2010: Nepal Health Sector Programme II, 2010-2015), the scope of having facilities under social security are almost non-existent. People have to face and manage problems by themselves, no matter what happens in their lives. They have to pay out of their pockets for all the expenditure involved in their health care and family affairs (Puri et al., 2008). Politicisation of ethnicity and identity among groups in the recent past has threatened to destroy social harmony on one hand, and interlocking community cooperation based on the 'we' and the 'other' principle on the other. The institutionalised corruption across sectors including civil service (NPC/UNCTN, 2013), the practice of syndicating and curtailing in business sectors and the emergence of widespread pernicious networks operating with detrimental effects to the wider society are all eroding the value of social capital, thereby giving rise to the downside of social capital (Adhikari & Goldey, 2010). The over politicisation of the families and communities by different political parties has further eroded the value of social capital and peace within and between families. The families and communities that do not have other safety nets such as wealth and resources, are the ones most affected for livelihood crisis.

### 11.8 Key determinant: Poor housing, sanitation and material living conditions

Poor housing, sanitation and material living are intricately linked to the state of poverty which has been previously discussed. Studies show that housing quality profoundly influence population health and well-being (Mikkonen & Raphael, 2010). According to UN Habitat, quality housing refers to affordable, decent, safe, and accessible; housing should also have a reasonable amount of space free from hazards, and be centrally located (Table 8). Housing which cannot meet these parameters is considered as substandard housing.

Children exposed to substandard housing conditions have been associated with many common chronic diseases such as asthma, respiratory complications and infectious diseases (Lanphear et al., 2001). Mounting evidence shows that higher exposures to infestations of cockroaches, rats and mice, as well as poor ventilation, excess moisture and mold which are associated with poor housing can contribute to childhood asthma (IoM, 2000; Rosenstreich et al., 1997; Lanphear et al., 2001; Acevedo-Garcia et al., 2004). Overcrowding and unsanitary conditions adds to higher rates of infectious diseases, such as rheumatic fever, tuberculosis, hepatitis, and respiratory infections (Healthabitat Pvt. Ltd., 2013). Studies have found that over 40% of asthma cases could be attributed to residential exposures such as cockroaches, dust mites, environmental tobacco smoke or pets in the home (Lanphear et al., 2001). The continuous exposure with cockroaches further worsens children’s asthma with additional wheezing and breathing difficulties.

**Table 8:** Characteristics of quality housing

| | |
|---|---|
| Affordable | If it does not cost more than 30% household income; |
| Decent | Clean, with good ventilation, free from excessive heat and cold, leaks and mold, bad smell, garbage, graffiti and regularly maintained; |
| Safe | Locks that work on doors and windows; |
| Accessible | Particularly for seniors and with disabilities; |
| Enough space | Free from crowding for those who live in; |
| Free from hazard | Toxic chemicals, lead paint, rodent and cockroach infestation etc; |
| Centrally located | In reasonable reach of shopping, public transportation, recreation, and health and human services, and with good neighbourhoods with playing space and greenery. |

(Source: United Nations, Human Settlements Programme UN-Habitat (online): http://unhabitat.org/)

Homeless families and those in unsanitary conditions are imminent victims of these hazards (Krieger & Higgins, 2002). Significantly higher proportion of upper respiratory infections, skin infestations (e.g. lice and scabies), gastrointestinal problems (e.g. diarrhoea), and ear infections have been found in homeless children. Children, who are exposed to lead and arsenic generally from contaminated house dust or environmental pollution, can experience adverse cognitive and behavioural effects (Lanphear et al., 2000; Parajuli et al., 2014a). Also poor families who cannot afford costs associated with housing are compelled to make trade-offs between rent and other basic necessities, such as food or medical care. This leads to food insecurity, malnutrition, and missed preventative medical care, all of which have lasting effects on family health and development. In addition, high exposure to violence and crime victimisation due to hardships within family circles and neighbourhoods (Anderson et al., 2002; 2003) result in prolonged stress and stress-related disorders (Anderson et al., 2002).

Direct contact with animals, vermin and insects in the housing environment cause many diseases, such as malaria (caused by mosquito bites), chronic gut diseases (caused by a parasites carried by dogs) and eye disease (caused by flies carrying trachoma bacteria) (Health abitat Pvt Ltd., 2013). Unsealed roads or vacant land in the rural community are the source of dust which causes irritation, eye diseases, respiratory disease and skin infections. Living in houses that are too cold or too hot can contribute to a range of physical illnesses, as well as emotional distress (Healthabitat Pvt Ltd., 2013). Similarly, exposure to dirt, soil (walking barefoot) and improper hand washing (e.g. not using soap) can cause the intensity of infections related to roundworm, hookworms and whipworm (Parajuli et al., 2014b).

Data from the 2011 census of Nepal (GoN, 2012) shows poor foundation and walls of households, primarily constructed from mud-bonded and cement-bonded bricks/stones, indicate sub-standard housing structure. Drinking unsafe water is also a grave risk faced by the population as the majority of drinking water sources are unsafe. Furthermore, cooking materials in the kitchen setting are found to be unhygienic, with the burning of fire-wood and cow-dung in a congested space. Similarly, four in ten households have no toilets. Although toilets are there in standard houses, they lack enough water to flush, hand wash and clean. In addition, a large proportion of people in Nepal come into contact with animals, vermin and insects, as 88% of households have owned livestock (Food and Agriculture Organization (FAO), 2011). They also use unsafe drinking water, and are exposed to poor sanitation and a range of hazardous conditions (e.g. indoor air pollution, exposure to cockroaches, dust particles, dust mites, tobacco-smoke). The accumulated knowledge synthesised from a range of studies regarding the status of housing and related conditions in Nepal clearly shows that the majority of people live in sub-standard houses and suffer from a range of complications such as asthma, respiratory complications and infectious diseases. These circumstances clearly prove that housing, sanitation and material living conditions are important social determinants of health in Nepal.

### 11.9 Key determinant: Physical infrastructure and transportation

Physical infrastructure and transportation plays a critical role for sustainable development. They facilitate the movement of people, goods and services, as well as promote access to necessary goods and services; it allows for market expansions needed for various activities impacting economic and human development (WHO, 2014). In Nepal, the Ministry of Physical Infrastructure and Transport was established in 2000 to contribute to infrastructural development and to effectively and efficiently manage infrastructural services. With continuous efforts from the Ministry and its associated partners, a total of 62,579 kilometres road network in Nepal has been built by 2013. Of that total, only 11.4% of the roads are blacktop, with the rest being gravelled (26.3%) and earthen (62.3%) (Thapa, 2013). Although 815 village development committees (VDCs) out of the 3,915 total VDCs in Nepal have not still been connected with road networks (Upadhaya, 2014), 1,545,988 vehicles in Nepal are running on these earthen roads (Upadhaya, 2014); this creates dust clouds during dry seasons and large muddy ditches in rainy seasons.

In recent years, construction of rural infrastructure is gaining momentum. However, the current focus lies on increasing the scale of such infrastructure without considering their quality and environmental impact. Due to the poor quality of road networks, road accidents and injuries have been one of the major causes of premature death and disability in Nepal. The statistics of Nepal Police Traffic Directorate (Thapa, 2013) show that 13,582 accidents occurred in 2012/13 alone. Of them, 1,816 were fatalities, 3,986 were serious injuries, and 8,000 were slight injuries. In addition, the dust pollution caused by earthen roads has been contributing significantly to irritation and diseases such as, eye diseases, respiratory diseases and skin infections. If transport networks could be well developed and safe, and could promote cycling, walking and the use of public transport, health could be promoted in three ways: providing healthy exercise, reducing fatal accidents and reducing air and dust pollution.

### 11.10 Key determinant: Food security

Food security, or adequate food supply with nutritious diet, is the key to good health and well-being. “When all people at all times have physical and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life” (FAO, 2011), they can live healthy lives. However, if people experience “a shortage of food and lack of variety as needed for subsistence livelihood” then, this causes malnourishment and immune deficiency diseases. In Nepal, the situation of food sufficiency through local production is gradually decreasing and 43 out of 75 districts have experienced food deficiency (NPC/UNCTN, 2013). Across the country, 3.33 million people, most of whom are from rural sectors, are estimated to be vulnerable to food shortages (MoAD/WFP, 2012; Bohle and Adhikari, 1998; Parajuli et al., 2012). Overall about 27% of rural households are food insecure with very poor food consumption patterns. Women and children are the most disadvantaged groups. For example, chronic malnutrition and low weights are common among children, where 49% of children aged 0-59 months are underweight and 46% are stunted (UNICEF, 2009; Dahal et al., 2009).

The top quintiles of economically well-off families in Nepal enjoy good housing and sanitation and have less issues of nutritious food supply. Knowingly or unknowingly, they have excess food intake. Evidence shows that excess food intake is also a problem by which people easily develop cardiovascular diseases, diabetes, obesity, dental issues, cancer and degenerative eye diseases (Wilkinson & Marmot, 2003). When food supply and diets improve with housing and sanitation as a result of economic growth, it causes an epidemiological transition from infectious to chronic diseases. Emergence of a new and shifting of disease burden in Nepal, as shown in Table 3, clearly indicates this scenario.

Although agriculture is a very important sector in Nepal, the performance of this sector has been inadequate to meet increasing food demands and low agricultural productivity has been a major cause of food insecurity. Therefore, food security is an important SDH in the country.

### 11.11 Key determinant: Early life and childhood development

Evidence shows that building good health conditions starts from the earliest developmental stage of the embryo (the zygote). During pregnancy, if mothers suffer from poor nutrition, stress, exposure to smoking, misuse of drugs and alcohol, insufficient exercise, prenatal care, and emotional support, the new-born children of such mothers will suffer from adult ill-health and immature death (Wilkinson & Marmot, 2003). Poor childhood development due to poor nutrition, exposure to smoking and other forms of pollution and poor sanitation as well as poor emotional support causes slow brain responses resulting in reduced readiness for school, low educational achievement, problematic behaviour and the risk of social marginalisation in adulthood (Ibid:14). Similarly, if an infant’s physical growth is slow or retarded due to the impact of adverse circumstances, it can lead to reduced development of cardiovascular and respiratory organs, pancreas, kidney and their functions, which increase the risk of developing diseases related to these organs in adulthood (Ibid:14).

In Nepal, widespread poverty combined with ignorance and insufficient knowledge related to the impact of early life and childhood development on adult life (as well as rooted gender discrimination in the name of socio-cultural norms) have been contributing to affect children's growth and development of diseases even among relatively educated masses. Similarly, a large prevalence of maternal smoking and children's exposure to second hand smoke (Dahal et al., 2009) and indoor air pollution (GoN, 2012) has been contributing to the development of diseases and premature deaths in early lives and beyond (Table 5).

### 11.12 Key determinant: Stress

As discussed earlier, various life conditions result in stress. For example, when the national government and its policies cannot support citizens enough to manage their minimum basic needs, and if the citizens have only limited means to survive, they face several challenges in life (even simply meeting household needs). Inability to meet basic family requirements such as sending children to school or looking after elderly parents makes them feel frustrated, insecure, shameful and worthless, often leading to them losing their hope and self-esteem. This unfavourable socio-economic and psychological condition can cause anxiety and social isolation which can result in a person being unpredictable, uncontrollable and irrational (Mikkonen & Raphael, 2010).

In many cases, stress and high level of exhaustion drives individuals to adopt unhealthy coping behaviours. They use to feel 'short term momentary relief' consuming excessive alcohol, and smoking tobacco and drugs (Mikkonen & Raphael, 2010). If these conditions continue, the individual will be the victim of depression. The WHO in 2014 revealed that depression is the predominant cause of illness and disability, which does not only affect the victim, but also all family members. Eventually, this leads to chronic illnesses and premature deaths (WHO, 2014; Marmot, 2003). Therefore, stress is an important social determinant of health, but has been neglected in Nepal not only in societal level but also in policy formulation.

### 11.13 Key determinant: Access to health services and health seeking behaviour

When people do not have favourable conditions related to all social determinants of health as outlined above, the outcome is to be a victim of various diseases or illnesses from multiple burdens. If the victim believes in and can afford the health care system they go to health facilities for treatment. In some settings, people still prefer to go to traditional healers rather than going to health facilities. "Who tend to prefer which service option" also depends on the knowledge about the nature of illness, exposure towards health facilities, affordability to access health care, level of health literacy and trust on health care services (Dahal et al., 2013).

In any case, good population health depends on the effective supply (delivery) and demand (health seeking behaviour) of health services. Effective health services do not only depend on the facilities of diagnosis and treatment of diseases, but also on the combined effect of the availability of funding, staff, equipment and drugs that allow the delivery of health interventions in a sustainable manner (WHO, 2014). Similarly preventive treatments and management of population health can only be effective when the users are sincere enough to seek care in a timely fashion, according to their needs. Improving access, universal coverage and quality of services depends on the key resources available, on the ways services are organised and managed and on incentives influencing providers and users (WHO, 2014).

The current situation of population health in Nepal, including structure, systems, governance and health financing, are well documented (MoHP, 2010; WHO, 2007; Tiwari et al., 2012; NPC/UNDP, 2010; NPC/UNCTN, 2013). The overall message of various research reports is that Government in Nepal has achieved significant progress in strengthening health care systems over time, although the magnitude of achievement is relatively small compared to the potential end goals. To address the current policy challenges, Shrestha and Pathak (2012) stated 24 specific recommendations under four main themes to: increase access to and use of health services, improve the provision not only of essential health care services (but also of noncommunicable diseases), strengthen and expand health facilities and improve the quality of health services.

In addition, the real challenge is to scale up services that are working and to continually improve effectiveness and accelerate progress, and to strengthen the value of universalism in health services. There is also a need to better target the hardest-to-reach segment of the population who have been overlooked in the past. This group includes the ultra-poor and those disadvantaged because of their sex, age, ethnicity, disability, or geographical location. (NPC/UNCTN, 2013). Similarly, people in rural areas still rely on traditional healers for the first attempts at treatment and they seek care from health facilities only when this becomes unsuccessful (Poudyal et al., 2003). The irony again is that most of the health facilities in the rural areas are under-resourced and run without trained health staff. Therefore, the level of access to health services combined with health service seeking behaviour of people is an important social determinant of health.

## 12. Conclusion

This paper discusses in detail how SDH play a significant role in shaping population health outcomes. The synthesis of facts as presented in this article highlights that the origin of people's entire burden of diseases, disabilities and premature deaths rely on their social structure operating through the socio-psychological, material and behavioural pathways which influence the living conditions into which people are born, grow, live, work and age. However, these well documented facts on social determinants of health have not yet been well recognised in the national health policies and programs. Greater awareness of such information means local people themselves can become active in managing many of the problems they face. For instance, school teachers can play a significant role by educating their students about SDH, and, over time, that could help to improve households and communities through the information relayed by these students. Embracing social determinants of health in Nepal's health policies and programs, and raising public awareness about them, is therefore crucial.

The primary step to succeed in achieving this goal is to help improve the living conditions of Nepalese through the implementations of appropriate evidence-based population health policies and programs. As population health and related policies are linked with a range of social determinants of health explained in this article, efforts of a Government Ministry (e.g. Ministry of Health and Population) alone cannot be sufficient to effectively address the root-causes of entire population health issues in Nepal. As elsewhere, this circumstance calls for effective collaborations between relevant Ministries, international, bilateral and other local partners. Similarly, collective actions of all partners including district authorities and local community groups is essential to effectively address the social determinants of health in order to reduce the current health equity gaps existing in Nepal.

It is hoped that this article will be useful for policy innovation and an important resource for health institutions in Nepal moving forward for developing curriculum on social determinants of health.

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## References

Acevedo-Garcia, D., Osypuk, T. L., Werbel, R. E. et al. (2004). Does housing mobility policy improve health? *Housing Policy Debate, 15(1), pp*. 49-98.

Adhikari, K. P. & Goldey, P. A. (2010). Social capital and its 'downside': the impact on sustainability of induced community based organizations in Nepal in formal and informal institutions and development. *World Development,* 38(2), pp. 184-194.

Anderson, L. M., Shinn, C., St Charles, J., Fullilove, M. T., Scrimshaw, S. C., Fielding, J. E., Normand, J. et al. (2002). Community interventions to promote healthy social environments: early childhood development and family housing, *MMWR: Morbidity and Mortality Weekly Report 2002,* 51(4), pp. 1-8.

Anderson, L. M., St Charles, J., Fullilove, M. T., Scrimshaw, S. C., Fielding, J. E., and Normand, J. (2003). Providing affordable family housing and reducing residential segregation by income: A systematic review, *American Journal of Preventive Medicine, 24*(3), pp. 47-67.

Anon. (September 25, 2013). *Revealed: Qatar's World Cup 'slaves'. The Guardian, UK Edition*. [online] Available at: *http://www.theguardian.com/world/2013/sep/25/revealed-qatars-world-cup-slaves*

AHRQ (2011). *Health Literacy Interventions and Outcomes: an Update of the Literacy and Health Outcomes Systematic Review of Literature.* Rockville, Maryland: Agency for Health Care Research and Quality. [online]. Available at *http://effectivehealthcare.ahrq.gov/ehc/products/151/392/ Health%20Literacy%20Protocol%20(2-9-2010).pdf*

Bennett, L., Dahal, D. R., & Govindasamy, P. (2008). Caste, ethnic and regional identity in Nepal: Further analysis in 2006. *Nepal Demographic and Health Survey.* Calverton, Maryland: Macro International Inc, pp. 1-36.

Basnet, S. R. & Adhikari, K. P. (2007). Do development interventions empower rural women? Women empowerment through income generating programmes in Nepal. *Journal of Global Management Research*, pp. 9-17.

Bohle, H. & Adhikari J. (1998). Rural livelihoods at risk: how Nepalese farmers cope with food insecurity. *Mountain Research and Development, 18*(4), pp. 321-332.

Braveman, P. & Gruskin, S. (2003). Defining equity in health. *Journal of Epidemiology and Community Health, 57*, pp. 254–258.

Bryant, T, Raphael D, Schrecker T, & Labonte R. (2011). Canada: a land of missed opportunity for addressing the social determinants of health. *Health Policy, 101*(1), pp. 44-58.

Coaleman, J. S. (1993). The rational reconstruction of society. *American Sociological Review, 58* (1), pp. 1-15.

Cornia, G. A. (2001). Globalization and health: results and options. *Bulletin of the World Health Organization, 79(9)*, pp. 834–841.

Dahal G. P, Qayyum A, Ferreyra M., Kassim, H. & Pottie K. (2013). Immigrant community leaders identify four dimensions of trust for culturally appropriate diabetes education and care. *Journal of Immigrant and Minor Health, 16, pp. 978-984.*

Dahal, G. P., Me, A. & Bisogno, E. (2007). *Challenges in measuring gender and minorities*. Rome: Global Forum on Gender Statistics, United Nations Economic Commission for Europe, pp. 1-13.

