Human Development Report
Croatia 2008

A Climate for Change

Climate change and its impacts on society and economy in Croatia

UNDP Croatia

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FOREWORD

Dear Reader,

I have great pleasure in presenting to you one of the first UNDP National Human Development Reports concerning the most prominent challenge of our time – climate change and its impact on our society and economy. It is a breakthrough report for Croatia and the first of its kind following the new analysis released by the International Panel on Climate Change (IPCC). More reports from other countries will follow in the coming years and will highlight the vulnerability of individual countries and the issues that the South and Central European region face because of climate change.

Climate change is not only about polar bears and glaciers and it does not happen just because somebody else is burning more fossil fuel than we are, meaning that they should act first and we can follow later. It is not only about complying with the Kyoto Protocol or new European Union targets. It has far more to do with the quality of life and with the choices of every Croatian citizen. Its impacts will be felt in Croatia even though Croatia's greenhouse gas emissions account for only about 0.1% of global emissions. The impacts of climate change bring significant risks for the future and perhaps some opportunities for each of us. We have a responsibility to do something about it, to manage that risk and to mitigate the damage in the most effective way.

It is a scientifically proven fact, recognised by a Nobel Prize last year, that the climate is changing and humans are at least in part responsible. It is obvious that the consequences of that change and of climate variability are already being felt all over the globe. Croatia is not an exception. With this Report, we have accounted for and quantified the damages in several sectors of the Croatian economy over the past several years as a result of climate variability. Agriculture, fisheries, health, hydropower, tourism and the coastal zone - the sectors we have analysed - represent 25% of the Croatian economy, employ almost half the working population and represent a total annual GDP of 9 billion Euro.

Because climate change is such a broad-based and multi-sectoral issue, the Government, business and civil society will need to be engaged in the discussion on what Croatia does to address it. Our aim is to inform those involved in this discussion, to break the silence and to illustrate the linkages between climate change and human development, ranging from health impacts to economic damage.

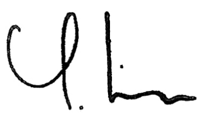
The potential exists to influence new thinking about adaptation and mitigation of climate effects in Croatia. First, agriculture and coastal tourism are important to the economy. Both sectors are vulnerable to climate change and low-income Croatians in these sectors would be more vulnerable to the negative effects and to the rising costs of adapting to them.

Second, the country is at a crossroads: emissions of greenhouse gases have rebounded to 1990 levels and are increasing. While Croatia is on target to meet its obligations under the United Nations Framework Convention on Climate Change and the Kyoto Protocol (with its promised 5% reduction from 1990 levels), it will need to pursue emissions reductions measures in the post-Kyoto period. This is especially true given the EU-wide target of a 20% cut in emissions from 1990 levels by 2020. How the Government chooses to reduce emissions will affect the economy as a whole.

Both the Government and citizens are concerned and interested in the climate change issue. The Government is already pursuing several strategies to reduce greenhouse gas emissions, thus allowing the Human Development Report to focus on identifying key gaps and to provide specific recommendations on "climate-proofing" human development strategies. In addition, the Report can help to address public concerns: in a recent survey, 8 out of 10 Croatians felt that climate change was really happening, and of that group, 4 out of 10 thought it worse than experts were saying.

While this Report is not meant to be a comprehensive overview of all aspects of climate change, it does reflect the breadth and depth of research that has been done in many sectors to date, and it provides a link between a global phenomenon and the everyday human development issues facing Croatia. The research and analysis in this Human Development Report indicates that, while climate change is likely to pose serious threats to human development in Croatia, it also has the potential to bring several beneficial opportunities. The "climate for change" that currently exists in Croatia will provide the country with the motivation it needs to rise to the challenge.

Yuri Afanasiev



Resident Representative
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ABBREVIATIONS

ADAM – Adaptation and Mitigation Strategies

AWU – Average annual working unit

BAT – Best available technology

BAU – Business as usual

CAEI – Croatian Agricultural Extension Institute

CARDS – Community Assistance for Reconstruction, Development and Stability

CBA – Cost-benefit analysis

CBS – Croatian Central Bureau of Statistics

CDM – Clean Development Mechanism

CEA – Croatian Environment Agency

CES – Croatian Employment Service

CFLs – Compact fluorescent light-bulbs

CGE – Computable General Equilibrium (model)

CNG – Compressed natural gas

CODEF – Central Office for Development Strategy and Coordination of EU funds

COST – European Cooperation in the field of Scientific and Technical research

CW – Croatian Waters

DHMZ – Meteorological and Hydrological Service of Croatia

DIVA – Dynamic Interactive Vulnerability Assessment

DSSAT – Decision Support System for Agrotechnology Transfer

EC – European Commission

EEA – European Environment Agency

EIONET – European Environment Information and Observation Network

ENSO – El Niño Southern Oscillation

ETS – European Trading Scheme

EU – European Union

FADN – Farm Accountancy Data Network

FAO – Food and Agriculture Organisation

FER – Faculty of Electrical Engineering and Computing at the University of Zagreb

GCM – Global Climate Model

GDP – Gross Domestic Product

GEF – Global Environment Facility

GHGs – Greenhouse gases

GIS – Geographic Information Systems

GM – Gross-margin

GVA – Gross value added

GWh – Gigawatt hour

HAK – Croatian Auto Club

HDI – Human Development Index

HDR – Human Development Report

HEP – Hrvatska Elektro Privreda (Croatian Electricity Provider)

HEP-ESCO – HEP Energy Services Company

HTM – Hamburg Tourism Model

ICCAT – The International Commission for the Conservation of Atlantic Tunas

ICZM – Integrated Coastal Zone Management

IMSP – Integrated Maritime Spatial Planning

INA – Industrija Nafte d.d. (Croatian Oil Company)

IPARD – Instrument for Pre-Accession Assistance Rural Development

IPCC – Intergovernmental Panel on Climate Change

IPCC SRES – IPCC Special Report on Emissions Scenarios

JI – Joint Implementation

LNG – Liquefied Natural Gas

LPG – Liquid petroleum gas

LULUCF – Land Use, Land Use Change and Forestry

MAC – Maximum admissible concentration

MAF – Ministry of Agriculture and Fisheries

MAFRD – Ministry of Agriculture, Fisheries and Rural Development

MAFWM – Ministry of Agriculture, Forestry and Water Management

MELE – Ministry of Economy, Labour and Entrepreneurship

MEPPP – Ministry of Environmental Protection and Physical Planning (Now known as MEPPPC)

MEPPPC – Ministry of Environmental Protection, Physical Planning and Construction