Dahal G. P., Johnson F. & Padmadas S. S. (2009). Maternal smoking and acute respiratory infection symptoms among children in Nepal: A Multilevel analysis. *Journal of Biosocial Science, 41(6)*, pp.747-761.

Dahal G.P., Padmadas, S.S. & Hinde, P.R.A. (2008). Fertility limiting behaviour and contraceptive choice among men in Nepal. *International Family Planning Perspectives, 34(1)*, pp. 6-14.

Dahal G. P. (2008). *Sexual and Contraceptive Behaviour Among Men in Nepal: The Need for Male-Friendly Reproductive Health Policies and Services*. New York: Edwin Mellen Press.

Dahal G. P. (2000). Population and environment issues in Nepal and the need for the community development policy. *Contribution to Nepalese Studies, 27(1)*, pp.23-50.

Dahal G. P. (1999). The impact of maternal education on child's health. *Nepal Population Journal, 8(7)*, pp. 119-126.

Dahlgren, G. and Whitehead M. (1992). *Policies and strategies to promote social equity and health.* Copenhagen: World Health Organization.

FAO (2004). *Food-Based dietary guidelines.* Rome: Food and Agriculture Organization [Online]. Available at: *http://www.fao.org/nutrition/education/food-dietary-guidelines/regions/countries/nepal/en/*

Gostin, L. O., Bayer, R. & Fairchild, A. L. (2003). Ethical and legal challenges posed by Severe Acute Respiratory Syndrome: implications for the control of severe infectious disease threats. *Journal of the American Medical Association,290*, pp. 3229-3237.

GoN (2012). *National population and housing census 2011: National report*. Kathmandu: National Planning Commission Secretariat, Central Bureau of Statistics, Government of Nepal. [online]. Available at: *http://unstats.un.org/unsd/demographic/sources/census/2010_phc/ Nepal/Nepal-Census- 2011-Vol1.pdf.*

GoN, MOHP (2010). *Nepal Health Sector Programme-II 2010-2015.* Kathmandu: Government of Nepal Ministry of Health and Population.

GoN/NPC/UNDP (2010). *Millennium Development Goals needs assessment for Nepal 2010*. Kathmandu: Government of Nepal, National Planning Commission and United Nations Development Programme.

Gupta S., de Belder A, O'Hughes L. (1995). Avoiding premature coronary deaths in Asians in Britain: spend now on prevention or pay later for treatment. *British Medical Journal, 311*, pp. 1035–1036.

Gwatkin, D. R. (2002). R*educing health inequalities in developing countries*. Oxford Textbook of Public Health, Fourth Edition.

Harvard School of Public Health (2011), *About health care policy*. Boston: Department of Health Policy and Management.

Healthabitat Pvt Ltd. (2013). *Housing for health, the guide.* [online]. Available at: *http://www.housingforhealth.com/*

Higgins, C, Lavin, T. & Metcalf, O. (2008). *Health impacts of education: A review.* Ireland: Institute of Public Health. [online]. Available at: *http://www.publichealth.ie/files/file/Health%20Impacts%20of%20Education.pdf.*

*Horton, R. (2012). 'GBD 2010: Understanding disease, injury, and risk', The Lancet, 380 (9859), pp. 2053-2054.*

IHME (2013). *The Global burden of disease: Generating evidence, guiding policy: South Asia regional edition.* Seattle, WA: Institute for Health Metrics and Evaluation, Human Development Network, The World Bank.

ILO (2013). *Global Employment trends for youth 2013: A Generation at risk*. Geneva: International Labour Office.

IoM (2000). *Clearing the air: Asthma and indoor air exposures.* Washington DC: Institute of Medicine, National Academy Press.

Keon, W. J. & Pepin, L. (2009). *A Healthy productive Canada: A determinant of health approach, the standing Senate Committee on Social Affairs*. Canada: Science and Technology, Final Report of the Subcommittee on Population Health.

Krieger, J. & Higgins, D. L. (2002). Housing and health: Time again for public health action. *American Journal of Public Health, 92(5)*, pp. 758-768.

Lanphear, B. P., Kahn, R S., Berger, O., Auinger P, Bortnick S. M., Nahhas R. W. (2001). Contribution of residential exposures to asthma in US children and adolescents. *Pediatrics6-1, 107(6),* pp. 98.

Mackenbach, J. (2005). *Health inequities: Europe in profile.* Brussels: UK Presidency of the EU.

Men, C. R., Frieson K., Socheat, C., Nirmita, H. & Mony, C. (2011). Gender as a social determinant of health. In: *Presentation inGender analysis of the health sector in Cambodia. Reo De Jeneiro Brazil: World Conference on Social Determinants of Health, 19-21 October.*

Marmot, M. & Wilkinson, R. (1999). *Social Determinants of Health.* New York: Oxford UP.

Marmot, M. (2005). Social determinants of health inequalities. *The Lancet: 365(9464)*, pp. 1099 -1104.

Mikkonen, J., and Raphael, D. (2010). *Social determinants of health: The Canadian facts.* Toronto: York University School of Health Policy and Management.

Ministry of Health and Population (MOHP) [Nepal], New ERA, and ICF International Inc. (2012). *Nepal Demographic and health survey 2011*. Kathmandu: Ministry of Health and Population, New ERA, and Calverton: ICF International.

MoAD/WFP (2012). *Nepal Food Security Bulletin. Issue 34.* Kathmandu: Ministry of Agriculture and Development and World Food Program.

Nelson, K. B. & Leviton A. (1991). How much of neonatal encephalopathy is due to birth asphyxia? *The American Journal of Disease of Children, 145(11)*, pp. 1325-1331.

NIH (2014). *Low Back Pain.* Maryland: National Institutes of Health, U. S. Department of Health and Human Services. [NIH Publication No. 15-5161].

Nobelius, A. M. (2004). *What is the difference between sex and gender?* Victoria, Australia: Medicine, Nursing and Health Sciences, Monash University. [online]. Available at: *http://www.med.monash.edu.au/gendermed/sexandgender.html*.

NPC/UNCTN. (2013). *Nepal Millennium Development Goals progress report 2013*. Kathmandu: Government of Nepal, National Planning Commission / United Nations Country Team of Nepal.

Parajuli R.P., Fujiwara T, Umezaki M, Furusawa H, Watanabe C, (2014a). Home environment and prenatal exposure to lead, arsenic and zinc on the neurodevelopment of six-month-old infants living in Chitwan Valley, Nepal. *Neurotoxicol and Teratol,* pp. 89-95. doi: 10.1016/j.ntt.2013.12.006.

Parajuli RP, Fujiwara T, Umezaki M, Konishi S, Takane E, Maharjan M, et al. (2014b). Prevalence and risk factors of soil-transmitted helminth infection in Nepal. *Transactions of the Royal Society of Tropical Mediciene & Hygiene.,108(4)*, pp.228-236. doi: 10.1093/trstmh/tru013.

Parajuli R. P., 'Umezaki M. and Watanabe C. (2012). Diet among people in Terai region of Nepal, an area of micronutrient deficiency. *Journal of Biosocial Sciences, 44(4)*, pp. 401-415. doi: 10.1017/S0021932012000065.

Poudyal, A. K., Jimba, M., Murakami, I., Silwal RC, Wakai S. & Kuratsuji T. (2003). A traditional healers' traditional model in rural Nepal: strengthening their roles in community health. T*ropical Medicine and International Health, 8(10)*, pp. 956-960.

Puri, M, Horstman, R., Matthews, Z., Falkingham, J., Padmadas, S. & Devkota, S. (2008). Examining out-of-pocket expenditures on reproductive and sexual health among the Urban Population of Nepal. *Population Review,* 47(2), pp. 50-66: 10.1353/prv.0.0006

Putnam, R. (1993). The prosperous community-social capital and public life. *American Prospect(13)*, pp. 35-42.

Schrecker, T. and Taler, V. (2013). *How to think about social determinants of health: Revitalizing the agenda in Canada*. Working Paper, 4(6), July 2013.

Sheldon T. A. and Parker H. (1992). Race and ethnicity in health research. *Journal of Public Health, 14,* pp. 104–110.

Shrestha, I. B. and Pathak, L. R. (2012). *Review of National Health Policy 1991*. Kathmandu: NHSSP, Ministry of Health and Population [Nepal].

Rogers R. (1992). Living and dying in the USA: socio-demographic determinants of death among blacks and whites. *Demography, 29,* pp. 287–303.

Rosenstreich, D. L., Eggleston, P., Kattan, M., Baker D., Slavin R. G. & Gergen, P. (1997). The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma, *The New England Journal of Medicine, 5-8 336(19)*, pp. 1356-1363.

Stewart J. A., Dundas R., Howard R. A. et al. (1999). Ethnic differences in incidence of stroke: prospective study with stroke register. *British Medical Journal, 318*, pp. 967–971.

Tarlov, A. R. (1999). Public policy frameworks for improving population health. *Annals of the New York Academy of Sciences, 896*, pp. 281-293.

The National Academy of Sciences (2002). Dietary risk assessment in the WIC program. Washington DC: *Institute of Medicine.*

Thapa, A. J. (2013). *Status Paper on Road Safety in Nepal.* Europe-Asia Road Safety Forum and the 67th Session of the Working Party 1 (WP 1) of UNECE New Delhi, 4 to 6 December 2013.

Tiwari S., Lekhak S. C., Adhikari R., Paudel, L. R., Thapa, M. B. & Lieuens, T. (2012). *Budget Analysis 2011/12.* Kathmandu: NHSSP, Ministry of Health and Population.

USDA/HHS (2000). *Healthy People 2010.* Washington DC: U.S. Government, Printing Office, Second edition.

United Nations (2002). *Report of the world summit on sustainable development. Johannesburg, South Africa, August 26 - September 4*. New York: UN Department of Publications.

United Nations (1995). *The Copenhagen Declaration and Program of Action: World summit for social development 6-12 March.* New York: UN Department of Publications.

UNDP (2013). *Human Development Report 2013. The rise of the south: Human progress in diverse World.* New York: United Nations Development Program.

UNICEF (2009). *Tracking Progress on Child and Maternal Nutrition: A survival and development priority.* New York: UNICEF.

Upadhaya, B. (2014). *Radio-interview with Bhim Upadhya Director General of Department of Local Infrastructure Development and Agricultural Roads about the programs and progress.* Kathmandu: March 22, 2014.

Wade, R. H. (2004). Is globalization reducing poverty and inequality? *World Development, 32(4)*, pp. 567-589.

FAO, 2011. *World Livestock 2011, Livestock in Food Security.* Rome: Food and Agriculture Organization, United Nations.

WHO (2013, April). *Diarrhoeal disease*. [online]. Available at: *http://www.who.int/mediacentre/ factsheets/fs330/en/*

WHO (1946, June 19-22). *The constitution of the World Health Organization*. International Health Conference, New York: World Health Organization.

WHO/HWC and CPHA, (1986). *Ottawa charter for health promotion*. Ottawa: World Health Organization/ Health and Welfare Canada and Canadian Public Health Association.

WHO (2008). *Closing the gap in a generation: Health equity through action on the social determinants of health.* Geneva: WHO Commission on Social Determinants, World Health Organization.

WHO (2007). *Health system in Nepal: Challenges and strategic options*. Kathmandu: World Health Organization, Country Office Nepal.

WHO (2011, October 19-21). *Rio political declaration on social determinants of health.* Rio De Janeiro: World Conference on Social Determinants of Health, World Health Organization.

WHO (2011a). *Social determinants of health sartorial briefing Series 2, Education: shared interests in well-being and development.* Geneva: World Health Organization.

WHO (2013). *World Health Statistics 2013.* Geneva: World Health Organization.

WHO (2013a). *The NCD Alliance: Putting non-communicable disease the global agenda.* Geneva: World Health Organization.

WHO (2013b). *World Health Organization Country Office for Nepal Report: WHO Country Cooperation Strategy Nepal 2013–2017*. [online]. Available at: *http://www.who.int/countryfocus/cooperation_strategy/ccs_npl_en.pdf?ua=1.*

WHO (2010). *Gender, women and primary health care renewal. Geneva: World Health Organization.*

WHO (2010a). Action on the social determinants of health: Learning from previous experiences, social determinants of health. *Discussion Paper 1*. Geneva: World Health Organization.

WHO (1986). *The Ottawa Charter for Health Promotion*. Geneva: World Health Organization.

Wilkinson R & Marmot M. (2003). *Social determinants of health: the solid facts*. Copenhagen: World Health Organization, European Office.

Wilkinson R. (2005). Drug metabolism and variability among patients in drug response. *New England Journal of Medicine, 26, 352(21)*, pp. 2211-2221.

World Bank (1997). *Expanding the measure of wealth, indicators of environmentally sustainable development.* Washington, DC: Environment Department.

Yazbeck, A. S. (2009). *Attacking inequality in the health sector: A synthesis of evidence and tools.* Washington, DC: The World Bank.

15

# Mobile Health and Health Risk Communication Strategies to Improve Noncommunicable Disease Risk Factor Awareness in Nepal

Michael G. Tyshenko

## Abstract
Nepal, like many other low-income countries, is facing an increasing burden of disease and deaths from Noncommunicable Diseases (NCDs). The main NCDs causing some of the highest mortality in Nepal are cardiovascular diseases (CVD), cancers, chronic obstructive pulmonary disorder (COPD) and chronic respiratory diseases and diabetes. When compared, these NCDs share some common modifiable risk factors of tobacco use, physical inactivity, alcohol use, unhealthy diet, and obesity. To address the common risk factors sustainably, one of the first actions Nepal can implement is to raise awareness of NCD risk factors. Achieving this goal is a daunting task as Nepal has a large proportion of its population living in rural and remote areas with limited access to health care services. As a way forward to addressing NCD risk factors, a scalable communication strategy combined with mobile health (mHealth) technologies can help to deliver innovative low-cost solutions. Many of these mHealth strategies can augment the World Health Organization's 'best buy' health care initiatives. Mobile health holds much promise to improve health care by tackling the emerging burden of NCDs in Nepal.

## 1. Introduction
Nepal is a small, landlocked country located in South Asia with a population of approximately 28.8 million people (World Population Clock, 2015). Nepal is bordered by China and India, two of the most populated countries in the world. Nepal has only a few major cities, with 82.8% of the population still living in rural areas (GoN-NPCS-CBS/UNICEF, 2015). The country is divided into 5 development regions, 14 zones and 75 districts. Many parts of Nepal are still largely inaccessible by modern transport. Despite its biodiversity, natural resources, cultural diversity and rapid urbanisation, Nepal still remains a developing country.

Nepal is similar to many other countries designated as least-developed and is burdened with communicable diseases such as HIV, malaria, measles and tuberculosis. These and other infectious diseases cause a significant amount of mortality. However, the occurrence of Noncommunicable Diseases (NCDs) is increasingly recognised as causing the highest levels of mortality in Nepal (IHME, 2013). NCDs are disease processes that are neither contagious nor transferable from one human to another. Random genetic abnormalities, heredity, lifestyle or environment can cause NCDs (Gautam, 2010).

The World Health Organization Global status report estimated that NCDs are the leading cause of mortality in the world causing over 60% of all deaths. More troubling is that data demonstrate the burden is disproportionately distributed with nearly 80% of all NCD deaths occurring in low- and middle-income countries (Alwan et al., 2010). The World Bank highlighted Nepal's situation stating that NCDs are its next major health challenge due to the effects of rapid urbanisation, widespread changes in dietary patterns, behavioural risk factors and improved maternal-child health helping to raise life expectancy. It is estimated that Nepal is experiencing an epidemiological transition with infectious diseases now being outpaced by NCDs (IHME, 2013); the latter being responsible for more than 44% of deaths and 80% of all outpatient contacts occurring in hospitals (Neupane & Kallestrup, 2013).

A cross-sectional hospital-based research study was conducted to determine the prevalence of four major NCDs. The research found chronic obstructive pulmonary disease (COPD) at 43%, cardiovascular disease (CVD) at 40%, diabetes mellitus (DM) at 12% and cancers at 5%. They estimated that the hospital-based prevalence of all NCDs was 31% (Bhandari et al., 2014). A larger population health study in Nepal showed 36.5% of admitted patients suffered from NCDs, of which 38% presented with CVD followed by COPD (33%) and diabetes and cancers (29%) (Nepal Health Research Council, 2010). In a nation-wide urban population health study the prevalence of diabetes in Nepal was estimated at 14.6% for people aged 20 years and above, and at 19% among those aged 40 years or older (Shrestha et al., 2006). The WHO Global Health Observatory Data (2011) highlighted the prevalence of CVD in Nepal. The WHO data suggests that CVD, along with cancer, COPD and diabetes are responsible for the majority of NCD deaths (World Health Organization, 2015a). The studies point to the same conclusion that there is an enormous burden of disease occurring in Nepal from NCDs. The problem of NCDs in Nepal is a huge challenge that may undermine the efforts of the government and stakeholders working tirelessly to achieve the Millennium Development Goals, universal primary health care improvements and actions to improve upon Nepal's least developed country status (Government of Nepal, 2014).

With limited resources Nepal must implement low-cost, scalable and cost effective health care initiatives. Electronic Health (eHealth) programmes used in other countries can provide real world examples that could be adapted to suit the needs of Nepal. eHealth is a general term that includes four distinct but related components of: mobile Health (mHealth), health information systems, Telemedicine, and distance learning. eHealth components rely heavily on the use of electronic devices by medical professionals and the public. These devices can include: desktop computers, laptops, netbooks, notebooks, personal digital assistants (PDAs), mobile cell phones and patient monitors. eHealth uses information technology and communications within a health care setting (Clarke, 2010).

For improving health risk communication recommendations for Nepal will focus on the public's use of mobile Health and Telemedicine. The first component of mHealth is defined as "the delivery of health care services via mobile communication devices". The field broadly encompasses the use of mobile telecommunication and multimedia technologies in health care delivery (Torgan, 2009). Mobile technologies include a broad array of devices but for mHealth services under discussion, it would apply primarily to mobile phones, smart phones (e.g., iPhones) and tablet PCs (e.g., iPads and Smartbooks). These devices have a range of functions from mobile cellular communication using text messages (SMS), audio, photography and video (MMS), telephone, and internet access (World Wide Web) (Free et al., 2013). Mobile Health lets individuals connect and use a variety of health care resources to overcome geographic and accessibility barriers. The second component, Telemedicine, is defined as the use of telecommunications technology to provide, enhance, or expedite health care services through accessing offsite databases, linking clinics or physicians' offices to central hospitals, or transmitting x-rays or other diagnostic images for examination at another site. Telemedicine lets clinicians connect with other clinicians to overcome geographic barriers for consultations.

The purpose of this chapter is to review the main NCD risk factors affecting Nepal and identify potential mHealth and Telemedicine technologies that could be implemented by the government of Nepal and stakeholders.

## 2. Methodology

The literature review used a standard keyword search approach identifying relevant peer review articles using PubMed, Ovid and Scopus databases. Topic areas and keywords included: 'Noncommunicable Disease', 'burden of disease', 'sustainable development', 'risk factors', 'Nepal', 'low-income countries', 'mobile Health', 'electronic Health', 'Telemedicine', 'health care', and 'health risk communication'. Internet webpage sources were used to gather information germane to the topic area from Google search engine (http://www.google.com). Grey literature from government and non-governmental organisation (NGO) websites was obtained from Google and Google Scholar (http://scholar.google.com) search engines.

## 3. The NCDs in Nepal causing significant burden of disease and death

The World Bank (2011) reports that the major NCDs in Nepal are cardiovascular diseases (CVD), cancers, COPD and chronic respiratory diseases, and diabetes. The percentage of deaths due to NCDs in Nepal was estimated at 49.7% for men and 50.7% for women. Collectively NCDs resulted in approximately 900,000 deaths or the equivalent of 705.5 deaths per 100,000 people (as reported for the year 2008) (World Health Organization, 2010). These NCDs share common risk factors which can be addressed collectively with a mobile health and health risk communication approach. Details of the top NCDs and their risk factors are summarised herein:

**1) Cancer:** This disease describes a large group of almost 100 diseases. It possesses two main properties of uncontrolled cell growth and the ability of these cells to migrate from the original site and spread to distant sites (metastasise). If the spread is not controlled, cancer can result in death. Cancer is a NCD that affects all ages. Approximately 27.0% (95% CI: 23.7-30.4%) of men and 10.3% (95% CI: 8.7-11.9) of women aged 16-69 reported smoking tobacco in Nepal (Aryal et al., 2014). As a result, the most common reported cancer among men is lung cancer, it is and the third most common cancer among women (Hashibe et al., 2010). The main cancers identified occurring in hospital cases in Nepal were lung, stomach and ovarian cancer that accounted for 38% of all reported cancers (Bhandari et al., 2014).

**2) Diabetes:** This condition affects the way the body uses blood glucose. The dysfunction of type 2 diabetes is a result of cells that resist the action of insulin and cause an increase of glucose in the blood (Livestrong, 2014). One study among the elderly population over 60 years of age in the Kathmandu Valley of Nepal by Chhetri and Chapman (2009) found an overall diabetes prevalence of 25.9% (with one-third diagnosed with diabetes uncovered during the research study). The high prevalence of diabetes in the elderly population and the numbers of elderly undiagnosed prior to the study show diabetes is an important and overlooked NCD problem in Nepal (Chhetri & Chapman, 2009). The results are consistent with a second study carried out in urban Kathmandu showing similar results with a high prevalence of diabetes (19%) occurring in the over 40 years of age group (Shrestha et al., 2006). Overall, the per capita diabetes prevalence in Nepal for both sexes is lower than in developed countries but remain comparable to other South Asian countries.

**3) Cardiovascular disease (CVD):** A broad category of NCD that affects the way the heart and circulatory system performs. Heart disease includes rhythm irregularities, heart attack, congenital heart disease, heart failure, mitral valve prolapse, unstable angina, mitral stenosis, endocarditis, aortic regurgitation and cardiogenic shock (Livestrong, 2014). The majority of CVD-related cases reported in Nepal during a hospital cross-sectional study were hypertension (47%) followed by cerebrovascular accident (16%), congestive cardiac failure (11%), ischemic heart disease (7%), rheumatic heart disease (5%) and myocardial infarction (2%) (Bhandari et al., 2014).

**4) Chronic obstructive pulmonary disease (COPD):** A lung disease characterised by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible. In Nepal, COPD was a major disease found almost equally among males (42%) and females (45%) but it was found more predominantly in older age groups (Bhandari et al., 2014). Smoking is the number one cause of COPD and other respiratory diseases affecting the respiratory tract making it the primary cause of premature deaths and disabilities (Gostin et al., 2003). The second leading risk factor for respiratory diseases is household air pollution, which contributes to the development of acute respiratory infections among children, COPD, and cancer in adults. The majority of the population living in rural areas (86%) rely on traditional indoor stoves using dung, coal, firewood, agricultural residues or liquefied petroleum as fuels for cooking and heating (Government of Nepal, 2012). The use of traditional indoor stoves leads to excessive exposure levels of particulates (PM10, PM2.5) and carbon monoxide (World Health Organization, 2014). Outdoor air pollution (mainly particulates) is another contributing cause exasperating the problems of COPD and respiratory problems (World Health Organization, 2014).

## 4. Modifiable NCD risk factors in Nepal

The trend globally and in Nepal shows that the majority of NCDs are caused primarily by four behavioural risk factors (tobacco use, unhealthy diet, lack of physical activity, and alcohol abuse) that are pervasive aspects of economic transition, rapid urbanisation and modern lifestyles (Alwan et al., 2010). A brief review of the main modifiable risk factors for NCDs is provided along with current stakeholder policy and programme response that has been implemented in Nepal.

### 4.1 Tobacco use (Risk factor for CVDs, COPD and Cancer)

The leading cause of cancer deaths is from lung cancer, which accounts for almost one in five cancer deaths worldwide. Tobacco use also causes a number of other types of cancer including cancers of the throat, mouth, bladder, kidney, stomach and cervix. Smoking increases the risk of heart disease and stroke by two to four times. Similarly, smokeless tobacco causes oral and other cancers, hypertension and heart disease. Smoking causes chronic lung diseases that can be severely disabling or fatal, increasing the risk of death 12 times. Smoking is an independent risk factor for diabetes (Thakur et al., 2011). The burden of disease impedes economic and social development in low-income South Asian countries as the purchase of tobacco can divert up to 40% of the total household income at the cost of their basic needs exasperating existing poverty (World Health Organization, 2011a).

In Nepal's nationwide Demographic Health Survey in 2011 it was reported that 51% of men and 13% of women smoked. According to Nepal Cancer Relief Society around 16,000 people die each year in Nepal from tobacco related diseases with 90% of these deaths from lung cancer (Nepal Cancer Relief Society, 2013). Besides tobacco use, indoor air pollution is a contributor to cancer, COPD and CVD in Nepal. The majority of the rural population relies on solid fuels (coal, wood, animal dung, crop wastes) and traditional stoves for cooking and heating needs which leads to high levels of indoor air pollution that increase risk of childhood pneumonia, chronic lung disease and lung cancer. Indoor air pollution from cooking stoves represents a major risk factor in chronic lung disease particularly in non-smoking women (World Health Organization, 2011a; IARC Monographs, 2006).

#### *4.1.1 Stakeholder policy and programme response for tobacco use*

Multiple tobacco control efforts were implemented in Nepal and it is hoped collectively the actions will yield positive results in the future. The Ministry of Finance has set a tax on tobacco products since 1992. Tax levies are one of the most important policies to reduce the use and demand of tobacco (Nepal Cancer Relief Society, 2013). There is a partial ban on tobacco advertising (applicable to electronic media only). Smoking was banned in major public places as of August, 2011. Anti-tobacco programmes are implemented by a tobacco control group within the Ministry of Health and Population (MOHP) and the National Health Education Information and Communication Center (NHEICC). The Ministry of Education also includes elements on the negative effects of tobacco use in the school curriculum. The Nepal Health Research Council recently conducted a training programme in alcohol and tobacco control (World Bank, 2011).

The sale of duty-free tobacco products makes cheaper tobacco products more readily available for consumption. This defeats the health purpose of taxation, creates tax avoidance opportunities and harms public health by encouraging personal consumption. Duty free tobacco product sales were banned since 2008 in Nepal (World Health Organization, 2015b). The Nepal Cancer Relief Society (NCRS) is a non-profit community-based nationwide organisation that has been operating in Nepal for the last 16 years with the goal of reducing the rates of cancer by specifically targeting smoking and tobacco use. NCRS is a pioneer organisation for tobacco control in Nepal. NCRS played a significant role towards WHO Framework Convention on Tobacco Control (FCTC) ratification (World Health Organization, 2003a), and lobbying government to promulgate the Tobacco Products Control and Regulatory Bill 2010 which is now an enforceable Act. NCRS carries out various tobacco control programmes in schools, colleges, youth clubs and in local communities to reduce tobacco usage (Nepal Cancer Relief Society, 2013). Screening camps for the detection of breast and cervical cancer were held in three districts in Nepal (World Bank, 2011) and two cancer registries have been established in Nepal.

### 4.2 Alcohol consumption (Risk factor for Cancer)

The prevalence of alcohol use is reported to be high in Nepal. It is more common among men (39%) but it is common among women too (30%) (World Bank, 2011). Alcohol usage is influenced by caste in Nepal. Matwalis (Rai, Limbu, Gurung, Tamang, Magar and Newar) use alcohol from home-brewing and often trade alcohol. In most households it is routinely used even during breakfast. Tagadhari (Brahmins, Kshetriyas and Thakuris) do not permit alcohol use. Some lower castes belonging to the non-Matwali Tagadhari community (Biswokarma, Damai and Sarki) do not encourage alcohol consumption. Research by Jhingan et al. (2003) established some baseline data for alcohol use in eastern Nepal. Within the study group 25.8% were found to suffer from alcohol dependence. The prevalence of alcohol dependence increased with age peaking at 45–54 years and was more than twice as common in men as in women. Alcohol dependence was more common among those with lower levels of education, widowers, divorcees and those belonging to the Matwali community.

#### *4.2.1 Stakeholder policy and programme response for alcohol consumption*

Shakya (2013) describes the problem of alcohol use and abuse among Matwali communities in Nepal as ‘remarkably high’. A lack of baseline survey data makes it difficult to understand the scope of the problem and to plan for appropriate risk management responses. The government has imposed a levy on alcohol and banned electronic advertisement of alcohol. However, no programmes have been implemented to limit alcohol production, distribution or consumption. With rapid urbanisation alcoholic beverages are increasingly prevalent in stores and shops allowing for easier access. There are few NGOs in eastern Nepal working to address alcohol substance abuse issues. Existing rehabilitation management efforts are mainly directed towards opioid abusers with little emphasis on prevention of alcohol abuse problem (Shakya, 2013).

Recently, due to increased awareness of this problem the Nepal Health Research Council, which is an apex body of the Ministry of Health and Population, conducted a training programme in alcohol control (World Bank, 2011).

## 4.3 Physical inactivity (Risk factor for CVD, Cancer and Diabetes)

There is strong evidence to show that physical inactivity shortens life expectancy and increases the risk of NCDs such as coronary heart disease, type 2 diabetes, and some cancers (breast and colon cancers) (Lee et al., 2012). The WHO STEPS survey (2013) reported that 3.5% of the Nepalese population are physically inactive expending less than 600 Metabolic Equivalent of Task (MET)- minutes per week. The MET or metabolic equivalent is a physiological measure expressing the energy cost of physical activities (Aryal et al., 2013).

Lee et al. (2012) calculated the population attributable fraction (PAF) caused by physical inactivity for Nepal. PAF is a measure used to estimate the effect of a risk factor on disease incidence in a population and the proportion of new cases that would not occur if the risk factor was not present. For physical inactivity they found it contributed 2.6% to coronary heart disease (Adjusted relative risk CI: −0.3 to 6.2), 3.2% to type 2 diabetes (Adjusted relative risk CI: −0.4 to 7.4), 4.4% to breast cancer (Adjusted relative risk CI: −1.0 to 10.1), and 4.6% to colon cancer (Adjusted relative risk CI: −0.8 to 10.2). A decrease in or removal of this risk factor could improve health considerably.

Cardiovascular health which is influenced by physical activity has poor literacy and linkage among individuals in Nepal. Data from the Jhaukhel-Duwakot health demographic surveillance site (JD-HDSS) in two urbanising villages located near the capital city of Kathmandu showed that 44% of the population lacks sufficient understanding of the causes of heart disease and its prevention. There exists a gap between knowledge and practice regarding cardiovascular health (Vaidya et al., 2013; Oli et al., 2014).

### *4.3.1 Stakeholder policy and programme response for physical inactivity*

Implementation of the WHO Global Strategy on Diet, Physical Activity and Health has started in Nepal (World Bank, 2011). The WHO Global Strategy recommends that individuals should engage in adequate levels of physical activity throughout their lives (World Health Organization, 2003b; 2004). Different types and amounts of physical activity are required for different health outcomes: at least 30 minutes of regular, moderate-intensity physical activity on most days reduces the risk of cardiovascular disease and diabetes, colon cancer and breast cancer. Muscle strengthening and balance training can reduce falls and increase functional status among older adults. More activity may be required for weight control. The WHO report considers a number of factors regarding physical activity such as working, home life, school life, increasing urbanisation, and various aspects of urban planning. Recommendations for physical activity are linked with dietary habits and lifestyles often rooted in local and regional traditions. As a result, national strategies should therefore be culturally appropriate and able to challenge cultural influences to respond to changes over time (such as ongoing urbanisation and increased fast food consumption occurring in Nepal).

### 4.4 Unhealthy diet - obesity (Low fruit and vegetable consumption) (Risk factor for CVD, Cancer Diabetes)

Nepal faces dual problems with malnutrition and obesity both diametrically opposed aspects resulting from unhealthy diet. For the purpose of this chapter 'unhealthy diet' as a risk factor refers primarily to overweight and obesity. The problem with obesity was described by Vaidya et al. (2010) who emphasised that contrary to popular belief, obesity has become common in many low- and middle income countries mirroring the trend already established in developed countries with obesity occurring in young children and adolescents. A 2010 meta-study on obesity in Nepal concluded that, "urbanisation is the major driving force behind obesity in Nepal." A study of 14,425 subjects in Nepal found that 32% were obese, 28% were overweight, 6.3% were diabetic and 34% had hypertension. Prevalence was higher in the less educated, those working at home and women (Sharma et al., 2011).

The trend toward urbanisation has resulted in a change in traditional diets from a previously fibre and complex carbohydrate rich diet to one that contains predominantly more processed sugars and fats. It has resulted in a significant health challenge and increased obesity prevalence in the country (World Bank, 2010; Vaidya et al., 2010). In Nepal, rice is a major component in the regular diet that is high in carbohydrate content. The amounts consumed and the methods of cooking may be adding to the dietary causes of metabolic syndrome (Sharma et al., 2011) and type 2 diabetes (Singh & Bhattarai, 2003).

#### *4.4.1 Stakeholder policy and programme response for obesity and unhealthy diet*

The government of Nepal is in the beginning stages of addressing the problem of obesity and unhealthy diet through survey data, which will help determine the scope of the problem. The WHO STEPS 2013 national survey estimated the prevalence of overweight at about 17.7% and the prevalence of obesity at around 4% (Vaidya et al., 2010; Aryal et al., 2013). To address increasing obesity occurring in urban areas, one approach could involve banning advertisements for unhealthy junk food and increasing taxes on these foods and beverages. The WHO has asked its member states to establish strategies that promote responsible marketing of food and beverages to children. However, in Nepal, the use of such bans or taxes may not be currently feasible but could be implemented in the future in urban areas (Vaidya et al., 2010). Implementation of the WHO Global Strategy on Diet, Physical Activity and Health has started in Nepal (World Bank, 2011).

## 5. Health risk communication and mHealth

mHealth using mobile technologies can improve health care in several key areas and facilitate communication in places where it was not possible previously. The WHO reports that the majority of member states (83%) have already offered at least one type of mHealth service with many offering, on average, 4-6 programmes. The most often used mHealth initiatives were: health call centres (59%), emergency toll-free telephone services (55%), managing emergencies and disasters (54%), and mobile Telemedicine (49%). Two-thirds of mHealth programmes are in the pilot or informal stage to assess their efficacy (World Health Organization, 2011c). The WHO is helping to facilitate generic tools for mHealth development in the area of mobile tools for monitoring patients; evaluation of eHealth services; drug registries; patient information systems; and directories of health care professionals and institutions. mHealth technologies, can be adapted to low- and middle-income nations through advocacy campaigns for free and open-source software. There is much enthusiasm for mHealth applications and its potential for interventions with beneficial effects on the health and health service delivery processes, especially in resource-poor settings. A number of mHealth programmes conducted in low-income countries for various diseases have reported good results and purport good future potential (Roess et al., 2014; Hall et al., 2014; Hartzler & Wetter, 2014; Holeman et al., 2014; Peiris et al., 2014).

Mobile health interventions designed to improve health care service delivery processes have been used to provide support and services to health care providers (such as education, support in diagnosis or patient management) or target communication between health care services and consumers (such as appointment reminders and test result notification) (Free et al., 2013). Mobile technologies allow for low-cost interventions taking advantage of economies of scale. It is easy to deliver interventions to large populations such as small downloadable mobile technology applications. Similarly, automated systems can deliver text messages to large numbers of people at low-cost.

The mobile telephone features used most often for health interventions include text messages (SMS), software applications, and multiple media (SMS, photos) interventions. The technology allows interventions to be personalised and interactive. The features of mobile technologies that may make them particularly appropriate for improving health care service delivery processes relate to their popularity, their mobility, and their technological capabilities (DeRenzie et al., 2011; Free et al., 2013). mHealth can be used to offer interactive two-way communication, which provides a wide range of opportunities from improving self-monitoring of chronic diseases or as a way to improve public health infrastructure in rural areas by providing access to remote areas and access to health records (Vital Wave Consulting, 2008).

## 6. A way forward for Nepal to address NCD risk factors using mHealth strategies

The majority of NCD mortality occurs from a small number of diseases: CVD, COPD, diabetes, and cancers. Collectively these NCDs have common risk factors of tobacco use, physical inactivity, alcohol use, unhealthy diet and obesity. The WHO recommended a series of interventions referred to as 'best buys' for low-income countries like Nepal to control NCDs. The interventions can produce significant financial savings and improve public health with relatively low implementation costs. The best buys have the possibility of being scaled up, particularly in resource-constrained areas allowing successful, small initiatives to be expanded over time. Implementation of mHealth programmes could be used as a way forward to improve health knowledge for NCD risk factors. Over 70% of Nepal's households are equipped with a mobile phone allowing for the development of electronic banking services throughout the country (USAID-Nepal, 2013). Using a similar model the government should partner with interested NGOs and consider developing mHealth and Telemedicine services. Partnering interested health care NGOs, the Ministry of health and major hospitals may prove to be an excellent way to deliver health care information, health education, and health services information about communicable diseases, infectious disease outbreaks and NCDs to rural areas of Nepal.