MEUR – Million EUR

MSTI - Ministry of Sea, Transport and Infrastructure

MRDFWM – Ministry of Regional Development, Forestry and Water Management

MSES – Ministry of Science, Education and Sports

NAO – North Atlantic Oscillation

NGOs – Non-governmental organizations

NHDR – National Human Development Report

OECD – Organisation for Economic Cooperation and Development

PAP/RAC – Priority Action Programme – Regional Action Centre

PESETA – Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis

RCMs – Regional Climate Models

REC – Regional Environmental Centre

RES – Renewable energy sources

SAPARD – Special Accession Program for Agriculture and Rural Development

SGM – Standard gross margin

SMEs – Small and Medium Enterprises

SOM – Soil organic matter

TCI – Tourism Climate Index

UAA – Utilised agricultural area

UN – United Nations

UNDP – United Nations Development Programme

UNEP – United Nations Environment Programme

UNEP-MAPs – UNEP - Mediterranean Action Plan

UNESCO – United Nations Educational, Scientific and Cultural Organization

UNFCCC – United Nations Framework Convention on Climate Change

USD – United States Dollar

VAT – Value Added Tax

WB – World Bank

WFD – Water Framework Directive

WHO – World Health Organization

WWF – World Wildlife Fund

Chapter 1

Introduction - Climate Change and the Challenge for Human Development in Croatia

Chapter 1

Introduction - Climate Change and the Challenge for Human Development in Croatia

Climate change is one of the greatest challenges facing the world today. Its impacts can already be seen across the globe. Croatia may already be facing impacts from climate change and will inevitably see those impacts in the future. The 2007/2008 Global Human Development Report (HDR) demonstrated that climate change is happening and that actions must be taken to reduce its impacts and reduce the extent of that change.[1] Impacts from climate change – caused by increasing levels of greenhouse gases (GHGs) in the atmosphere – are expected to lead to a myriad of problems that affect human development. Negative impacts may include damages from more frequent natural disasters and sea-level rise, strains on food production, harm to human health, and many others. If not addressed, climate change in Croatia can restrict people's choices, slow down and undermine development gains, and have a negative impact on human development in general.

The Global HDR calls for international action to address both the mitigation of climate change and adaptation to the impacts of climate change. This recommendation is based on the fact that, even if emissions of greenhouse gases were reduced drastically today, emissions that have already been released would still have an impact in the immediate future, because most greenhouse gases stay in the atmosphere for long periods of time. For example, in 30 years the environment can only absorb half of the CO_2 contained in the atmosphere.[2] In addition to the Global HDR, "The Stern Review on the Economics of Climate Change" – hereinafter referred to as the "Stern Review"- represented a ground-breaking effort to quantify the global damages from climate change. It also estimated the global costs for reducing risks by reducing GHG emissions and implementing adaptation measures.[3] The Stern Review estimated that by the end of the 21st century, with a temperature increase of 2-3°C, the cost of climate change would be around a 0-3% loss of global Gross Domestic Product (GDP). If temperatures increase up to 5-6°C, which would be possible under business as usual (BAU) scenarios, climate change would result in a 5-10% loss in global GDP, with developing countries suffering costs in excess of 10%, even when only market impacts, such as losses to agriculture, energy use and forestry, were included. If non-market impacts are included, such as environmental and health damage, the estimates for damages are as high as 11-14%.[4]

To reduce the risks from climate change, emissions must be significantly reduced – by 50% from 1990 levels, by 2050 – and by beginning to adapt to existing climate variability and future climate change. In a later publication, Stern[5] explains that, to reach this goal given projected population growth, the current GHG emissions per person will need to be reduced to two tonnes. This target could be reached by having different levels of reduction in developing and developed countries. Developed countries would have to begin drastic cuts immediately (20-40% by 2020 and 80% by 2050). Developing countries would be allowed to increase emissions slightly until 2020, but would then need to cut emissions by half by 2050. Different countries would have different responsibilities based upon their previous emissions as well as the potential for reduction.

Looking beyond 2020, it is difficult to speculate about the costs of reduction and what each country will need to do to mitigate their emissions. However, a significant global shift will be necessary to avoid dangerous climate change. The estimated global cost for reducing emissions to avoid dangerous climate change is estimated at -1.0% to + 3.5% of global GDP - though the general estimate is 1%.[6] Achieving these reductions will require a drastic shift in the way energy is produced – shifting from fossil fuels to renewable energy sources. Additionally, it would be necessary to

“To reduce the risks from climate change, emissions must be significantly reduced – by 50% from 1990 levels, by 2050 – and by beginning to adapt to existing climate variability and future climate change”

reduce emissions from transportation and reduce deforestation. Discussions on climate change lead to the question of how much society should focus on adapting to climate change versus mitigating the GHG emissions that lead to climate change (See Box 1-1).

What is Croatia's role in addressing climate change? As a democratic country that emerged from the former Yugoslavia in the early 1990s, Croatia underwent a period of economic and social upheaval, including a shift from a socialist economy to capitalism, a war, and

Box 1-1: Moral dimension of mitigation vs. adaptation

Addressing climate change as an issue of human security raises many questions and concerns about the capacity of societies to respond to current and future change in a thoughtful and ethical manner. One of many questions put forward is: Should we focus on slowing future climate warming by reducing emissions through mitigation measures or focus on adapting to future climate warming, or both? Whether we choose to invest time, money and energy into mitigation vs. adaptation strategies - reducing greenhouse gas emissions or developing technologies to adapt to climate change - will raise social and political questions that cannot be answered in a simple manner.

Greenhouse gases do not remain where they are released; they disperse throughout the atmosphere around the world. A tonne of GHG is a tonne of GHG, no matter where it comes from.

In practice, however, climate change does not harm everyone equally. Its costs fall most heavily on vulnerable people – particularly upon vulnerable people in poorer countries. These vulnerable populations will tend to be the least able to adapt to changes in the climate. Further, the costs will be borne by future generations, which will inherit the planet the current generation helps to form. For this reason, there is a moral imperative to mitigate the effects of climate change by reducing emissions.

We need to contrast mitigation with adaptation. Adaptation measures have local impacts. Shifting to agricultural techniques that save water helps both the farmers and the population purchasing the food. Resettling a group of people away from a coastline benefits that group of people. Altering fishing practices to adjust to changing fish populations helps fishermen.

While it might be nice to think that there are enough resources to address both mitigation and adaptation, this is unlikely to be the case. However, we must work to do both. We must reduce emissions in order to ensure that climate change does not threaten human development and our environmental resources. Further, we must adapt to existing and future climate change in a way that helps protect people in Croatia from the dangers imposed by climate change.