### 6.1 Tobacco use cessation policies and integrating mHealth and health risk communication strategies

The most powerful and cost-effective strategies for reducing smoking in Nepal are those related to tobacco products fiscal and tax policy including improving risk communication at the local level in urban areas as outlined in the 2004 WHO Framework Convention on Tobacco Control (FCTC) (World Health Organization, 2011). Other important measures to reduce the tobacco consumption are related to information (ban on advertising in certain places, including warnings about the health risks of smoking), prohibiting the consumption of tobacco in certain public (urban) places with proper enforcement. Tobacco control interventions have a high impact on burden of NCDs and should be directed towards the entire population, which will benefit the poor and help to reduce inequities (Thakur et al. 2011).

Evidence suggests that smoking cessation programmes are more effective when they are part of a coordinated approach to tobacco control (World Health Organization, 2012). The government should collaborate with other stakeholders and add health risk communication as a cornerstone of any future smoking initiatives implemented in Nepal. Low-cost interventions for Nepal include appropriate medical advice provided by village health care providers to individuals. Within the general population, even simple interventions delivered by physicians in the form of brief encouragement or health risk communication can have a significant impact on short-term motivations for individuals to quit smoking and on future quitting rates (Stead et al., 2008).

mHealth programmes for smoking cessation have been in use for over a decade. Interventions such as SMS, progress tracking, distractions, peer chats and motivational messaging provided to users through mobile technology shows positive results to reduce tobacco usage. A systematic review by Ghorai et al. (2014) found that the most widely used programmes used were: SMS based quit smoking services, Tele-counselling and Multimedia messages based service for smoking cessation. The advantages of mHealth interventions included low-cost, better coverage of the population for programme delivery, easier message delivery, and a faster way to send tailored and personalised messages of support.

Most mHealth services to date focus on simple SMS based reminder intervention for smoking cessation; however, Ghorai et al. (2014) suggest a multi-intervention approach using motivational messages through SMS and MMS (short audio and video clips), social chat, instant peer support, and providing distractions for smoking cessation would provide a more powerful and interactive programme. A multi-intervention mHealth approach could be developed on a small scale as a pilot programme to test its effectiveness in Nepal.

### 6.2 Alcohol use and integrating mHealth and health risk communication strategies

The First Global Ministerial Conference on Healthy Lifestyles and Non Communicable Disease Control offered some low-cost interventions to change alcohol use behaviours (World Health Organization, 2011). Decreasing harmful alcohol use will reduce certain cancers, CVDs and road traffic accidents. The best cost effective interventions include an increased tax on alcohol and alcoholic beverages and a comprehensive ban on alcohol advertising and marketing (Anderson et al., 2009; World Health Organization, 2011).

Savic et al. (2013) reviewed 87 available addiction recovery mobile telephone applications identified on the Google Play store in 2012. Of these, there were 27 mHealth applications designed specifically for alcoholism (31.0%). Analysis revealed that user applications typically provided information on recovery, as well as content to enhance motivation, promote social support and tools to monitor progress.

Gustafson et al. (2011) reported on an eHealth solution for people with alcohol problems using a mobile telephone application called: Alcohol–Comprehensive Health Enhancement Support System (A-CHESS). The programme is designed to be compatible with two models of how people can change their behaviours towards alcohol using a self-determination theory approach (Larimer et al., 1999) and a behavioural change model that identifies stages preceding relapse allowing for intervention and prevention (Witkiewitz & Marlatt, 2004). Patients are supported by ongoing monitoring and their risk of relapse (coping ability) is assessed through communication. Alerts encourage adherence to therapeutic goals, and give individualised addiction-related materials and tools. Social support is through communication with peer support groups and addiction experts (Gustafson et al., 2011). A-CHESS could be adapted with local community input and used at the village level throughout Nepal. Finally, video-conferencing to deliver an evidence-based alcohol intervention programme that focuses on motivational enhancement therapy with at-risk alcohol users in real-world settings has been shown to be highly effective for alcohol use problems in rural communities (Staton-Tindall et al., 2012); such a program could be tested in Nepal on a small scale to determine its effectiveness. mHealth mobile applications to reduce high risk and alcohol abuse drinking among underage students are also available (Kazemi et al., 2014; Pereira et al., 2015).

### 6.3 Unhealthy diet, obesity and physical inactivity - integrating mHealth and health risk communication strategies

Excessive salt intake is linked to increased blood pressure and results in more than seven million deaths worldwide each year from heart attacks and strokes. For obesity and comorbid conditions caused by high salt intake (e.g. hypertension, type 2 diabetes, high blood pressure) WHO recommends a best buy programme of reducing salt content in processed foods. Another WHO best buy programme is partial or complete substitution of partially hydrogenated trans-fat with polyunsaturated fats introduced at the point of manufacture and estimated to be highly cost-effective. A number of other low-cost and feasible interventions that tackle unhealthy diet focus on promoting public awareness and physical activity (World Health Organization, 2011). mHealth based health communication using video clips and audio podcasts can help to bridge these knowledge gaps and can be provided through mHealth platforms.

### 6.4 mHealth strategies for combating physical inactivity

The positive effects of physical activity are well known in developed countries (Bauman, 2004) and research implies that similar health benefits of physical activity occur in developing countries undergoing epidemiological transitions due to rapid urbanisation and diet changes (WHO, 2005). Physical activity reduces all cause mortality, diabetes, cardiovascular diseases, cancer rates (positive effects in relation to colon and breast cancer), blood pressure, lipid levels and obesity. These data, together with increasing NCDs provide the rationale for implementing physical activity programmes and actions in developing countries such as Nepal.

WHO public health best buys for preventing NCDs related to physical inactivity include promoting public awareness about diet and physical activity using mass media and to promote physical activity through the media (in combination with information about healthy diets). Such programmes are cost-effective, low-cost and highly feasible options (World Health Organization, 2011b). In Nepal behavioural change communication (BCC) has been implemented since 1995 as a way to increase health awareness but this promotion could easily be extended to mobile health platforms at low-cost. A second WHO best buy strategy is to develop policies to encourage walking, cycling, and other physical activities especially in urban areas. Many mobile applications can be used to highlight and encourage active lifestyles.

## 7. mHealth strategies to help create a national health surveillance system

Over the last ten years Nepal has been slowly building a system to be used for national health surveillance. Using the WHO STEPS methods several surveys were completed. Nepal conducted a subnational STEPS survey in 2003 (Kathmandu), another subnational STEPS survey in 2005 (Ilam, Lalitpur, Tanahu) and national STEPS surveys in 2007 and 2013 (World Bank, 2011; Aryal et al., 2013). The challenge from NCDs can only be overcome if local, qualitative, and current surveillance information is available. In Nepal, a system of collection of cancer incidence data from seven major hospitals around the country was introduced in 2005 with the support of WHO. Currently, as of 2015, two cancer registries have been established, and a National Injury Surveillance system is under development. The information generated by using mHealth data collection and surveillance can help build on these existing registries and inform effective and sustainable National Health Policies for NCDs.

The use of mHealth technologies can help reduce health care costs by improving efficiencies in the health care system through data collection. Additionally, health disparities can be improved through the use of mobile technologies to improve communication and information sharing. mHealth technologies used to help augment existing health systems and improve health care outcomes requires implementing them at the local level. For example, USAID's ASSIST programme in Uganda introduced mHealth and made it possible for the village health care teams to obtain answers quickly to their patients' questions, while also facilitating communication with their supervisors. A similar programme could be introduced at the village sub-health post and village health posts partnering local health care workers with zonal hospitals in Nepal (USAID, 2015).

Mobile Health applications are helpful for data collection. In Uganda, a mobile phone data collection and records access tool named EpiHandy helped to reduce data entry errors and improved cost-efficiency compared with paper surveys (Vital Wave Consulting, 2008). The MOHP should consider adopting similar mHealth technologies to help with its next WHO-STEPS survey.

Some excellent open source computer programs are available for use that could help Nepal develop a scalable, nation-wide data collection system and assist in creating a national surveillance system for NCDs (and other diseases). One program, Magpi (formerly named EpiSurveyor) (from DataDyne), is a java-based program that allows users to create personalised geo-tagged, data-collection forms specific for their needs. A generic form can be downloaded, modified to fit the needs of the user and then used for data collection. Afterwards, forms can be resent back to a central database for further analysis. Magpi mobility applications are currently being used in over 170 countries (Magpi, 2015).

A second program, Open Data Kit (ODK) (from Dimagi Inc.) is a free, open-source javaROSA based group of tools that help to collect, collate, and visualise data. Mobile based programs such as ODK can replace paper forms and record various data types such as text, geo-location, photographs, short video clips, audio, and barcodes. The program also supports editing saved forms, question grouping, data constraints, complex logic, and multiple languages allowing for great flexibility in its design and use (Open Data Kit, 2015; DeRenzie et al., 2011). JavaROSA applications have been designed for an ever-increasing variety of tasks including taking survey data, disease management tracking, helping health workers through treatment protocols at point of care, and collection of medical records for longitudinal studies. JavaROSA based programs have been field tested and tried in several countries with excellent results (e.g. Kenya, Pakistan, South Africa, Tanzania, Uganda, Bangladesh, Mexico, and Zambia) (JavaROSA, 2015).

Some may argue that mobile technologies are unworkable in Nepal due to the significant amount of either remote regions or rural areas. However, according to the Ministry of Health demographic survey and work by USAID-Nepal, it is estimated 70-75% of households in Nepal own a mobile telephone. mHealth is one of the few strategies that has the capability to reach a majority of rural and remote households in Nepal (Ministry of Health and Population Nepal, 2011; USAID-Nepal, 2013). In remote areas with limited electricity infrastructure, the re-charging of mobile devices for ongoing day-to-day data collection at health posts could be achieved by using portable, off-grid solar technologies (Voltaic Inc., 2015).

Mobile devices can be equipped with microSD or SD cards (currently most mobile phones can accommodate 32 or 64 gigabytes of memory storage per card) that are capable of holding a significant amount of health information. The memory cards could be pre-loaded to contain health information on NCD risk factors, data collection applications (e.g. ODK, Magpi), data collection forms, audio podcasts, instructional videos for diagnostics, instructional videos for minor treatments, and typical case assessments for minor health problems.

The ability to pre-install applications for data collection to be used by rural health care workers with no connectivity will still allow for surveillance and daily data collection. The pre-loading of health resources and applications on SD cards would allow rural health care workers access to resources if internet connectivity is limited. Survey, surveillance and other data collected on memory cards could be updated and exchanged periodically with the hospitals or government health departments. The small size and negligible weight of the memory cards allow them to be easily sent to Ministry officials by posted mail.

In areas where mobile data connections are sufficient for data transfer there is the ability to use mobile data tracking, and data collection by health care workers. Referrals from health posts and sub-health posts could be completed using a standardised mobile health application (e.g. Magpi, ODK). In this Telemedicine scenario mobile phones connect remote health workers with medical specialists for advice and coordination of care (Mossman et al., 2014). Cases could be prioritised and treatment provided on a weekly basis for non-urgent patients requiring added medical assistance. The partnering of doctors in urban centres with rural and remote village health care workers would provide help to those patients most at risk. The use of Telemedicine has shown promise for managing NCDs (Paré et al., 2007).

## 8. Conclusion

Hospital based and demographic health studies completed to date reveal that Nepal is facing an increasing burden of disease from NCDs similar to other developing nations in South East Asia. Programmes that will improve NCD risk factor communication and provide resources to health care workers in rural health posts and sub-health posts need to be developed. To achieve health communication goals in low-income settings like Nepal many barriers must be overcome. The largest hurdle involves redirecting already scarce health resources, both financial and human, towards the problem of NCD risk factor awareness. In Nepal there are many competing interests related to public health such as infectious diseases and maternal/ perinatal/ neo-natal health in addition to NCDs. mHealth and Telemedicine can provide low-cost, scalable and cost effective health care programmes.

Another major barrier is low literacy in rural areas. Using mHealth programmes designed with a heavy reliance on videos, audio podcasts and icon or pictogram based navigation can help communities with low literacy levels to collect data or obtain useful content through mobile devices. Mobile Health and Telehealth services that provide health information on NCD risk factors provided as audio and video through mobile platforms would overcome one of the foremost barriers of low literacy and low health literacy to improve knowledge. For professional education, audio and video-based e-Learning programmes offered through mHealth technologies could be a way to offer skills improvement training for Village Health Workers (VHW) and Female Community Health Volunteers (FCHVs).

The use of mHealth programmes provides a number of potential new avenues for the government of Nepal, hospitals, and other stakeholders to work together to deliver improved health care, access to health care services, health communication, and data acquisition. A review of existing mHealth programmes and open source computer programs used in other low-income countries may reveal which ones can be adapted to meet the needs of Nepal. Doing so requires a collaborative effort between all stakeholders. Robust mHealth and Telemedicine systems in Nepal will allow for a sustainable and scalable suite of programmes for urban, rural and remote areas to combat NCD risk factors.

## References

Aryal, K.K., Neupane, S., Mehata, S., Vaidya, A., Singh, S., Paulin, F., et al. (2014). *Non communicable diseases risk factors: STEPS Survey Nepal 2013.* Kathmandu: Nepal Health Research Council and World Health Organization. [online]. Available a *thttp://www.who.int/entity/chp/steps/2012-13_Nepal_STEPS_Report.pdf?ua=1.*

Alwan, A., T. Armstrong, D., Bettcher, F., Branca, D., Chisholm, M., Ezzati, R. et al. (2010) *Global status report on noncommunicable diseases.* Geneva, Switzerland: World Health Organization [online]. Available at: . *http://whqlibdoc.who.int/publications/2011/9789240686458_eng.pdf?ua=1.*

Anderson, P., Chisholm, D. & Fuhr, D. (2009). Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. *Lancet, 373*, pp. 2234-2246.

Bauman, A.E. (2004). Updating the evidence that physical activity is good for health: an epidemiological review 2000-2003. *Journal of Science and Medicine in Sport, Physical Activity Supplement, 7(1)*, pp. 6–19.

Bhandari, G.P., Angdembe, M.R., Dhimal, M., Neupane, S., & Bhusal, C.( 2014). State of Non Communicable Diseases in Nepal. *BMC Public Health, 14,* pp. 23.

Chhetri, *M.R. & Chapman, R.S. (2009). Prevalence and determinants of diabetes among the elderly population in the Kathmandu Valley of Nepal. Nepal Medical College Journal, 11(1), pp. 34-38.*

*Clarke, L. (2010). M-Health and eHealth: Using technology to improve the level of care and education to patients.* [online]. Available at: *http://www.healthguideinfo.com/health-apps/p97066/#sthash.r4YuicyK.xHpSwlZn.dpuf.*

DeRenzi, B., Borriello, G., Jackson, J., Kumar, V.S., Parikh, T.S., Virk, P. et al. (2011). Mobile phone tools for field-based health care workers in low-income countries. *Mount Sinai Journal of Medicine, 78*, pp. 406–418.

Free, C., Phillips, G., Watson, L., Galli, L., Felix, L., Edwards, P. et al. (2013). The effectiveness of mobile-Health technologies to improve health care service delivery processes: a systematic review and meta-analysis. *PLoS Medicine, 10*(1), e1001363.

Gautam, K.C. (2010). 10+2 agenda for public health in Nepal. *Journal of Nepal Medical Association, 49*(178), pp. 174-177.

Ghorai, K., Akter, S., Khatun, F. & Ray, P. (2014). mHealth for smoking cessation programs: A systematic review. *Journal of Personalized Medicine, 4*(3), pp. 412-423.

Gostin, L.O., Bayer, R. & Fairchild, A.L. (2003). Ethical and legal challenges posed by Severe Acute Respiratory Syndrome: implications for the control of severe infectious disease threats. *Journal of the American Medical Association, 290*,pp. 3229-3237.

GoN-NPCS-CBS /UNICEF. (2015). (Government of Nepal National Planning Commission Secretariat, Central Bureau of Statistics/UNICEF). *Nepal Multiple Indicator Cluster Survey 2014:* Key Findings. [online]. Available at: *http://cbs.gov.np/wp-content/uploads/2015/01/nmics5_key-findings-_report.pdf.*

Government of Nepal. (2012). *National population and housing census 2011: National report,* Kathmandu: National Planning Commission Secretariat, Central Bureau of Statistics, Government of Nepal. [online]. Available at: *http://www.cbs.gov.np/wp-content/uploads/2012/11/National%20Report.pdf*.

Government of Nepal. (2014). *An approach to the graduation from the Least Developed Country by 2022*. Available at: *http://www.npc.gov.np/web/new/uploadedFiles/allFiles/LDC_Final_draft.pdf*

Gustafson, D.H., Boyle, M.G., Shaw, B.R., Isham, A., McTavish, F., Richards, S., et al. (2011). An e-Health solution for people with alcohol problems. *Alcohol Research and Health, 33*(4), pp. 327-337.

Hashibe, M., Siwakoti, B., Wei, M., Thakur, B.K., Pun, C.B., Shrestha, B.M. et al. (2011). Socioeconomic status and lung cancer risk in Nepal. *Asian Pacific Journal of Cancer Prevention, 12*(4), pp. 1083-1088.

Hall, C.S., Fottrell, E., Wilkinson, S. & Byass, P. (2014). Assessing the impact of mHealth interventions in low- and middle-income countries--what has been shown to work? *Global Health Action, 7, 25606.*

Hartzler, A. & Wetter, T. (2014). Engaging patients through mobile phones: demonstrator services, success factors, and future opportunities in low and middle-income countries. *Yearbook of Medical Informatics, 9*(1), pp. 182-194.

Holeman, I., Evans, J., Kane, D., Grant, L., Pagliari, C. & Weller, D. (2014). Mobile health for cancer in low to middle income countries: priorities for research and development. *European Journal of Cancer Care, 23*(6), pp.750-756.

IARC Monographs. (2006). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 95. Household Use of Solid Fuels and High-temperature Frying. Household use of solid fuels.* Lyon, France: IARC Monographs, pp. 45-143. [online]. Available at: *http://monographs.iarc.fr/ENG/Monographs/vol95/mono95.pdf.*

IHME. (2013). *The Global Burden of Disease: Generating Evidence, Guiding Policy – South Asia Regional Edition.* Seattle, WA: Institute for Health Metrics and Evaluation, Human Development Network, The World Bank. [online]., Available *at http://www.healthdata.org/sites/default/files/files/data_for_download/2013/WorldBank_SouthAsia/IHME_GBD_WorldBank_South%20Asia_FullReport.pdf*.

JavaROSA. (2015). *JavaRosa, Open Source Mobile Data Collection.* [online].,Available at: *http://www.dimagi.com/javarosa/.*

Jemal, A., Thun, M.J., Ries, L.A., Howe, H.L., Weir, H.K., Center, M.M., et al. (2008). Annual report to the nation on the status of cancer, 1975-2005, featuring trends in lung cancer, tobacco use, and tobacco control. *Journal of the National Cancer Institute, 100*(23), pp. 1672-1694.