Much of what we do in terms of mitigation will also serve the goal of adaptation. In a way, mitigation itself can be seen as a kind of adaptation. Moving away from centralised energy based on fossil fuels towards de-centralised renewable energy and greater community self-sufficiency will make our society more flexible and resilient, not only in terms of physical infrastructure and settlement patterns, but also in terms of governing institutions and cultural habits.

To address the problems created because of global climate change, we need to pay attention to both adaptation and mitigation. Further knowledge about the costs and benefits of adaptation and mitigation measures will be necessary in order to make the right choices so that human development is not hurt by climate change.

Dr. Sc. Daniel R. Schneider, Assistant Minister, Directorate for Environmental Management, Ministry of Environmental Protection, Physical Planning and Construction of the Republic of Croatia other profound changes. It is currently on its way to becoming an EU member state, which will bring opportunities and challenges for human development. Croatia is ranked 46th in the Human Development Index.[7] As such, it is among the upper tier of middle-income countries. Croatia has many economic sectors that could be very vulnerable to climate change. Its agricultural sector has already shown significant vulnerability to climate variability in recent years, experiencing severe damages due to drought. Furthermore, sectors such as fishing and mariculture, electricity production from hydropower and tourism, are all linked directly to climate. What could climate change impacts mean for human development in Croatia? Will there be positive impacts?

Box 1-2: Climate variability, climate disasters, climate change?

When discussing climate-related impacts in Croatia, it is important to clarify what is meant by the various terms used to describe them. Climate variability refers to changes in temperature or precipitation that depart from the average. Part of this variability may be due to normal climate cycles and part may be attributable to climate change - a departure from average temperatures and precipitation patterns due to the increased levels of GHGs in the atmosphere. Impacts due to climate variability, such as droughts or floods, are referred to in various reports as climate shocks, climate extremes and climate disasters. These terms do not refer to the actual cause of the events.

However, the lack of a proven link between climate-related impacts and climate change is not the central issue for human development in Croatia. The UNDP Global HDR poses the question as follows: "Is climate change implicated in the increase in climate disasters? Direct attribution is impossible. Every weather event is the product of random forces and systemic factors…. However, climate change is creating systemic conditions for more extreme weather events…. The precise role of climate change in increasing the number of people affected by climate disaster is also open to debate. However, uncertainty does not constitute a case for inaction."[8]

In addition to addressing impacts from climate change, Croatia will have to reduce its own emissions as part of the global effort to prevent disastrous climate change. Croatia is not a major emitter of GHGs, with approximately 5 tonnes per person in 2004[9] (after including land use changes) compared to an average of 11.5 tonnes per person in 2004 amongst all Organisation for Economic Co-operation and Development (OECD) countries.[10] However, its emissions are rising, and its commitments under the Kyoto Protocol and its commitments which will come with EU membership may be a limiting factor in the future. The Government will have to decide which path of emissions reductions it will follow. Can/should Croatia be a part of the push to reduce emissions drastically by at least 20% by 2020? What would that cost Croatian citizens?

This National Human Development Report (NHDR) takes the global discussion about climate change and brings it to the local level. It is organized into three sections to give an overall picture of climate change issues and Croatia:

What do we know about the changing climate? - setting the stage for priority-setting by evaluating popular perceptions of climate change and the level of public interest in helping to address the problem. This section also explores expected changes of climate in Croatia in terms of changes in temperature, precipitation and other factors.

What would climate change affect in Croatia? – assessing the current and potential future vulnerability of key Croatian economic sectors to climate change. It also discusses potential positive impacts that may result from climate change. This section also examines the current ability to adapt to climate impacts as related to human development. There are recommendations for adaptation measures that have other key benefits regardless of climate change – "no regrets" measures.

What can Croatia do to change the climate? – assessing the costs of reducing emissions and the institutional capacity of Croatia to mitigate its own effect on climate change – what level of reduction can/should Croatia move towards by 2020, given the current state of emissions in Croatia and the economic and institutional realities within the country?

Overall, the Report aims to further the discussion about climate change in Croatia. It provides a concrete analysis and recommendations for policies that could help to mitigate climate change by reducing emissions and could protect Croatia against the impacts of climate change through adaptation measures. It is designed to raise awareness about the often-overlooked human development aspect of climate change and to provoke a national debate about how Croatia should best respond to the climate challenge.

Section 1

What Do We Know About the Changing Climate?

Chapter 2

Public Perceptions/ Knowledge about Climate Change

Chapter 2 Summary

Public Perceptions/ Knowledge about Climate Change

A public that is well-informed about climate-related threats and measures to address them is crucial. This is because mitigation and adaptation to climate change cannot occur without changes in individual behaviour and public support for political decisions.

For the purposes of this Report, UNDP Croatia carried out the first comprehensive national public survey on public attitudes towards climate change in Croatia. The results show that Croatians have a very high level of concern for the environment – higher even than in many EU member states.

Croatians believe that climate change is a serious problem, especially in the coastal regions where it is likely to have more impact. However, they generally only recognise the direct impacts of climate change as being a threat, such as impacts on health. They do not associate climate change with indirect impacts to society, such as potential damage to food production or changes to the energy production system due to restrictive mitigation measures or a loss of hydropower.

Furthermore, while Croatians believe they are highly knowledgeable about climate change, actual knowledge about the causes and effects of climate change is not that high. The media – especially television – has a key role to play in informing the public about climate change issues. Most Croatians obtain information about the environment from the media rather than from the internet, friends or family, or school/ university – even more so than in EU member states.

Most Croatians are very supportive of proactive solutions to reduce emissions by Croatian industries and the Government. They also believe that the Government and companies that produce emissions should be most responsible for reducing emissions.

Additionally, a large majority of Croatians claim that they already take environmentally friendly actions and are willing to take further action in the future. Many also state they are willing to pay extra to make sure the energy they use for electricity and transport comes from environmentally friendly sources. This willingness to act and to pay is higher than in most EU countries. Because of this, public education and programmes encouraging efficiency, environmentally responsible behaviour and environmentally responsible purchasing, can be used to motivate people to become involved in issues related to climate change.