Jhingan, H.P., Shyangwa, P., Sharma, A., Prasad, K.M. & Khandelwal, S.K. (2003). Prevalence of alcohol dependence in a town in Nepal as assessed by the CAGE questionnaire. *Addiction, 98*(3), pp. 339-343.

Kazemi, D.M., Cochran, A.R., Kelly, J.F., Cornelius, J.B.& Belk, C. (2014). Integrating mHealth mobile applications to reduce high risk drinking among underage students. *Health Education Journal, 73*(3), pp. 262–273.

Larimer, M.E., Palmer, R.S. & Marlatt, G.A. (1999). Relapse prevention. An overview of Marlatt's cognitive-behavioral model. *Alcohol Research and Health, 23*(2), pp. 151–160.

Lee, I.M., Shiroma, E.J., Lobelo, F., Puska, P., Blair, S.N., Katzmarzyk, P.T. et al. (2012). Effect of physical inactivity on major Non Communicable Diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet, 380*(9838), pp. 219-229.

Livestrong. (2014). *Non Communicable Diseases*. [online]. Available at: *http://www.livestrong.com/article/88312-list-noncommunicable-diseases/*

Magpi. (2015). *Magpi*. [online]. Available at: *http://home.magpi.com/company/.*

*Mossman, K., McGahan, A., Mitchell, W. & Bhattacharyya, O. (2014). Evaluating high-tech health approaches in low-income countries. Stanford Social Innovation Review. [online] Available at: http://www.ssireview.org/blog/entry/evaluating_high_tech_health_approaches_in_low_income_countries.*

Nepal Cancer Relief Society. (2013). *Tobacco Control Programs.* [online]., Available at: *http://www.ncrs.org.np/?comp=com_contents&task=details&id=205&title=tobacco-control-programs.*

Nepal Health Research Council. (2010). *Prevalence of Non Communicable Disease in Nepal: Hospital Based Study.* Kathmandu: Nepal Health Research Council. [online]., Available at: *http://www.ncf.org.np/upload/files/611_en_Non_Communicable_diseases.pdf.*

Neupane, D. & Kallestrup, P. (2013). Non Communicable Diseases in Nepal: Challenges and opportunities. *Journal of Nepal Health Research Council, 11*(24), pp. 225-228.

Oli, N., Vaidya, A., Subedi, M. & Krettek, A. (2014). Experiences and perceptions about cause and prevention of cardiovascular disease among people with cardiometabolic conditions: findings of in-depth interviews from a peri-urban Nepalese community. *Global Health Action, 7*, 24023.

Open Data Kit. (2015). *Open Data Kit Home*. [online]. Available at: *http://www.opendatakit.org.*

Paré, G., Jaana, M. & Sicotte, C. (2007). Systematic review of home telemonitoring for chronic diseases: the evidence base. *Journal of the American Medical Informatics Association,14*, pp. 269-277.

Peiris, D., Praveen, D., Johnson, C. & Mogulluru, K. (2014). Use of mHealth systems and tools for Non Communicable Diseases in low- and middle-income countries: a systematic review. *Journal of Cardiovascular Translational Research, 7*(8), pp. 677-691.

Pereira, C.A., Wen, C.L. & Tavares H. (2015). Alcohol Abuse Management in Primary Care: An e-Learning Course. *Telemedicine and e-Health, 21*(3), pp. 1-7.

Roess, A., Gurman, T., Ghoshal, S. & Mookherji, S. (2014). Reflections on the potential of mHealth to strengthen health systems in low- and middle-income countries. *Journal of Health Communication, 19*(8), pp. 871-875.

Savic, M., Best, D., Rodda, S. & Lubman, D.I. (2013). Exploring the focus and experiences of smartphone applications for addiction recovery. *Journal of Addictive Diseases, 32*(3), pp. 310-319.

Shakya, D.R. (2013). Alcohol ab/use in eastern Nepal: a review of studies. *Health Renaissance, 11*(1), pp. 74-82.

Sharma, S.K., Ghimire, A., Radhakrishnan, J., Thapa, L., Shrestha, N.R., Paudel, N. et al. (2011). Prevalence of hypertension, obesity, diabetes, and metabolic syndrome in Nepal. *International Journal of Hypertension, 2011*, Article ID: 821971.

Shrestha, U., Singh, D. & Bhattarai, M. (2006). The prevalence of hypertension and diabetes defined by fasting and 2-h plasma glucose criteria in urban Nepal. *Diabetic Medicine, 23*, pp. 1130-1135.

Singh, D. & Bhattarai, M. (2003). High prevalence of diabetes and impaired fasting glycaemia in urban Nepal. *Diabetic Medicine, 20*, pp. 170-171.

Staton-Tindall, M., Wahler, E., Webster, J.M., Godlaski, T., Freeman, R. & Leukefeld, C. (2012). Telemedicine-based alcohol services for rural offenders. *Psychological Services, 3*, pp. 298-309.

Stead, L.F., Bergson, G. & Lancaster, T. (2008). Physician advice for smoking cessation. *Cochrane Database Systematic Reviews, 2*, CD000165.

Thakur, J.S., Garg, R., Narain, J.P. & Menabde, N. (2011). *Tobacco use: A major risk factor for non communicable diseases in South-East Asia region. Indian Journal of Public Health, 55*, pp. 155-60. [online]. Available at: *http://www.ijph.in/text.asp?2011/55/3/155/89943*.

Torgan, C. (2009). *The mHealth summit: local and global convergence.* November 6. [online]. Available at: *http://caroltorgan.commhelath-summit*.

United Nations. (2013). *Nepal Millennium Development Goals progress report 2013*. Kathmandu: National Planning Commission, Government of Nepal and United Nations Nepal Country Office. [online]., Available at: *http://www.un.org/millenniumgoals/pdf/report-2013/mdg-report-2013-english.pdf*.

USAID-Nepal. (2013). *Quarterly Newsletter. Spotlight on Resilience.* Washington, D.C.: USAID.[online]. Available at: *http://www.usaid.gov/sites/default/files/documents/1861/USAID%20Nepal%20Newsletter_nov%2022_final.pdf.*

USAID. (2015). *USAID Assist Project*. Washington D.C.: USAID. [online]., Available at:*https://www.usaidassist.org/blog/using-mhealth-improve-performance-and-engagement-village-health-teams*.

Vaidya, A., Shakya, S. & Krettek, A. (2010). Obesity prevalence in Nepal: public health challenges in a low-income nation during an alarming worldwide trend. *International Journal of Environmental Research and Public Health, 7*(6), pp. 2726–2744.

Vaidya, A., Aryal, U.R.& Krettek, A. (2013). Cardiovascular health knowledge, attitude and practice/behaviour in an urbanising community of Nepal: a population-based cross-sectional study from Jhaukhel-Duwakot Health Demographic Surveillance Site. *BMJ Open, 3(10), e002976.*

*Vital Wave Consulting. (2008). mHealth for develop*ment: mobile communications for health. United Nations Foundation and Vodafone Foundation Technology Partnership. Palo Alto: Vital Wave Consulting. [online]., Available at: *http://www.globalproblems-globalsolutions-files.org/unf_website/assets/publications/ technology/ mhealth/mHealth_for_Development_full.pdf.*

Voltaic Inc. (2015). *OffGrid Solar Backpack*. Brooklyn, NY: Voltaic, Inc. [online]., Available at: *http://www.voltaicsystems.com/offgrid.*

Witkiewitz, K. & Marlatt, G.A. (2004). Relapse prevention for alcohol and drug problems: that was Zen, this is Tao. *American Psychologist, 59*(4), pp. 224–235.

World Bank. (2011). *Non Communicable Diseases (NCDs)-Nepal's next major health challenge*. The World Bank, South Asia Human Development, Health Nutrition, Population, 2011. Washington D.C.: The World Bank. [online]., Available at: *http://siteresources.worldbank.org/SOUTHASIAEXT/Resources/223546-1296680097256/7707437-1296680114157/NCD_NP_Policy_Feb_2011.pdf*.

World Health Organization. (2003a). *WHO framework convention on tobacco control*. Geneva: World Health Organization. [online]., Available at: *http://www.who.int/tobacco/framework/WHO_FCTC_english.pdf.*

World Health Organization. (2003b). *Health and development through physical activity and sport*. Geneva: World Health Organization. [online]., Available at: *http://whqlibdoc.who.int/hq/2003/WHO_NMH_NPH_PAH_03.2.pdf*.

World Health Organization. (2004). *Global strategy on diet, physical activity and health*. Geneva: World Health Organization. [online]., Available at:
*http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf.*

World Health Organization. (2005). *eHealth tools and services: Needs of member states. Report of the WHO Global Observatory for eHealth*. Geneva: World Health Organization: Available at: *http://apps.who.int/medicinedocs/documents/s16468e/s16468e.pdf*

World Health Organization. (2010). *The global status report on Non Communicable Diseases*. Geneva: World Health Organization: [online]., Available at: *http://whqlibdoc.who.int/publications/2011/9789240686458_eng.pdf?ua=1*

World Health Organization. (2011a). *Profile on implementation of WHO framework convention on tobacco control in the South-East Asia region.* Geneva: World Health Organization. [online]., Available at: *http://www.searo.who.int/tobacco/wntd/wntd_profile_tfi.pdf?ua=1*

World Health Organization. (2011b). *First global ministerial conference on healthy lifestyles and Noncommunicable Disease control.* Moscow. 28-29 April 2011. [online], Available at: *http://www.who.int/nmh/publications/who_bestbuys_to_prevent_ncds.pdf*

World Health Organization. (2011c). *mHealth: new horizons for health through mobile technologies: second global survey on eHealth.* Geneva: World Health Organization. [online]., Available at: *http://whqlibdoc.who.int/publications/2011/9789241564250_eng.pdf?ua=1*

World Health Organization. (2012). *Tobacco Control in Practice. Article 13: Tobacco advertising, promotion and sponsorship. Case studiers of implementation of the WHO Framework Convention on Tobacco Control in the WHO European Region. Regional Office for Europe.World Health Organization 2012*. Geneva: World Health Organization. [online]., Available at: *http://www.euro.who.int/__data/assets/pdf_file/0005/168062/Tobacco-Control-in-Practice-Article-13.pdf.*

World Health Organization. (2014). *Health Topics.* Geneva: World Health Organization. [online]., Available at: *http://www.who.int/topics/en/.*

World Health Organization. (2015a). *Global Health Observatory - Noncommunicable diseases (NCD)*. Geneva: World Health Organization. [online]., Available at: *http://www.who.int/gho/ncd/en/.*

World Health Organization. (2015b). Chapter 4. *The political economy of tobacco taxation*. Geneva: World Health Organization. [online]., Available at: http://www.who.int/tobacco/publications/en_tfi_tob_tax_chapter4.pdf.

World Heart Federation. (2015). *Cardiovascular disease risk factors*. Geneva: World Heart Federation. [online]., Available at: http://www.world-heart-federation.org/press/fact-sheets/cardiovascular-disease-risk-factors/.

World Population Clock. (2015). *Nepal Population, World Population Clock, 1st of January, 2015*. [online], Available at: http://countrymeters.info/en/Nepal.

16

# Reforming Health Insurance Policy in Nepal: An Integrated Self Financing Model

Ratna K. Shrestha

## Abstract
The existing health care insurance policies in Nepal, particularly the community-based health insurance schemes, have been ineffective. Many studies have found the participation rates in these schemes too low to be financially sustainable--a classic adverse selection problem. This paper proposes an alternative insurance scheme in which the participation from the formal-sector employees is mandatory. With this mandatory enrollment from the formal sector, the proposed scheme may adequately diversify the financial risk, thereby avoiding the problem of adverse selection.

## 1. Introduction
Every year, 14% of households in Nepal face severe financial hardship due to one or more family members becoming ill and the resulting out-of-pocket medical expenses (Saksena et al., 2010). Even worse, many others particularly from marginalised and low-income households die either due to the absence or prohibitively high cost of health care treatment. To increase the affordability of health care and diversify the financial risk caused by unforeseen medical expenses, in 2013, the Government of Nepal announced a plan to create a National Health Insurance Fund under its National Health Insurance Policy initiative (WHO, 2013). The purpose of this new initiative is to pool the premiums raised from the existing community-based health insurance (CBHI) schemes into one national fund and use that fund to finance the medical needs of the policyholders.[i] However, while the creation of a national insurance fund is a policy shift in the right direction, this fund alone is unlikely to adequately diversify the financial risk facing the population. In its own policy report titled, National Health Insurance Policy the WHO (2013) clearly identifies the expected low enrolment and the overuse of health care services as two potential roadblocks for this national initiative.

In an insurance market where enrolment is voluntary, if the premium is based on the average health care need of the population, only unhealthy individuals with higher than average expected medical expenses will choose to enrol. In contrast, healthier people who believe their healthcare expenses will be less than the premium they have to pay for medical insurance will simply opt out of the market—a classic adverse selection problem. As the number of healthy enrolees in an insurance scheme or plan shrinks, so does the size of its financial pool.[ii] This shrinking financial pool can ultimately lead the scheme to bankruptcy, defeating the very purpose for which it is implemented.

Apart from adverse selection, there are other reasons for which households in Nepal and many developing countries may not buy insurance plans. First, most low-income households with very limited disposable income cannot afford insurance premiums. Second, many rural households either are unaware of such plans or live too far away from their nearest health care service providers. Whatever the reason, the participation rate for the existing CBHI schemes in Nepal is extremely low; it stands at about 3.4 % of the population in the coverage area, despite heavy subsidies on premiums from the government (Health Sector Support Program, 2012).[iii] While enrolment rates are extremely low, the claim ratios (ratio of medical expenses paid to service providers to premium received) in these government-funded CBHI schemes are very high, ranging from 47% to 386%, with an average of 129%.[iv] In the case of privately funded schemes, this ratio is even worse at 189% (Health Sector Support Program, 2012).

The aim of this paper is to review the existing health insurance policies in Nepal, particularly community based health insurance schemes. The issues of limited financial risk diversification are likely to be associated with the National Insurance Fund (NIF) because of low enrolment and the overuse of services due to moral hazard problem (a tendency among the policyholders when they are fully insured). To address this issue, with evidence based on review of scientific literature, this paper also proposes an alternative scheme – integrated self-financing model in which every household from across the country is offered an assortment of insurance plans. The premium under this proposed scheme is based on the insurance coverage and the extent of health care costs shared by the policyholders, among other factors such as income. This cost-sharing arrangement between the insurer and the policyholders can minimise the overuse of the services. The other potential problem of low enrolment caused by adverse selection is mitigated by making it mandatory for formal-sector employees (civil servants and private sector workers with regular wages and hours) to buy one of the insurance plans of their choice. Unfortunately, given the socio-economic condition of Nepal, it is impossible to make health insurance plans mandatory for all citizens. Nevertheless, the proposed scheme, by virtue of its mandatory provision for at least the formal sector employees, can help maintain the number of policyholders and hence adequately spread the financial risk among the policyholders.

The proposed scheme, by design, will first target formal sector employees and urban population. The idea is to start with a fully, self-financing insurance scheme targeting only the formal sector. Given limited financial resources and inherent difficulty in attracting voluntary participation to insurance plans due to adverse selection and possibly other problems, it is logical to launch a scheme that requires mandatory enrolment from the formal sector. Once the scheme becomes fully self-sustaining, the enrolment can gradually be expanded to rural and marginalised population, thus ultimately covering the entire nation.

## 2. Existing CBHI schemes: How well have they fared?

The concept of CBHI schemes came into force with the aim of providing basic health care services to the rural population in less developed countries. Administered on a not-for-profit basis either by community organisations, hospitals, non-governmental organisations or directly by the governments, these schemes are entirely based on voluntary participation. In a sense they are micro-insurance schemes motivated by sharing the risk of unforeseen healthcare expenses among the member households.

Lalitpur Medical Insurance Scheme in Ashrang Health Post, Lalitpur, which was implemented in 1976 by United Missions to Nepal, is the first CBHI scheme of Nepal. Other Nepali schemes include: the Public Health Concern Trust and one run by General Federation of Nepal Trade Union. Unfortunately, the enrolment rates of all these schemes have remained chronically low despite huge government subsidies and foreign assistances. For example, even after many years of operation, the enrolment rate within the Lalitpur scheme has remained between 27% and 48% (British Council, 2003). In the case of other privately-funded CBHI schemes (other than those mentioned above), the enrolment rate is dismal at only 2.7% of the target population. Similarly, the enrolment rates within the existing government run CBHI schemes in Nawalparasi, Morang, Udayapur, Rautahad, Dang, and Kailali are not much better, averaging at less than 3.4%. Table 1 summarises the enrolment rates at some of the existing CBHI schemes in Nepal (Health Sector Support Program, 2012).

**Table 1:** Enrolment rates in publicly funded CBHI schemes (FY 2010/11)

| Schemes | Number of Households Covered by CBHI | % of Total Households |
|---|---|---|
| Mangalabare | 697 | 1.60 |
| Dumkauli | 264 | 1.34 |
| Chandranigahapur | 493 | 3.30 |
| Katari | 392 | 11.0 |
| Lamahi | 1,310 | 8.90 |
| Tikapur | 988 | 4.30 |
| Total | 4,144 | 3.50 |

While enrolment rates are extremely low, the claim ratios in most of the CBHI schemes are very high. Table 2 summarises the claim ratios at five publicly-funded and six private CBHI schemes for FY 2010/11 (source: Health Sector support Program, 2012).

**Table 2:** Claim ratio in existing CBHI schemes (FY 2010/11)

| Schemes | Type of Schemes | Claim Ratio (%) |
|---|---|---|
| Mangalabare | Public | 46.80 |
| Dumkauli | Public | 386.10 |
| Chandranigahapur | Public | NA |
| Katari | Public | 68.90 |
| Lamahi | Public | 139.00 |
| Tikapur | Public | 190.80 |
| Madhesa | Private | 125.70 |
| Syaphru | Private | 102.40 |
| PHCRC, Chapagaun | Private | 363.00 |
| Saubhagya | Private | 12.90 |
| Rajmarga | Private | 95.90 |
| Bikalpa | Private | 134.00 |

Despite the low enrolment rates but high claim ratios of the existing schemes, the government recently announced a plan to expand the CBHI schemes in selected areas of five districts: Ilam, Sarlahi, Baglung, Banke and Kailali (MoF, 2012). With this expansion, every family from the service area can buy medical coverage of up to Rs 50,000 upon paying an annual premium of Rs 2,000. But the households from marginalised groups and below the poverty line would be exempted from paying the premium. More recently, in view of further expanding and strengthening the policy, the government announced a plan to pool the premiums raised from all government-supported health insurance schemes into one national fund (WHO, 2013). But with the participation rate as low as 2.7% among some of the existing schemes, it is difficult to see how the creation of a national fund alone, without any effective mechanism for expanding the pool of policyholders, can sufficiently cover the health care needs of the people. Moreover, it is doubtful if this national fund can be economically viable in the long term in the face of expected high claim ratios.

Recognising the inherent nature of the adverse selection problem associated with voluntary-based insurance schemes, the government plans to make the enrolment mandatory for every household that is covered by the scheme within five years of its implementation. While such a mandatory scheme may be viable in the United States, Canada, and many other developed countries with a well-managed tax governance structure, it could be an administrative nightmare in Nepal. The country has over 96% of its economically active population engaged in the informal sector (CBS, Nepal, 2008) and lacks even a basic tax-governance structure, let alone the infrastructure to run a mandatory insurance scheme for its rural population.

## 3. The conceptual framework

In principle, all resources available for health care can be pooled together centrally through a general tax system and the associated medical services can be provided based solely on clinical needs. This arrangement implicitly redistributes wealth from the healthy to the sick. If the country's tax structure is progressive, then it also redistributes wealth from the rich to the poor (Smith & Witter, 2004). Canada's single payer system and United Kingdom's National Health Service are motivated by this principle of equal access to all based on health service needs. In both of these countries, health care is mostly funded by general tax revenue and medical coverage is solely based on need. To some extent, the existing public healthcare system of Nepal also follows a similar approach. In all government hospitals or health posts, patients pay some minimum fee for each visit (called co-payment), but most of the other services such as medical procedures and hospital stays are free. Patients have to pay the costs of prescription drugs out of their own pockets[v] as do Canadians and Britons under their respective single-payer system. Although this single-payer scheme (also called universal health care system) has worked well in Canada, United Kingdom and other countries, it has not been very successful in Nepal due to its limited financial resources and weak tax-governance structure. In addition, Nepal lacks political stewardships and the stability required for a successful implementation of major policies.

Another way to achieve a complete risk pooling is by charging the same premium across the population, regardless of individual health status (such as pre-existing health conditions) or health care use. This scheme (that charges the same premium) transfers financial risks from the sick to the healthy as does the single-payer system. However, it does not transfer wealth from the rich to the poor.[vi] Moreover, if the premium is equal to the average costs of health care of all population, then only the sick with above-average health care needs will buy insurance coverage. As the pool of policyholders becomes less and less healthy overtime, insurers are forced to increase premiums to cover the increased cost of health care. This in turn leads to further withdrawal of relatively healthy policyholders. Eventually, the scheme would be left with only the most unhealthy population, in which case the revenue raised (from premiums) would fall short of the cost of medical expenses, leading to the collapse of the scheme altogether. Evidence from around the world has confirmed adverse selection as the foremost source of market failure in an insurance market, ranging from health care to automobiles. One striking example of how adverse selection led to the collapse of an insurance scheme is that of Harvard University in mid 1990s. When the university decided to contribute the same subsidy amount to both Preferred Provider Organizations (PPOs) plan and Health Maintenance Organizations (HMOs) plan, the enrolment in the higher coverage and more expensive PPO plan decreased substantially. Particularly, the employees who were younger, healthier and had spent less on medical care the previous year switched to less expensive HMO plan. By 1997, the PPO plan was discontinued altogether (Cutler & Zeckhauser, 1997). Another example from Nepal is the collapse of a micro-insurance scheme administered by B. P. Koirala Institute of Health Sciences in Dharan in the 1990s. In order to transfer wealth from the rich to the poor, the scheme charged four times higher premiums to urban households than their rural counterparts. As a result, the participation rate in this scheme was less than 10% of the target population. Faced with a chronically low participation rate, the scheme collapsed within five years of its first operation (NHEA, 2012).

Only when insurance coverage is provided to a large population (both healthy and unhealthy) can the risk facing both insurers and policyholders be minimised. Patient Protection and Affordable Care Act in the United States (popularly known as Obamacare) aims to maintain the size and mix of both healthy and unhealthy policyholders by requiring everyone to purchase insurance coverage by the end of 2014 or else face financial penalties (US GPO, 2012; Downey, March 24, 2010). In the case of Nepal, given its current tax governance structure, levying a penalty for not buying health insurance is certainly not feasible.

A scheme where premiums are based on individual health risk profiles (such as age, gender, habits, and pre-existing medical conditions) eliminates the uncertainty associated with individual health care expenditure. But this type of discriminatory scheme does not transfer wealth from the healthy to the sick. Nor does it reallocate wealth from the rich to the poor. In effect, this scheme only spreads an individual's expenditure needs across their own lifetime. An individual can also spread the financial risk across their lifespan by saving a part of her current income to defray anticipated expenditure later in life when needed. One such plan which has been implemented in Singapore, China, South Africa and also the United States at a limited level with much success over the past 20 years is the "Medical Savings Account" (Hsu, 2010). In this scheme, every citizen is allowed to save a certain predetermined percentage (with some cap) of her income in their personal Medical Savings Account, which is tax deductible. The savings can be withdrawn or used for (allowed) medical expenses in the future without paying any taxes. This scheme provides incentives to individuals to save now for future use due to its favourable tax implication. However, in the absence of a well-administered personal income tax system, this scheme, although looks promising, cannot be implemented anytime soon in Nepal.

In Nepal where about 25% of population falls below the extreme poverty line (World Bank Country Report, 2013), what matters most is a health insurance policy that also transfers wealth from the rich to the poor and from the healthy to the sick. At the same time, for the scheme to be fully self-financing, revenue raised must fully cover the costs of health care. As Nepal already spends 7-10% of its annual budget on health care (RTI, 2010) and any further increase in this budget is likely to severely compromise other essential services such as education, water supply, and sanitation, a case for a fully self-financing health insurance policy needs no further emphasis.

## 4. The proposed scheme

Unfortunately, there is no single system that achieves all the attributes of an ideal health insurance policy. The proposed scheme, which integrates mandatory enrolment from the formal sector with the government proposed national insurance fund, is likely to be more economically viable and sustainable in the long run as it is likely to be more effective in addressing both the adverse selection and moral hazard problems that have crippled the existing schemes. The two main features of this scheme -- the mandatory enrolment from the formal sector and the cost-sharing arrangement between the policyholders and the insurer -- can potentially address both adverse selection and moral hazard problems, the two principal causes of market failure in an insurance market.

**4.1 Mandatory enrolment, assortment of plans and adverse selection**

The mandatory enrolment from the formal sector employees and their families can ensure at least 3.6 million policyholders, more than 10% of Nepal's population.[vii] It is important to note that out-of-pocket medical expenses account for about 55% of Nepal's health care expenses (MoHP, 2012), most of which comes from this 10% of Nepal's population. Consequently, the mandatory inclusion of this population in the scheme not only takes care of adverse selection problem (that is healthy population opting out of the scheme) but also can significantly diversify financial risk well beyond what a national fund without such mandatory provision could accomplish. Figure 1 shows how the degree of risk diversification or sharing can increase with the number of policyholders. As illustrated in the diagram, the risk diversification is more likely to increase at a decreasing rate as the number of policyholders increases. The exact shape of the curve can vary depending on the local situations, however.

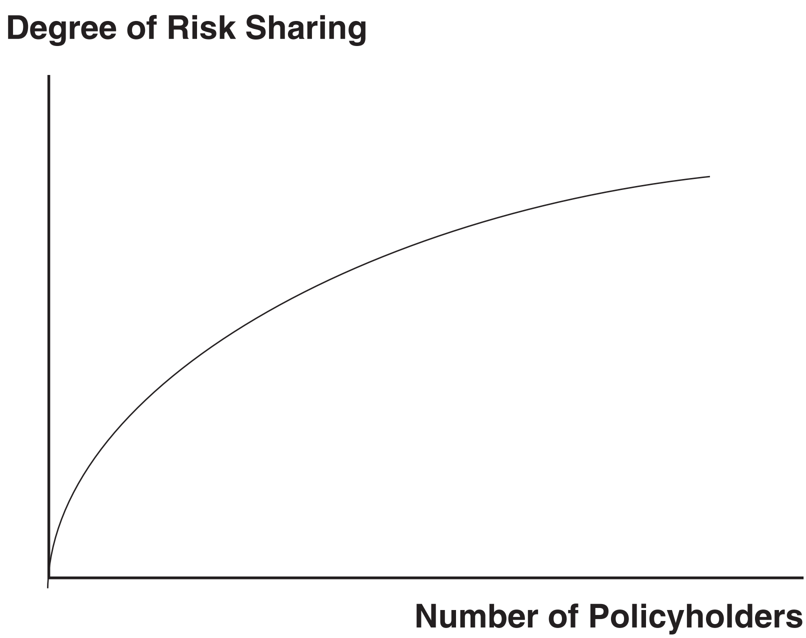



Figure 1: Degree of risk diversification

In an insurance scheme, as long as health care expenditure uncertainties that enrolees face are not perfectly positively correlated,[viii] an increase in the number of policyholders reduces the uncertainties for both the insurer and the policyholders (Martin et al., 1998). This is particularly true if the proportion of healthier policyholders in an insurance pool is relatively high. Since formal sector employees are likely to be healthier than rural population, the proposed scheme can begin with a relatively healthy insurance pool, which is very critical for the financial viability of any insurance scheme. Moreover, such mandatory provision can spread the fixed administrative costs of health care delivery across many policyholders, and consequently help drive the average administrative costs per policyholder down. The proposed national fund with mandatory enrolment for the formal sector is particularly important in developing countries such as Nepal where frequent epidemics of cholera, malaria and other communicable diseases in some localised areas is commonplace. Without a reasonably high number of policyholders, the size of the national fund will be too small and hence the scheme can go bankrupt quickly in the event of such epidemic.

The Ministry of Health and Population (MoHP), in collaboration with private or semi-private insurance companies, can create a national insurance fund where all the premiums raised from across the communities can be pooled together. The Ministry can then develop health insurance packages and claim settlement mechanism. The health insurance scheme consists of an assortment of plans, with better plans requiring higher premiums. Offering numerous plans (different coverage at different premiums) will reduce adverse selection problem as this will allow healthy people to buy cheaper plans and hence prevent them from opting out of the market altogether. This assortment of plans is more important for informal sector (than the formal sector) as buying the plans is not mandatory for the informal sector under the proposed scheme. But, while lowering the adverse selection, this provision would undoubtedly compromise risk-spreading in that sick would pay more than healthy. So, it is important to strike a right balance between the number of plans and risk sharing. Figure 2 illustrates a scheme that performs the best overall when it consists of Q* number of plans. The shape of the curves, and therefore the optimal number of plans (Q*), depends on local circumstances and preferences. Obamacare, for example, consists of four so-called ‘metal plans’—bronze, silver, gold and platinum, the latter being the most expensive one (US GPO, 2010).

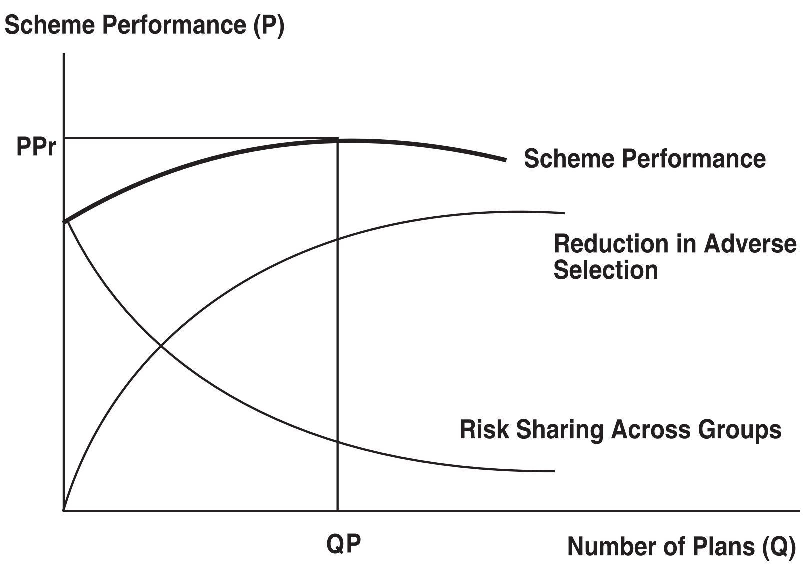



Figure 2: Optimal number of plans

The MoHP with its existing network of hospitals and health posts can act as both insurer and provider of health care. As well, households can buy an insurance package of their choice from a local network of hospitals and/or health posts; they can seek medical services from any hospitals or health posts in the network, depending on the plans they have purchased. Once the service is provided, these hospitals can submit claims to the national insurance fund. If necessary the MoHP can utilise the expertise of private or semi-private insurance companies (such as National Insurance Authority) in administering the insurance claim process. The following schematic diagram summarises how the proposed scheme could work.

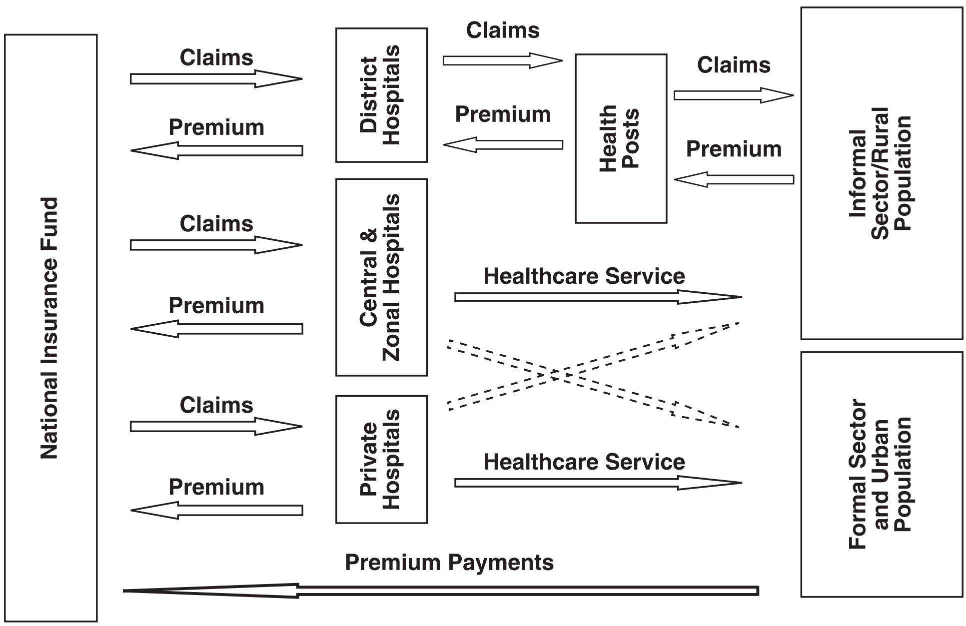



Figure 3: Schematic diagram of the proposed scheme.

### 4.2 Cost sharing and moral hazard

As with any insurance policy, when service providers, particularly private hospitals, are reimbursed based on the services they deliver, they might try to induce policyholders to use an excessive amount of services (McGuire, 2000). For example, a private hospital can encourage a patient to stay longer than necessary at the hospital so that it can claim reimbursement for those extra stays as well. This practice of inducing excessive demands is very widespread in Nepal and many other countries, both developing and developed. To minimise this problem, the MoHP can set an upper limit on the amount of reimbursement a provider can get for the treatment of a particular kind of disease or a medical procedure. The provider-induced demand can be further reduced by having a cost-sharing arrangement between insurers and policyholders whereby policyholders also share a portion of their health care costs. The cost sharing could be in the form of one or more of the following: a) a co-insurance, which requires policyholders to bear a certain fraction of their medical costs, b) a deductible, which requires each policyholder to pay a fixed lump-sum amount out of total medical bill and insurer to pick up the tab beyond that fixed amount, and c) a co-payment, which requires each policyholder to pay a fixed amount for each visit to a service provider. While minimising the overuse of services (popularly known as moral hazard problem) this built-in cost sharing structure can also help make the scheme fully self-financing.

### 4.3 Equity and political issues

Another potential problem is that this scheme might face resistance from formal sector employees who are generally not happy with the mandatory enrolment. However, this problem can be mitigated by offering health insurance packages as a reward or perk rather than a forced policy. Government can provide employers with flexibility when they want to offer health insurance coverage to their respective employees. In turn, employers can offer an insurance package as a perk to their employees instead of a salary raise when the next raise is scheduled. With this type of strategic timing during scheme implementation, employers would not be burdened with extra costs. At the same time, workers would also feel that they are being rewarded with extra perks. It is important to strike this strategic balance because the formal sector employees (particularly the public sector employees) are not only the most advantaged but are also the most powerful lobbying group in Nepal. Care must also be taken to make sure that employees themselves pay for their premiums by strategically timing the introduction of this scheme. To make the scheme more equitable, however, the premium can be assessed as a percentage of employees' salaries. This progressive premium system can also be politically more attractive.

Since this scheme is self-financing, it can free up significant government borne health care costs that can be used for improving existing services to rural population. The freed-up funds can also be used to subsidise the participation from poorer households, particularly those who fall below the poverty line. To determine whether a household falls below the line, the government can require each applicant who requests a subsidy to disclose his/her income in the preceding years. The proposed scheme is thus not only more equitable but also Pareto improving. It is more equitable in that it frees up government resources that can be transferred to rural population. And it is Pareto improving in that it improves services among the existing policyholders without compromising (or even enhancing) the services for yet to be insured rural population. A good example of such a scheme with similar features is that of South Korea, which was started for civil servants in 1977. By mid 1990s, it expanded insurance coverage to 94% of the South-Korean population (Yang, 1996).

## 5. Conclusion

Evidence shows that the success rates of the existing CBHI schemes in Nepal have been low despite very large subsidies from the government and foreign donor agencies. These schemes neither have diversified the financial risk adequately nor have they avoided adverse selection and moral hazard problems. The creation of a national insurance fund can spread the risk of unforeseen expenses to some extent. In the absence of a mechanism for attracting more participation in the scheme, it is hard to foresee how the mere creation of a national fund alone can spread financial risk and, at the same time, address adverse selection and moral hazard problems.

Unlike the government proposed national fund, the self-financing scheme proposed in this paper maintains the size of the pool (both financial and number of policyholders) by mandating that every formal sector employee buy an insurance package of their choice. While maintaining the size of financial pool, the provision for mandatory enrolment also addresses the adverse selection problem. Providing an array of insurance packages with different premiums and coverage will also further help minimise the adverse selection problem. The problem of moral hazard can be alleviated by having a built-in cost sharing structure whereby policyholders also share a portion of their respective health care costs out of their own pockets. Another advantage of the proposed scheme is the built-in economies of scale in health care delivery. As the pool of policyholders gets larger, the administrative costs per enrolee can fall, leading to lower overall average cost of health care delivery. As the government hospitals start enjoying cost savings through scale economies and possibly by ‘learning-by-doing’, such savings can be used in subsidising more participation from the marginalised population and expanding health care facilities to rural areas.