2.1. Introduction

Public involvement is critical to an effective response to climate change. A public that is well-informed and educated about climate-related threats and measures to address them is crucial because the process of mitigation and adaptation cannot happen without changes in individual behaviour and sufficient public support for political decisions. This chapter evaluates public knowledge, willingness to act, and support for policies that reduce emissions and increase Croatia's ability to adapt to climate change. Understanding the level of public support for these measures can provide helpful information for decision-makers in the public and private sectors about which policies to pursue. Should the Government aggressively pursue mitigation policies? Should it be aggressive in addressing risks from climate change by moving forward with adaptation? Should businesses, especially large emitters like energy companies, include emission reductions in their marketing – potentially providing "Green Energy" programmes or carbon offsets programmes? Should public education be expanded to ensure basic public knowledge about climate change? How much is the public "willing to pay" and "willing to act" to reduce the risks of climate change? These are all questions that this section hopes to address before examining the more technical aspects of climate change mitigation and adaptation.

For the purposes of this Report, UNDP Croatia carried out the first comprehensive national public survey on public attitudes towards climate change in Croatia.[I] In examining the results of the survey it should be noted that this kind of survey often shows a social desirability bias because the results are the product of self-assessment; i.e. respondents may tell the interviewer what they think they "should" say when reporting opinions or behaviour.[1] To provide a baseline, the evaluation compares some results with other surveys regarding climate change and similar topics in Croatia and in other countries, including a recent EU-wide survey.[2]

Using results from other research, the UNDP Global Human Development Report on climate change concludes that "public attitudes continue to be dominated by a mindset that combines apathy and pessimism."[3] Croatians, on the other hand, seem more proactive in their attitudes towards climate change. Research shows that public concern about climate change is not necessarily dependent on wealth and scientific knowledge,[4] nor is apathy and pessimism equally distributed between populations.[5] Overall, the public concern among Croatians and their willingness to act could be a major factor in pushing forward climate change mitigation policies.

> "The results of this survey show that the public is, indeed, very concerned about the environment and climate change"

2.2. Levels of awareness and concern about the environment and climate change

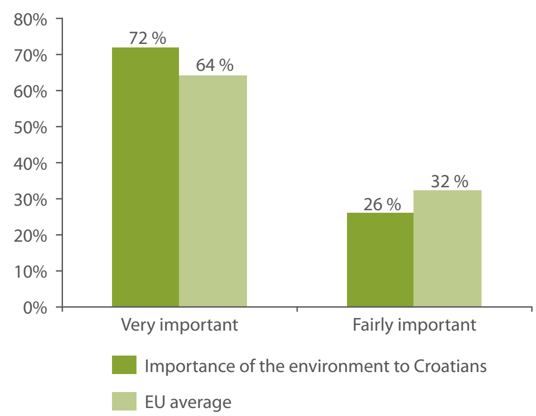
By questioning people on their views related to the environment and climate change, it is possible to gauge the level of concern Croatians have for climate change. This is crucial information for the Government and others in order to ascertain how much public support there is for addressing climate change. It is also important to know where people get their information from and how much they actually know about climate change. If the public is not concerned, then perhaps the Government and other actors would be justified in not taking a proactive stance. Similarly, if the public is unaware of climate change issues and needs to be made aware in order to reduce emissions, this would also be helpful to know. The results of this survey show that the public is, indeed, very concerned about the environment and climate change.

[I] The survey was conducted by AUDEO, a public opinion and market research agency. AUDEO relied on telephone interviews of a randomly selected sample of 1,000 Croatian citizens aged 14 and over with well-balanced socio-demographic variables – including age, level of income, education level, gender, and location of residence (See Annex 2)

2.1.1. Levels of concern about the environment

Q. 1: "How important is protecting the environment to you personally?"

Figure 2-1: Responses to Survey Q. 1 in Croatia and the EU average

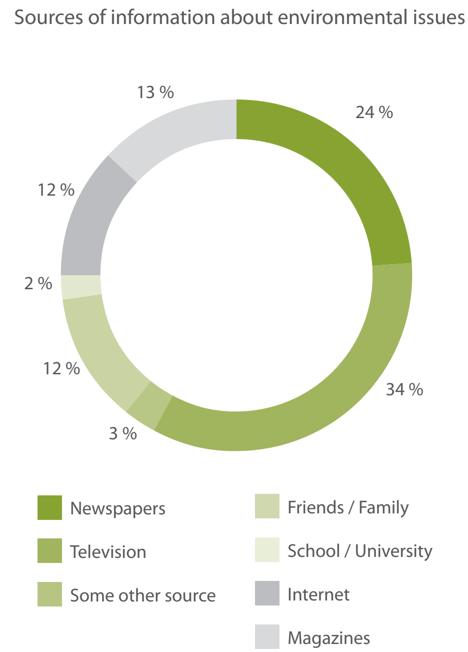


As Figure 2-1 suggests, Croatians have environmentally friendly attitudes, with few (>2%) regarding the protection of the environment as "unimportant". When compared to the EU27 countries in terms of level of environmental concern, Croatia ranked tenth.[6] Neither gender, age nor region represent a discernible difference in the responses, which is not surprising given the high level of regard for the environment. However, education level does act as a good indicator for environmental concern, with over four-fifths of respondents with a university degree stating that environmental protection is very important to them personally. As the education level decreases, so does concern for the environment.

Q. 2: "From where do you get information about environmental issues?"

The media plays an important role in educating, raising awareness, and mobilising the public to take action regarding climate change. The importance of the media's role (especially television) should be stressed, because the survey's results show that Croatian citizens primarily obtain information about climate change from television, newspapers and magazines. Institutions wishing to communicate with the public about climate change issues should take this into consideration.