By design, the participation in the proposed scheme starts from formal-sector employees and urban population. The idea is to begin with a fully self-financing insurance scheme and expand it to rural population gradually, ultimately covering the entire nation. Since the formal sector employees and urban population are more likely to be healthier than their rural counterparts, the national fund will be financially healthier to begin with. The (medical) expenses saved on these healthier people can then be used for covering the costs of insuring the rural and marginalised population.

The experience with CBHI scheme in Nepal is not that different from other parts of the developing world. Evidence suggests that most of the CBHI schemes from around the developing nations have low population coverage and have also failed to cover the most vulnerable sector of the society. These schemes have very small risk pools and limited wealth transfer from the rich to the poor or from the healthy to the sick (McIntyre, et al. 2005). In light of this evidence, one might argue that Nepal should implement universal coverage funded by general tax revenue. But given Nepal's almost non-existence tax governing structure, weak political stewardship and limited resources, universal coverage is a very distant reality. In most countries with universal coverage from Costa Rica and Czech Republic to Germany and Japan, it took between 40-100 years to make a transition from partial to full coverage. The only exception was South Korea which did it in just 12 years (WHO 1995). In view of this experience from other countries, a smooth transition from partial coverage to full universal coverage, as proposed in this paper, seems to be the best option for Nepal.

## References

British Council (2003), *Alternate health care financing: Synthesis of existing experience in Nepal*, DFID/District Health Strengthening Project and theILO/ STEP programme. London: DFID.

CBS (2008), *Nepal labour force survey.* Kathmandu: Central Bureau of Statistics, Government of Nepal.

Cutler, D., & Zeckhauser, R.(1997),Adverse selection in health insurance.NBER *Working Paper* No. 6107.

Downey, J. (March 24, 2010), Tax implications of health care reform legislation. *The Boston Globe*.

Health Sector Support Program, (2012), Re*view of community-based health insurance initiatives in Nepal*. Kathmandu: GTZ.

Hsu, Justine, (2010), Medical savings accounts: What is at risk? In: *World Health Report (2010), WHO Background Paper 17*. Geneva: World Health Organization.

Koirala, K. (2009), Nepal govt employees get 4-6 percent hike in salary, NRs 1,200 as dearness allowance. *Asian Tribute*. [online]., Available at: *http://www.asiantribune.com/node/22134*

Martin, S., Rice, N. &Smith, P. (1998), Risk and the general practitioner budget holder. *Social Science and Medicine,* Vol. 47, pp. 1547-1554.

McGuire, T. (2000), Physician agency. In: Newhouse J. P. & Culyer, A. J. Eds., *Handbook of health economics*, Amsterdam: Elsevier.

McIntyre, D; Gilson, L; Mutyambizi, V. (2005). Promoting equitable health care financing in the African context: Current challenges and future prospects. *EQUINET Discussion Paper*. [online]. Available at: *http://www.equinetafrica.org/bibl/docs/DIS27fin.pdf.*

MoF (2012), *Immediate action plan on economic development and prosperity*. Kathmandu: Ministry of Finance, Government of Nepal.

MoHP (2012), *Nepal national health accounts, 2006/07–2008/09*. Kathmandu: Health Economics and Financing Unit, Ministry of Health and Population, Government of Nepal.

NHEA (2012), *Nepal national health insurance policy*. Kathmandu: Nepal Heath Economics Association.

RTI (2010), Healthcare financing in Nepal. *HSRSP Report* No. 2.21-5-10.

Saksena, P., Xu, K. & Durairaj, V. (2010), The drivers of catastrophic expenditure: Outpatient services, hospitalization or medicines? *World Health Report, Background Paper # 21*. Geneva: World Health Organization.

Smith, P. and Witter, S. (2004), Risk pooling in health care financing: The implications for health system performance. *HNP Discussion Paper*. Washington, D.C.: The World Bank.

US GPO, (2010), Patient protection and Affordable Care Act. [online]. Available at: *http://www.gpo.gov/fdsys/pkg/BILLS-111hr3590enr/pdf/BILLS-111hr3590enr.pdf.*

World Bank, (2013), *Country report.* [online]. Available at: *http://data.worldbank.org/country/nepal*

WHO, (2013), *Providing for health in Nepal*. Geneva: World Health Organization.[online]. Available at: *http://www.who.int/providingforhealth/countries/Nepal/en/index.html*

Yang, B. (1996), "The role of health insurance in the growth of the private health sector in Korea," *International Journal of Health Planning and Management*, Vol. 11, pp 231-252.

[i] Under an insurance plan, premiums raised from policyholders are pooled into one large fund. Then when one of the policyholders has medical expenses, he/she is reimbursed fully or partially by the fund. Currently, there are many health insurance schemes in Nepal, operated at local levels by nongovernmental organizations, labor groups and local communities. Some of these are funded and operated by the government run hospitals or health posts.

[ii] In an insurance market, the larger the number of policyholders, the higher the financial risk diversification or spreading. In the parlance of the insurance market, such risk diversification is also called risk pooling.

[iii] For example, the annual government subsidy or grant per enrolled household divided by the annual premium paid by the household (called grant premium ratio) ranges from 1.3 in Mangalabare to 5.2 in Dumkauli scheme (Health Sector Support Program, 2012).

[iv] A claim ratio that is higher than 100% indicates that the insurance claims paid out to service providers is higher than the revenue raised in premiums.

[v] There are some exceptions; however, in 2007, the government made all services up to primary health care center level and 35 medicines free for everybody. The services up to district level hospitals were also made free to six target groups: poor, ultra poor, female community health volunteers, senior citizens above 60 years old, helpless and disabled (Health Sector Support Program, 2012).

[vi] Wealth transfer from the rich to the poor occurs only when the rich pay higher premium than the poor for the same insurance coverage. Similarly, financial risks are transferred from the sick to the healthy only when both groups pay the same premium irrespective of their health care uses. Risk is transferred in the sense that healthy policyholders pay for the care of the sick.

[vii] This calculation is based on the estimation that the formal sector in Nepal consists of about 1.2 million employees and that one employee on the average covers 3 household members. There are about 425,000 government employees (Koirala, 2009), 100,000 armed and regular police force, 95,000 army (wikipedia) and about 300,000 semi-public sector employees. In addition, there are over 230,000 teachers (Education in Nepal, wikipedia).

[viii] For example, if a cholera epidemic hits a particular area, then every individual in the area will be adversely affected. This situation when one is affected all others are affected too poses a perfectly correlated risk. Other similar examples are: damages caused by hurricanes, earthquakes, etc.

# Brief Biography of Editors, Theme Editors and Contributors

## EDITORS:

**Adhikari, Dr. Ambika P.** also serves as a theme editor of two themes: (i) Development Policies, Human Resources and Sustainable Livelihoods, and (ii) Health and Sustainable Livelihoods. Dr. Adhikari is Portfolio and Program Manager (Research) at Office of Knowledge Enterprise and Development (OKED), Arizona State University. He is also a Research Professor (affiliate faculty) at the School of Geographical Sciences and Urban Planning, and Senior Sustainability Scientist at the Julie Ann Wrigley Global Institute of Sustainability. He worked as Senior Planner at SRPMIC, Scottsdale, Arizona, and Village Planner and Project Manager at City of Phoenix in Arizona. He was International Programs Director at DPRA Inc. in Toronto and Washington DC. In Nepal, Ambika was the Nepal Country Representative of the Switzerland based IUCN – International Union for Conservation of Nature. His international professional experience in urban planning, environmental policy and economic development spans more than 25 countries. Earlier, he was Associate Professor of Architecture and Planning, Institute of Engineering, Tribhuvan University. He also served as a Member of Water and Energy Commission, Government of Nepal. Ambika received Doctorate in Urban Design and Planning from Harvard University. He was a Fellow at the Special Program for Urban and Regional Studies (SPURS) at MIT. He received M. Arch. from University of Hawaii, and B. Arch from M. S. University of Baroda. He has held several leadership positions in NRNA, the Nepali Diaspora Association, and has widely lectured and presented papers in numerous international conferences and seminars. He has authored one and co-edited four books, and published numerous reports, and articles in journals. He is a Fellow of the American Society of Nepalese Engineers, and a Member of the American Institute of Certified Planners (AICP). Ambika serves as Advisor for Canada Foundation for Nepal (CFFN).

**Dahal, Dr. Govinda P.** also serves as a theme editor of two themes: (i) Development Policies, Human Resources and Sustainable Livelihoods, and (ii) Health and Sustainable Livelihoods. Dr. Dahal is a Senior Researcher at the Bryere Research Institute (BRI) and Faculty of Medicine at the University of Ottawa, Canada and works in the area of population health/epidemiology. He is also the Executive Director of Canada Foundation for Nepal. He is helping to build capacity on evidence-based health policy and practices and critical care management of hospital systems in Nepal, working with the teams of BRI, and Royal College of Physicians and Surgeons of Canada. He is former Executive Director of the Centre for Nepal Studies, UK. He previously worked for the United Nations Economic Commission for Europe, Geneva, World Health Organization-Geneva, DFID-Health Resource Center-UK and Johns Hopkins University as researcher/consultant in the area of population health and statistics. He also served as an advisor for NRN-UK (2008-2009). He holds a PhD degree in Social Statistics/Demography from the University of Southampton, UK, and MAs in Demography/Epidemiology/Population Studies from ANU Canberra and Nepal. He has authored one book, seven book chapters and more than 25 peer reviewed journal articles and reports- to his credit. He was born and raised in a rural village – Prapcha, Okhaldhunga – eastern part of Nepal.

**Mahat, Dr. Ishara** also serves as a theme editor of two themes: (i) Development Policies, Human Resources and Sustainable Livelihoods, and (ii) Health and Sustainable Livelihoods. Dr. Mahat is a lecturer of development anthropology at the University of Ottawa and Carleton University. Her research interests are development and underdevelopment, poverty and wellbeing, social change, gender and energy, and participatory research methodologies. She has worked as a Gender Consultant with the McGill Institute of Global Food Security. She also served as a consultant with different international agencies like CIDA, UNICEF and UNDP in the capacities of project development and planning, monitoring and evaluation for gender mainstreaming projects in Nepal. Dr. Mahat was a Visiting Scholar with the Institute of Women and Gender Studies at University of Toronto. She completed her Ph. D. in the Development Studies with a focus on gender and energy from Massey University New Zealand. She continued her Post Doctorate research at the University of Western Ontario further examining gender energy and poverty issues in the South Asia.

**Regmi, Dr. Bishwa** also serves as a theme editor of Natural Resources and Sustainable Livelihoods. Dr. Regmi has over a decade of experience in research studies and development actions in Nepal and abroad. He has worked on research and development projects in association with not-for-profit sectors in Nepal. He has led or contributed a wide range of research, development, training and publications with emphasis on agroforestry, community forestry, rural livelihoods, participatory action research, business plan development, and community mobilisation. He did doctoral research in Livelihoods (International and Rural Development) from University of Reading. He has some published and unpublished research publications to his credit. He served as secretary of CFFN since 2011.

**Subedi, Dr. Kalidas** also serves as a theme editor of Agriculture and Sustainable Livelihoods. Dr. Subedi has specialised in crop physiology, plant nutrition, and sustainable soil and crop management. He has over 25 years of experience in agricultural research, technology transfer and projects management. Since 2002, he is working with the Government of Canada as a Study Lead. He worked as a Senior Program Officer in Sustainable Soil Management Program, as a Senior Crop Scientist with DFID-UK supported Lumle Agricultural Research Centre, and Agronomist, with the Department of Agriculture, Nepal. Dr. Subedi has earned his Ph.D. and Master's degrees from the University of Reading, and B.Sc. (Hons) Ag. From Haryana Agricultural University. He has published over 60 papers in leading international journals, books and book chapters, over 100 research papers, training manuals, and proceedings. Dr. Subedi is the recipient of several awards and reorganisations including Youth Scientist Award by Nepal Academy of Science and Technology (NAST). He was born and raised in a subsistence farming family in Nepal.

**Shrestha, Dr. Bharat M.** also serves as a theme editor of Natural Resources and Sustainable Livelihoods. Dr. Shrestha is an active research professional with 15+ years' experience in forest, soil and natural resources management in government, academic, and industry sector. Expert in environmental analysis, forest inventory, ecosystem modelling, statistical analysis and community mobilisation. Excellent research and analytical skills with a track record of publications in a peer reviewed journals. Demonstrated expertise in remote sensing and GIS, project planning, and coordination and management. His research areas includes applied ecology, land use, land use change and climate change. He served as an executive member of CFFN since 2011.

## CONTRIBUTORS:

**Acharya, Dr. Umesh K.** is a Horticultural Scientist in Nepal Agriculture Research Council (NARC) since 2004. He worked in mid- to far western hill districts of Nepal. Mr. Acharya had completed his Bachelors and Masters' degree in Horticulture from the Institute of Agriculture and Animal Science, Tribhuvan University. He was awarded with Australia Awards to pursue Ph.D. in Central Queensland University. His Ph.D. research focus was on non-invasive assessment of fruit maturity and ripening using near infrared spectroscopy, a crucial tool for rapid assessment of fruit quality and applicable for fruit growers, wholesalers and instrument developers. He has published more than a dozen of horticulture related research articles on national and international journals. Dr. Acharya has interest in postharvest and supply chain management of fruit.

**Adhikari, Dr. Bhim** also serves as a theme editor of Natural Resources and Sustainable Livelihoods. Dr. Adhikari is an environmental social scientist working as a Senior Program Specialist at the International Development Research Centre in Ottawa, Canada, whose expertise includes the connections between poverty and environmental degradation, as well as forestry, climate change, rural livelihoods, ecosystem services and natural resource management. Before joining IDRC, Adhikari worked with a number of organisations and academic institutions, including the Institute for Water, Environment and Health, the United Nations think tank on water. At International Union for Conservation of Nature (IUCN) in Pakistan, rural energy project at the United Nation's Development Program in Nepal. Adhikari holds a PhD in environmental economics and management from the University of York, UK. There are several publications to his credit.

**Adhikari, Dr. Kedar N.** also serves as a theme editor of Agriculture and sustainable livelihoods. Dr. Adhikari was born and raised in Astam, Kaski district in Nepal. He completed B.Sc. (Hons) Ag. from the Haryana Agricultural University, India; M.Sc. in plant breeding from the University of Manitoba, Canada and Ph.D. in genetics and plant breeding from the University of Sydney, Australia. He has more than 25 years of experience in breeding different crop varieties in Nepal and largely in Australia. His focus has been mainly on grain legume improvements as a breeder with the release of a number of varieties of lupins and faba bean in Australia. For the last five years, Dr. Adhikari has been leading the pulse breeding program at the University of Sydney. Apart from breeding, Dr. Adhikari supervises post-graduate students in the field of plant breeding and genetics and has published more than 50 peer reviewed scientific papers in the international journals and conference proceedings.

**Adhikari, Dr. Krishna** is a Research Fellow at the Institute of Social and Cultural Anthropology, University of Oxford and Co-Investigator of ESRC Funded project on Caste, Class, and Culture (2013-17). Previously, he was a Research Associate for AHRC-ESRC-funded University of Oxford/ CNSUK project on Vernacular Religion in the Nepali Diaspora, and subsequently a John Fell Fellow (2012-13). He is affiliated to the Centre for Nepal Studies UK (CNSUK) as a Senior Researcher. He was the Executive Director of CNSUK between 2010 and 2011. He holds a PhD from the University of Reading on the dynamics of social capital and community institutions, for which he carried out intensive fieldwork in Nepal. His other past researches include Nepali diaspora, forest tenure and management regimes in Asia, community organisations, and local self-governance. Initially he worked for 12 years as a practitioner, manager and researcher in the field of rural development in Nepal.

**Bastakoti, Dr. Badri P.** has been working in the field of industrial, enterprise, rural and institutional capacity development for over 20 years in Nepal and abroad. His expertise are in the areas of economic and financial analysis, feasibility studies for the industries and small enterprises, comprehensive business planning, market development, value chain analysis, entrepreneurship, cooperatives and institutional development. He holds an MA in Industrial Development from the UEA in UK and earned a PhD in International and rural development from the University of Reading, UK. His research has focused on the issues of livelihoods diversification in the rural households through enterprise development in the post electrification phase. He also worked for the Nepal based international NGOs: UNDP, FAO and EU funded projects and private sector agencies.

**Bhattarai, Dr. Suryahas** specialised on crop physiology and agronomy for sustainable crop production system. He has over 20 years of experience on agriculture research. Currently, he is working as the Research Fellow at the Central Queensland University, Australia. He has worked as Assistant Professor, at the IAAS, Tribhuvan University and as a Horticulturist at Lumle Agricultural Research Centre. Dr. Bhattarai has earned his Ph.D. degree in crop physiology from the Central Queensland University, Australia in 2005. He has a master's degree in crop physiology from the University of Essex, UK, and B.Sc. (Ag) degree from the IAAS Rampur, Nepal. Dr. Bhattarai has published several research papers in national and international referred journals, proceedings, technical reports, and book chapters.

**Dhakal, Prof. Durga D.** has Specialised in horticulture. He has acquired Ph.D. degree in horticulture from the University of the Philippines at Los banos (UPLB), Philippine. He has several year of involvement with the higher education in agriculture for Nepal. He had served as the Dean of the Institute of Agriculture and Animal Science (IAAS), Tribhuvan University, Nepal. Currently, he is actively involved in different sustainable agricultural research and development projects in Nepal in collaboration with national and international institutions.

**Dhital, Dr. Bishnu Kumar** grew up in a remote rural farming household of Gorkha, Nepal. He has earned Master's degree on crop production from The University of Reading, UK and PhD on potato seed tuber physiology from the University of Newcastle, UK. During his over 25 years of professional experiences, Dr. Dhital has accumulated wealth of experience in agricultural research, sustainable livelihood improvement, local governance and promotion of grass-root level institutions Nepal. His major specialisations include—vegetables, potatoes and field crops production with low external inputs, sustainable soil management, participatory program planning, monitoring and evaluation, decentralised and participatory approach of agriculture extension, and development of grass-root level institutions. Currently he is working as an Agriculture Specialist in Food and Agriculture Organization (FAO) of the United Nations in Nepal.

**Dhital, Dr. Narayan P.** is a Forest Management Planning Expert at Forest Service branch of the Saskatchewan Ministry of Environment, Canada. His working area include sustainable forest management criteria and indicators, forest management planning and monitoring, woodland caribou range planning, forest growth and yield modeling, assessment of climate change impacts on forests, REDD+, community forestry and forest ecosystem modeling. Narayan was involved in registration of an NGO (collaboration-quebec-nepal.org) based in Quebec and served three terms as a member of the board of directors. He is also providing consultation services to UNFCCC secretariat. He previously worked as a post-doctoral fellow at University of Quebec, Canada, community development specialist at The Mountain Institute, USA and community forestry practitioner in Nepal. He holds a PhD an MSc degrees in forest science from Laval University, Quebec, Canada and Wageningen University, The Netherlands respectively. There are some research publications to his credit. He can be contacted at narayan-prasad.dhital.1@ulaval.ca.

**Di Falco, Dr. Salvatore** is a Professor in Environmental Economics at the Economics Department of the University of Geneva. He was awarded a MSc in Economics and a PhD in Environmental Economics from the University of York (UK). He also holds a Doctorate in Agricultural Economics from the University of Catania (Italy). He held a Lectureship in Environment and Development at the LSE and in Applied Economics at the University of Kent. He is an Associate Editor of Environment and Development Economics (Cambridge University Press) and of Food Security (Springer).

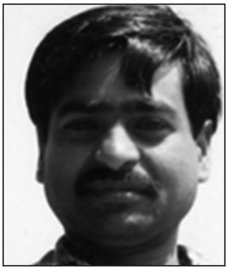
**Gautam, Dr. Sishir** is a Project Manager at Vitesse Re-Skilling Canada since February 2014. He has expertise in ecosystem modeling, climate change, carbon flux dynamics, forest management, project development, GIS and remote sensing. His professional expertise is built on a strong technical foundation, gained by working in various countries (Nepal, Finland, Austria, Gabon and Canada). He worked as an Assistant Forester to Tree Canada in 2013. He also worked as a Researcher (Ecosystem Modelling) at the University of Natural Resources and Life Sciences Vienna (BOKU) from 2008-2012 and as a Forest Ranger at the Department of Forests, Nepal from 1998-2007. He holds a PhD in Forestry from BOKU, Austria and a

Double Degree Master of Science in European Forestry (MScEF) from BOKU and University of Joensuu, Finland. He has published articles in scientific journals and presented in international conferences.

**GC, Dr. Yubak Dhoj** is currently Director General (DG) of the Department of Agriculture, Nepal. Prior to this, he was the DG of Department of Environment. He also served in various other positions including Program Director and National IPM Co-ordinator, Plant Protection Directorate, Agricultural Development, Assistant Professor, Tribhuvan University, Institute of Agriculture and Animal Science (IAAS), Entomologist at Lumle Agricultural Research Centre, and Technical Officer with Nepal Agriculture Research Council (NARC). Dr. GC has earned his Ph.D. in entomology in 2007 from Basel University, Switzerland, and Master's degree in plant protection from The University of Reading UK, and B.Sc. (Ag) from the IAAS. Dr. GC has published several research papers in national and international journals, working papers, and books including Pest Control, Plant Clinics, Biopesticides and Chemical Pesticides both in English and Nepali languages.

**Joshi, Dr. Krishna D.** is Senior Scientist with the Global Wheat Program at the International Maize and Wheat Improvement Center (CIMMYT) based in Pakistan. Before this, he was based in CIMMYT South Asia Regional Office in Kathmandu, Nepal for 11 years where he coordinated agricultural research for development (AR4D) projects in Bangladesh, Nepal and India managed by the Centre for Advanced Research in International Agricultural Development (CARIAD) at Bangor University, Wales, UK. He has contributed to the development of 10 varieties of cereals and five varieties of grain legumes released in Nepal while rice varieties he developed were also adopted in Bangladesh and India. Dr Joshi was instrumental in developing simple participatory approaches to crop improvement, varietal selection, fast-tracking varietal deployment and seed enterprise development. He has published more than 20 peer-reviewed articles and book chapters. He earned his Ph.D. at the University of Wales in Bangor, Wales, UK.

**Khatiwada, Mr. Bed Kumar** was born and raised in a farming family in Central Nepal. Mr. Khatiwada is a horticulturist by study and gained experiences of working with farming families in sustainable livelihood and economic empowerment issues for 8 years. Mr. Khatiwada got opportunities to see farming systems of Australia, Netherlands, Germany and USA while working in different development projects. He believes the agriculture based development initiatives should be geared up in Nepal by private sectors investment for agri-enterpreneurship with focus on quality and export. He is currently undertaking his Ph.D. study at the Central Queensland University, Australia in postharvest horticulture with focus on non-invasive fruit quality assessment.



**Lohar, Dr. Dasharath Prasad** grew up on a subsistence farm in rural Nepal. He earned Bachelor's degree from Tribhuvan University in 1989. From 1990 to 1997, he worked on horticultural research, particularly vegetable breeding. During this time, he earned Master's degree in plant breeding from the University of London. One of his contributions while in Nepal was the identification of determinate cowpea varieties with tender pods. He completed his Ph.D. in Plant Physiology and Genetics from University of Tennessee, USA in 2001. He worked as a research associate at North Carolina State University and University of Minnesota. Dr. Lohar has authored many publications while in academia. He joined BASF Plant Science in 2007. As a Senior Scientist, he continues to work on trait research in maize, soybean and rice. DR. Lohar has also acquired an MBA degree, and is actively involved in innovation management for bringing out the best in scientists for the benefit of farmers.

**McDonald Judy** is the Associate Director of the Operational Readiness Unit for the Centre of Risk Science with the Faculty of Medicine at the University of Ottawa. She has authored books on mental preparedness for high-risk occupations, such as for surgeons, air traffic controllers and for police entitled Gold Medal Policing: Mental Readiness and Performance Excellence. She has designed a research framework for operational readiness based on work with Olympic athletes. This has led to evidence-based tools for recruitment, curriculum development, scenario-based training, e-learning and evaluation. Her background also includes teaching in the School of Human Kinetics and serving as Faculty Council Member in Health Sciences at the University of Ottawa. McDonald's experience also includes extensive municipal program-event management and public-private partnerships.

**Pandey, Dr. Raju Raj** was born and raised in rural areas of Nuwakot district, Nepal. He received his BSc Ag from Punjabrao Agricultural University, India, MSc from University of Reading, England and PhD from University of Hawaii at Manoa, USA. After teaching plant pathology at IAAS, Rampur for four years (1985-1990) he moved to Lumle Agricultural Center as Entomologist where he initiated works on indigenous biological control agents of insect pests of tomato and citrus (1990-1997). Later, he developed method for mass production of a parasitic wasp to control pineapple mealybug in Hawaii. He also contributed to development of IPM technologies to suppress fruit flies in Hawaii (1997-2005). Since the beginning of 2010, he is stationed in Riverside, California and working on developing technologies for production of biological control agents of Asian citrus psyllid, a vector of

Huanglongbing, a deadly disease of citrus. His main interests are IPM, biological control and organic agriculture.

**Panthee, Dr. Dilip Raj** is an Assoc. Professor in the North Carolina State University (NSCU) since 2008. He has earned his Ph.D. degree in plant breeding and genetics from the University of Tennessee (UT) in 2005, an M.Phil. Degree jointly from the University of Birmingham and The University of Reading, UK, and undergraduate degree in agriculture from IAAS- Rampur, Nepal. He started his professional career as a Seed Technologist at Lumle Agriculture Research Center. He joined the Department of Plant Breeding at IAAS in 1998. He came to USA in 2001 to pursue his Ph.D. He continued his research as a Post-Doctoral Research Associate at UT. Currently, he is leading tomato breeding program at the NSCU. Dr. Panthee has released 6 hybrid cultivars and 6 breeding lines of tomato. He has published more than 50 refereed journal articles, 40 Abstracts and four book chapters.

**Paudel, Dr. Naya Sharma** is a senior researcher at ForestAction Nepal, a Kathmandu based forestry research institution. He did his doctoral research in political ecology from Reading University (UK), and has been working in Nepal and in the region for over two decades. He has gained rich insights of research and development experiences on forest tenure, environmental governance, participatory resources management and sustainable livelihoods.

**Rasali, Dr. Drona** is the Director of Population Health Surveillance and Epidemiology at the Provincial Health Services Authority in British Columbia of Canada. His professional background is from veterinary medicine, with specialisations in health-related sciences including pathology, endocrinology, quantitative genetics and epidemiology. In his career path between 1980 and 2003, he held various roles from veterinary officer to senior scientist (veterinary) with the Government of Nepal, working in the field of veterinary services and livestock development. For one year, he worked in a national epidemiological project studying food safety traceability systems in Canada that involved both veterinary and public health. In 2005, he joined the Saskatchewan Ministry of Health as a provincial chronic disease epidemiologist. After his seven year tenure there, he moved to his current role in 2012. He received his professional degree in veterinary medicine from the University of Agricultural Sciences, Bangalore (India), Post-Graduate Training in Veterinary Pathology from Western Australia Animal Health Laboratories, M.S. degree from the University of the Philippines at Los Banos, a short research fellow term in animal genetics at the University of Aberdeen, Scotland (UK) and Ph.D. degree from the University of Manitoba, Canada. He also holds a position of adjunct Professor at the University of Regina, Saskatchewan, Canada.

**Rijal, Mr. Baburam** is currently a PhD Candidate at Laval University, Canada. Introducing to forest science from basic sciences and statistics background, he has expertised his professional skills in quantitative research in natural resources, specially growth, development and disturbance dynamics of bio-products and environment for science and management. He has several published and unpublished worked in the quantitative methods in forestry. Before resuming his graduate life, he served for people-centered project planning and management through working in government and non-government organisations in Nepal for over a decade.

**Sharma, Dr. Sharad Kumar** is an Under Secretary (Statistics) at the Ministry of Culture, Tourism, and Civil Aviation Kathmandu Nepal. Previously, he worked with Department of Health Services, Teku, Kathmandu and IPAS Nepal as Monitoring and Evaluation expert. He did his PhD in Demography from Mahidol University, Bangkok and M. Sc. in Statistics from Tribhuvan University Nepal. He has many publications in national and international peer reviewed journals to his credit.

**Shrestha, Mr. Him Lal** is pursuing his PhD research on Carbon stocks under different land management regimes in Nepal from Kathmandu University. He has done Master's degree in Geoinformatics from IIRS, India and ITC, the Netherlands jointly. His main competency is on application of GIS and Remote Sensing in forestry. Since 2001, he worked with various organisations, academic institutions, NGOs and INGO in the field of natural resource management and conducted various trainings on the application of Geospatial technologies in forestry sector. From 2001 to 2002, he worked with ForestAction as Research Officer. Then, he worked as Academic Coordinator and Faculty with Kathmandu Forestry College from 2006 to 2010. He has published his work on renowned international journals and also presented his research work in many conferences.

**Shrestha, Dr. Ratna K.** is a visiting professor at the Faculty of Medicine and Vancouver School of Economics, University of British Columbia. His main research interest is in Environmental Economics with a particular focus on Mechanism Design. His first paper published in 1998 introduces citizens' participation in Emission Trading and demonstrates that such participation can enhance efficiency in environmental pollution control. Since then this paper has generated many follow up papers.

**Sloan, Mr. David** graduated from Muhlenberg College in Pennsylvania with a degree in political science in 1970. He began his career in publishing as a sports writer for a small town newspaper in New York. He joined Time Inc. in 1972 and became the director of editorial operations for Fortune Magazine. After retiring in 2009, he has continued as a freelancer with Time. His main responsibilities in addition to the production of Fortune Magazine focus on the management of Time Life Books. He also provides editorial input on research projects and publications.

**Subedi, Mr. Madhusudan** is a Professor in Patan Academy of Health Sciences, Department of Community Health Sciences, Nepal. He is also associated to Central Department of Sociology and Anthropology, and MPhil Programme in Sociology, Tribhuvan University (TU). Subedi holds an MA in Sociology (1992) from TU, Nepal and M.Phil. in Social Anthropology from University of Bergen, Norway (2000). Subedi has authored a book 'Medical Anthropology of Nepal (2001)', co-authored 'Role of Natural Products in Resource Management, Poverty Alleviation and Good Governance (2006)', The State of Sociology and Anthropology: Teaching and Research in Nepal (2014) and has published more than 30 articles in different academic journals..

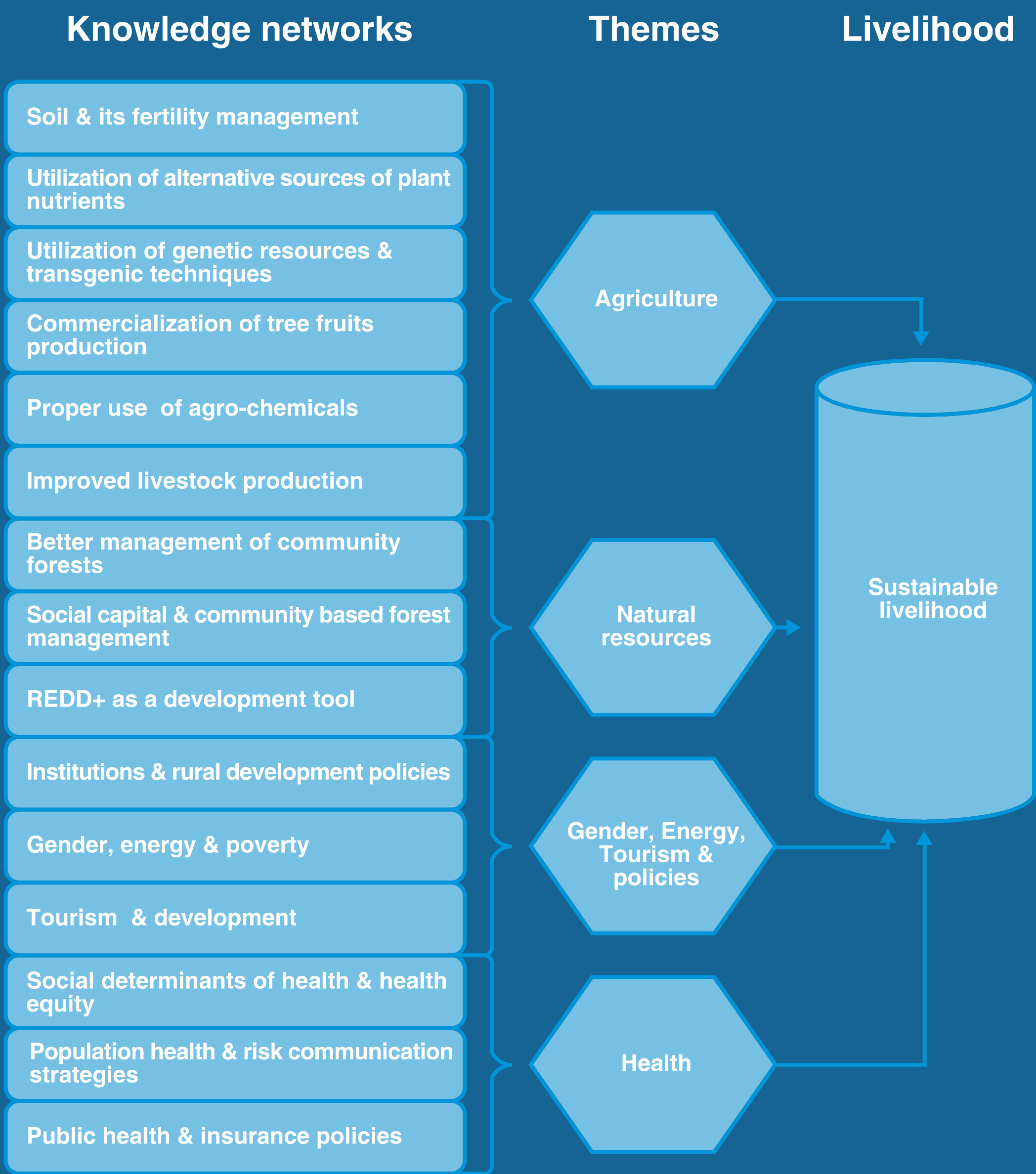
**Subedi, Dr. Phul Prasad** was born in remote village in Parbat district, Nepal. Currently, he is working as a Senior Research Fellow at Central Queensland University (CQU), Australia. He has 30 years of experience in horticulture gained in Australia, China, New Zealand, Nepal, and UK. He has obtained his postgraduate degrees (MSc, Ph.D.) in crop and horticulture disciplines from University of London, UK and CQU, Australia. He has been involved in R & D projects with tropical, sub-tropical and warm temperate horticulture crop industries particular focus on quality control and supply chain management. He has published over 100 conference proceedings, refereed journal articles and book chapters. In recent years, his research focus is on "Instrument and Technology training in Near Infrared spectroscopy (NIR) as non-invasive technology to assess fruit maturity on-tree and in-line internal quality detection of range of fruit crops." He is also currently involved as a Team Leader of an Australian Aid supported project in Nepal on improving mandarin supply chain management for domestic and export markets.

**Tripathi, Dr. Bhaba P.** has over 30 years of experience in soil science. Currently, he is working as Senior Associate Scientist with the International Rice Research Institute (IRRI)-Nepal. Before joining IRRI in 2005, he worked as Team Leader in Sustainable Soil Management Programme (SSMP), as the Head of Technical Division and Senior Soil Scientist in Lumle Agricultural Research Centre, and as a Soil Scientist in the Department of Agriculture in Nepal. He has acquired Ph.D. in soil science from the University of Philippines, MS. (Soil Science) from Central Luzon State University, Philippines, and B.Sc. (Ag) from Punjab Agricultural University. He has published 18 peer reviewed articles in different international and national journals, and several papers in proceedings. He is the recipient of National Award by National Academy of Science and Technology, and Gold Medal by the King of Nepal for the highest Grade Point Average in M.Sc.

**Tyshenko, Dr. Michael G.** holds the McLaughlin Chair in Biological Risk Assessment at the University of Ottawa, Ottawa, Canada. His academic background includes a Ph.D. in Molecular Biology, a MPA in Public Administration and post-doctoral training in Health Sciences, Public Health Policy and Health Risk Communication. His work in health communication explores the public policy interface between scientific research, technological risks and impacts upon society. He has published extensively on a variety of health risk communication areas including: expert opinion of transmissible spongiform encephalopathies uncertainties; equity and social justice of medical nanotechnology development; infectious disease transmission linkages with health risk communication; and increasing awareness of noncommunicable disease risk factors through new technologies such as mobile Health and Telemedicine.

**Walsh, Dr. Kerry B.** is a Professor of Plant Science at Central Queensland University, Rockhampton, Australia where he has worked in the field of fruit quality assessment, in terms of both on-tree and in-line applications. His postgraduate training (MSc, Ph.D.) was obtained at Queens University, Canada, and his undergraduate training at University of Queensland, Australia. He has published over 100 refereed articles and book chapters. He is currently involved in an Australian Aid supported project in Nepal that is striving to achieve a better market price for mandarin. Entry to the Bhatbatani retail chain has been achieved, and export to Tibet is targeted.

# Index

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