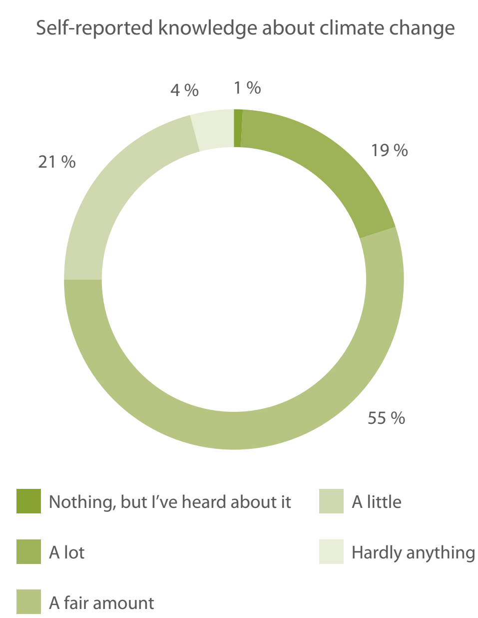
Figure 2-2: Responses to Survey Q. 2



2.2.2. Levels of understanding of climate change

Q. 3: "How much, if anything, would you say you know about climate change?"

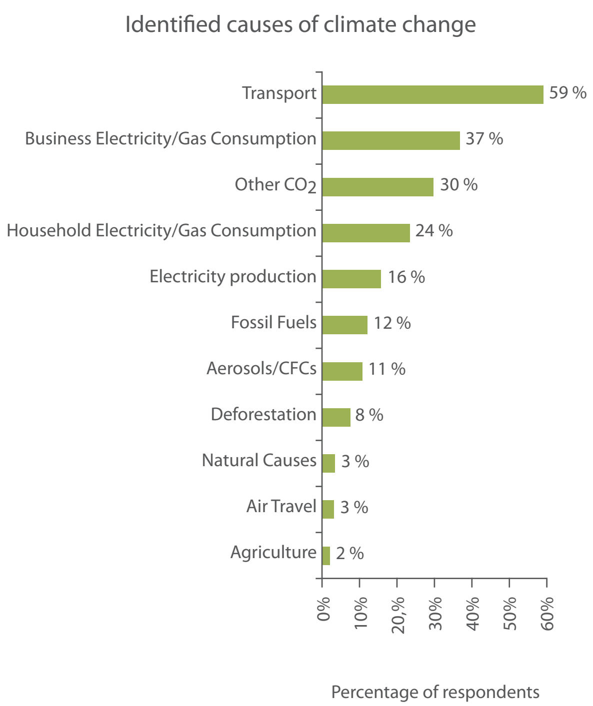
Figure 2-3: Responses to Survey Q. 3



Croatians believe they are very knowledgeable about climate change. Everyone questioned had heard of climate change before this survey. However, actual knowledge levels are lower than self-assessed levels. For people who claimed to know "a lot", fewer than half could name more than two correct causes of climate change (47%) and less than half (45%) could name more than two impacts of climate change.

Q. 4: "What types of things do you think contribute to climate change?" (Open answer)

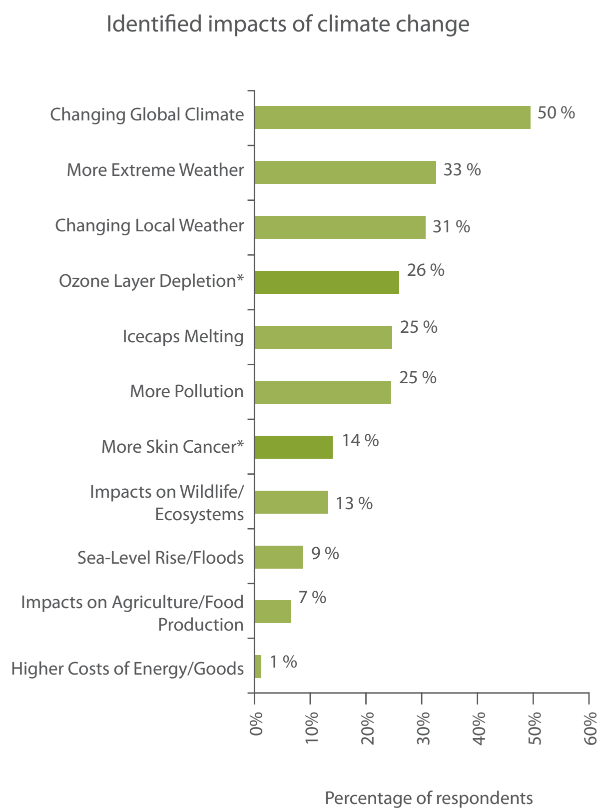
Figure 2-4: Responses to Survey Q. 4



Q.5: "What do you think are the consequences of climate change? (Open answer)

The majority of respondents identified transport as a key contributor to climate change, followed by consumption of electricity in business and other sources

Figure 2-5: Responses to Survey Q. 5



*Not a recognised immediate impact of climate change

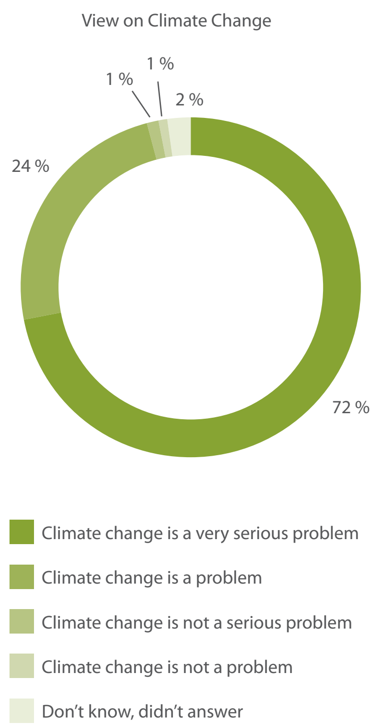
of CO_2. Very few named agriculture as a major contributor. In Croatia, transport is responsible for approximately 20% of emissions, while electricity production is responsible for another 13% and agriculture is responsible for around 11% of all emissions (See Chapter 12).

More than a third of people who said they knew a lot or a fair amount, named at least one impact that is not recognised as being due to climate change (ozone layer depletion, increased rates of skin cancer). The amount of mistaken knowledge about climate change may be due to a view among Croatians that climate change is something that "happens to others" or has abstract global effects, and a lack of awareness of the direct social and economic consequences in Croatia (see Question 8).

2.2.3. Levels of concern about climate change

Q. 6: "Which of these statements comes closest to your view on whether climate change is a problem?"

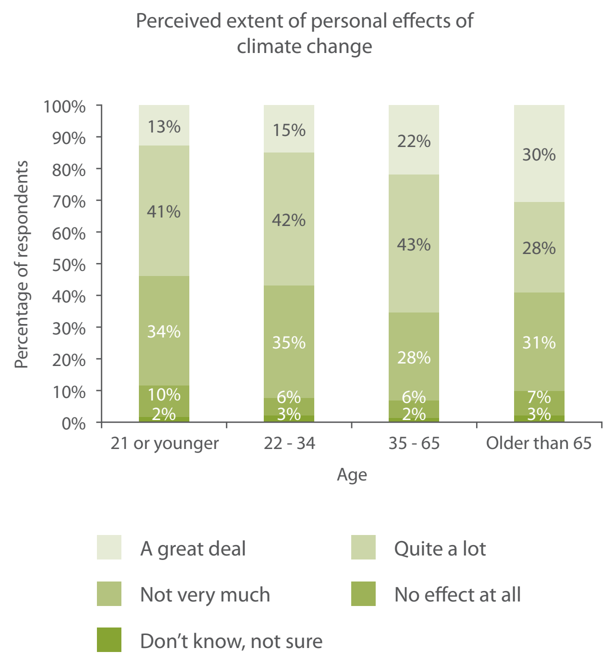
Figure 2-6: Responses to Survey Q. 6



A dramatically large proportion of citizens consider climate change to be a "very serious problem". This is similar to the results from the EU survey, wherein 54% of respondents in Croatia named global warming as "the most serious problem currently facing the world as a whole" (the EU average was 62%).[7] Women and respondents from the Adriatic region perceive climate change as a very serious problem more often than men and respondents from other regions of Croatia. A likely explanation is that the Adriatic Sea is a key natural resource linked to economic activities such as tourism. Climate changes may become most evident in the Adriatic due to sea-level rise, loss of biodiversity, and greater temperature changes (See Chapter 3). Assuming that Croatians perceive climate change as an environmental issue rather than a socio-economic one, the regional variation is not surprising.

Q. 7: "How much effect, if any, do you think climate change will have on you personally?"

Figure 2-7: Responses to Survey Q. 7



Q. 8: If the answer to the previous question was "a great deal" or "quite a lot," how do you think that climate change will affect you?

Despite their high degree of concern about climate change, less than two-thirds of Croatians believe it will drastically affect them personally. This is a considerably smaller value than might be expected, since 96% of the respondents agreed that climate change was a serious problem. There is no dramatic difference among age groups as to whether climate change will have an effect on their lives, but rather how much that impact will be. The older population is far more concerned than the younger. This might be explained by the increased health concerns of older Croatians. To a certain extent this is no surprise. Up to now, physical impacts in Croatia from climate variability (aside from some heat waves) have not been identified as being due to climate change in the media or among the general public. While droughts, forest fires and heat waves have had significant socio-economic impacts on Croatia (see, for example, Chapter 8 on agriculture and climate change), in the minds of the public, no link has been made.

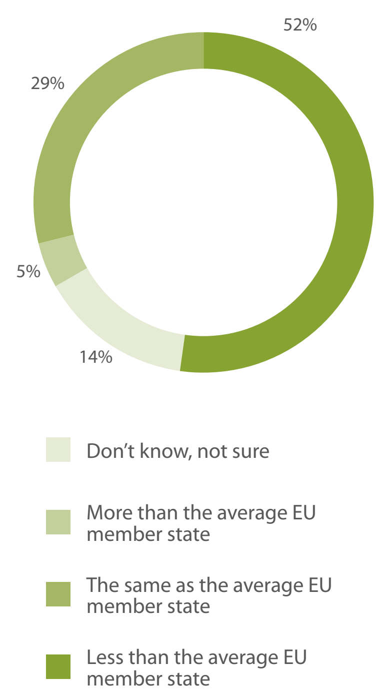
2.3. Public support to reduce emissions

The second aspect of public knowledge and opinion that should be examined is the level of public support for policies and actions to reduce emissions. The survey presented a series of questions to establish what Croatians felt their individual responsibility and the country's responsibility should be in addressing climate change. This perception is an important basis from which policies and actions involving people in climate change mitigation and adaptation measures can be developed.

2.3.1. Public support for policies to reduce emissions

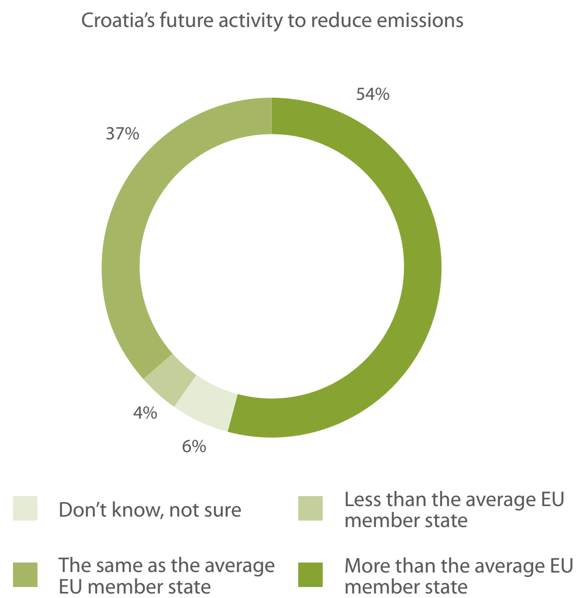
Q. 9: "With regard to reducing emissions that cause climate change, do you think that Croatia does more than/ less than/ the same as developed countries/ the average EU member state?"

Figure 2-8: Responses to Survey Q. 9



Q. 10: "Leaders of major developed countries are currently working to address their emissions, including the goal among EU countries of reducing energy consumption by 20%, emissions by 20%, and having 20% of energy come from renewable sources by 2020. With regard to reducing emissions that cause climate change, do you think that Croatia should do more than/ less than/ the same as developed countries/ the average EU member state?"

Figure 2-9: Responses to Survey Q. 10

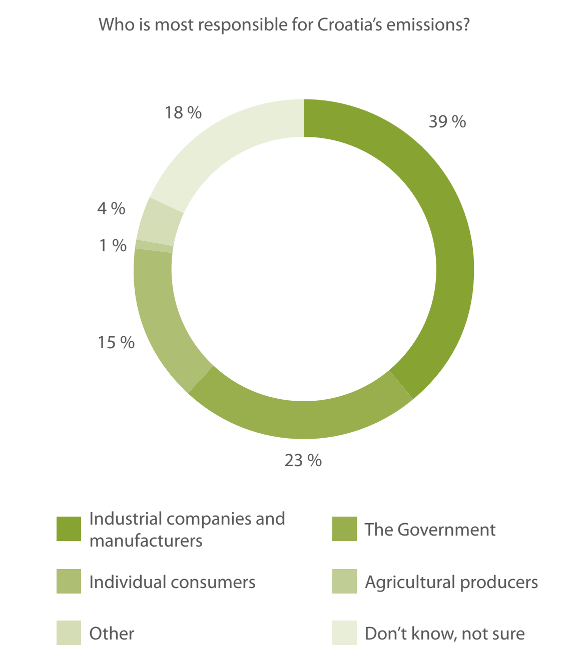


In general Croatians are very supportive of country-wide policies to reduce emissions and believe that more should be done. Question 9 was formulated to find out respondents' perceptions of how much Croatia *is doing* to address climate change. Question 10 sought to find out how much the country *should be doing* in comparison to the EU and other developed countries. Almost half of the respondents think Croatia is currently doing less to reduce emissions than EU members and other developed countries. A large number of respondents feel that in the future Croatia should do more than or the same as other EU members. In a recent Eurobarometer survey, the majority of Croatians expressed support for the three EU 2020 goals, believing these targets to be either "about right" or indeed "too modest."[8] High expectations from one's own government and institutions (such as businesses) serve as a good foundation for an active approach towards climate change. This may be expected given the sense among many countries in transition that the government should be "doing more" in general.

"A large number of respondents feel that in the future Croatia should do more than or the same as other EU members"

Q. 11: "With regard to the emission of the gases that cause climate change in Croatia, who do you think is most responsible for Croatia's emissions?"

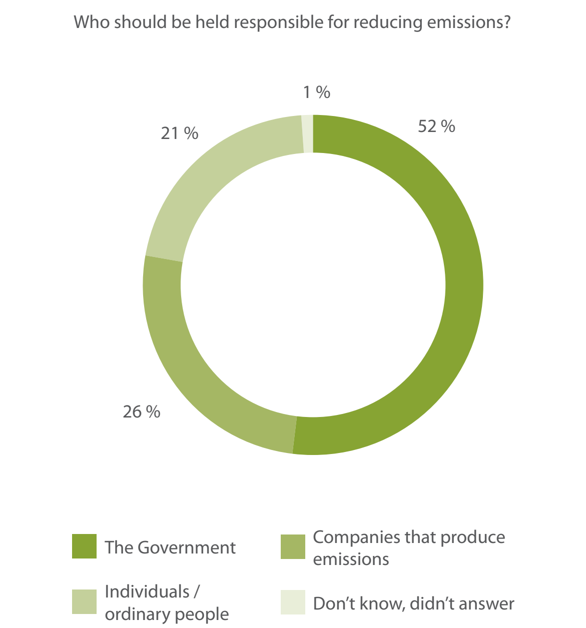
Figure 2-10: Responses to Survey Q. 11



The responses to Question 11 established that Croatians believe industrial/ manufacturing businesses and the Government are most responsible for GHG emissions, followed by individual consumers. However, as almost one in five respondents could not identify which sector was most responsible for emissions, this demonstrates the lack of knowledge about the causes of climate change.

Q. 12: "With regard to reducing the emissions from Croatia that cause climate change, who do you think should be held most responsible for their reduction?"

Figure 2-11: Responses to Survey Q. 12



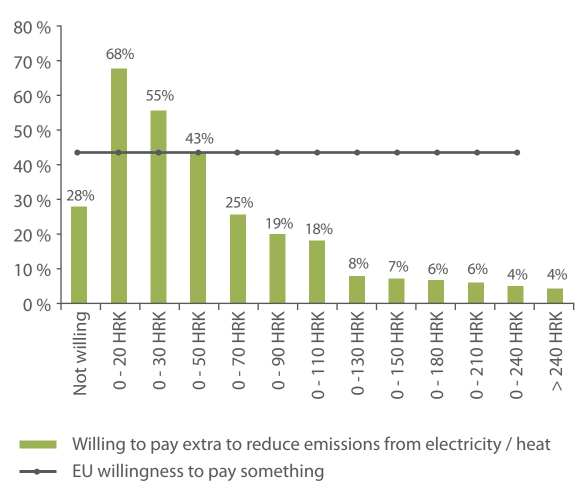
When asked who *should be most responsible* for actually reducing emissions, most Croatians believe that the Government should be primarily responsible. To obtain public support, policy makers and business leaders will not only have to ensure that emissions reductions take place, but also that the public is aware of those reductions.

2.3.1. Public willingness to pay to reduce emissions

While the responsibility of a government or business should not be understated, it is crucial that citizens also become actively involved. By personally choosing to change their behaviour and to buy and use environmentally friendly products, the public can contribute to sustainable development. This is especially important in countries such as Croatia, where personal consumption accounts for more than a third of total emissions.

Q. 13 - "There are technologies for electricity production that do not produce greenhouse gases, such as solar power, wind power, and hydro-electric power. How much, if anything, is the maximum amount that you are sure that your household would be willing to pay, every month, to ensure that your electricity and heat are produced from sources that do not emit greenhouse gases?"

Figure 2-12: Responses to Survey Q. 13



Respondents were told that a citizen's average monthly energy bill in Croatia was 500 HRK (EUR 68). When asked about their readiness to contribute financially to climate change mitigation, over two-thirds were willing to pay an additional sum to reduce emissions, by investing in the use of green technology for their energy. This is very similar to the percentage of positive responses (61%) in Croatia in the Eurobarometer survey.[9]

> "Over two-thirds were willing to pay an additional sum to reduce emissions, by investing in the use of green technology for their energy"

Q. 14: "Why are you willing to pay the amount that you indicated?"

The most important variable that affected respondents' decisions was their own financial situation. 84% of those who said they were not willing to pay more explained that they could not afford the additional monthly expense.

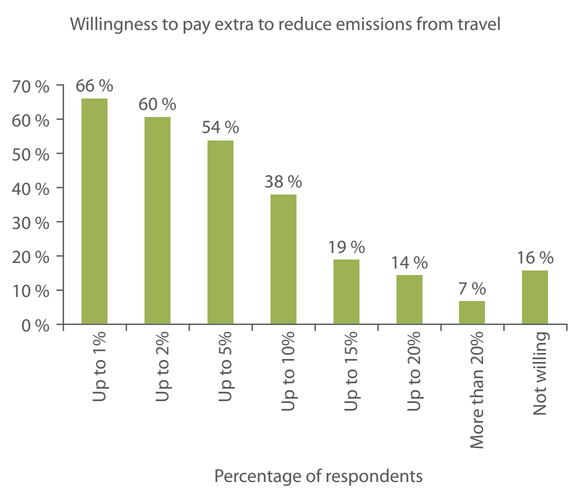
Responses varied by level of education and region. Better educated citizens and those from Adriatic Croatia were willing to pay more for green electricity and heat. The 2008 EU survey, which focused on European attitudes to climate change,[10] found that cumulatively 44% of people in the EU27 were willing to pay something extra for their energy to ensure it resulted in fewer emissions, far fewer than in Croatia. At present, Croatia's main energy company, HEP, does not offer a green electricity package as such. In light of these results, there may be a demand for electricity or heat products which come from environmentally friendly electricity generation, as is increasingly common in EU markets (e.g. British Gas Zero Carbon tariff).[II]

[II] Market penetration of green tariffs in Europe and US was estimated to approach 3% in 2008. Datamonitor 2005:24-29, 37-44.

Q. 15: "Do you drive a car more then twice a week or fly by plane more then twice a year?"

Q. 16: (If the answer to 15 was "yes.") "There are also programmes to offset emissions that result from driving cars and travelling by airplane. These programmes often involve paying for alternative sources of energy in the electricity sector or encouraging the growth of forests that "soak up" climate change causing gases. How much, if anything, is the maximum amount that you are sure that you would be willing to pay to offset the emissions resulting from the transport you are using?"

Figure 2-13: Responses to Survey Q. 16



The next series of questions sought to establish the willingness of Croatians to pay to offset/ reduce emissions caused by transportation. Approximately half (49%) of the respondents drive a car more than twice a week or fly more than twice a year. Given that Croatians believe the main contributor to climate change is transport a large percentage of frequent drivers and/or fliers are willing to pay extra for fuel or plane tickets.

Q. 17: "Why are you willing to pay the amount that you indicated (including indicating 0%)?"

Of those not willing to pay extra, 77% stated they couldn't afford it. However, as the survey took place in June/ July of 2008, when oil prices were over 130 USD (United States Dollars) per barrel, this may have had some impact on the results. Again, those who are more educated and in a better financial situation are willing to pay more.

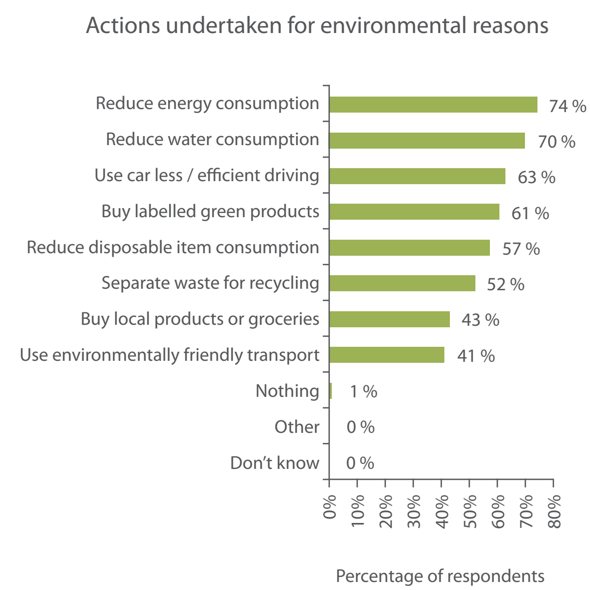
For more representative results, a more in-depth survey is required, as grouping people who drive more than twice per week with those who fly more than twice per year has little merit. Flying is still reserved for Croatians with higher incomes, and as the two items are very different activities, they should be separated.

2.3.2. Public willingness to act to reduce emissions

In addition to paying extra to reduce emissions, the public will also need to change their individual behaviour. This is one of the areas where leadership by the Government and by companies can be helpful, but it is critical that the public is actually willing to act.

Q. 18: "Have you done any of the following during the past month to prevent climate change or for environmental reasons?"

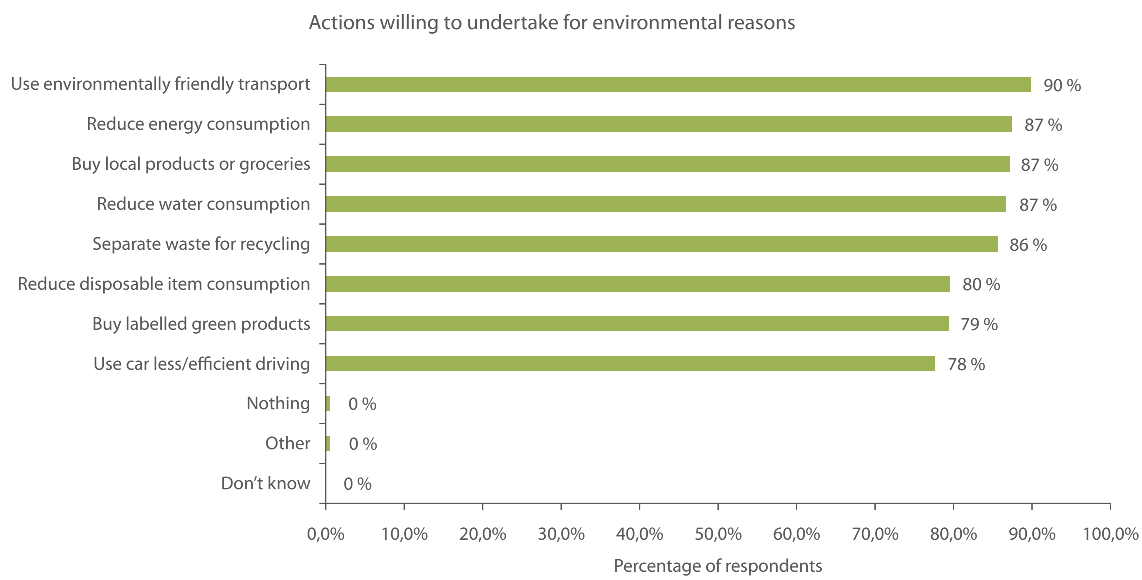
Figure 2-14: Responses to Survey Q. 18



Q. 19: "Would you be willing to do any of the following in order to fight climate change or for environmental reasons?"

ronmental reasons. This is compared with two-fifths of respondents nationally who claim to have altered their transportation habits for environmental reasons. Environmental factors may only be part of their reasons for doing so and access to actual sustainable means of transport is probably the most important factor.

Figure 2-15: Responses to Survey Q. 19



A high percentage of respondents claim they already behave differently in their daily lives to reduce climate change. Even more say that they are willing to do so in the future. The most widely undertaken activities are reducing energy consumption, reducing water consumption and using a car less or driving more efficiently. There is enormous enthusiasm for undertaking 'green' activities in the future. For example, an incredible 90% of respondents said they would use environmentally friendly modes of transport. It must be emphasised, however, that programmes would need to be developed to translate this interest in helping the environment into reality. For example, almost four-fifths of respondents in Zagreb (where there are extensive public transportation networks) say they use public transportation, walk, or take bicycles for envi-

Overall, the vast majority of people seem willing to act in the future, with only 0.4% unwilling to change their behaviour. Indeed, over 75% stated their willingness to undertake all the activities suggested by the survey. Of course, this willingness to act should be taken as a general indicator, as opposed to an indication of actual future behavioural change, as people tend to respond in a socially desirably way when participating in social surveys. As the EU survey on environmental attitudes notes[11], "environmentally friendly attitudes do not necessarily lead to environmentally friendly actions." The real challenge will be to transform the positive intent of many Croatians into actual actions.

2.4. Conclusion

Overall, the results of the survey show that the population has a significant interest in climate change issues. People are concerned. They are concerned for their own well-being as well as for the environment. They are supportive of actions taken by the Government and businesses to address climate change. Finally, they claim that they are ready to take action themselves and, therefore, through public education and programmes encouraging efficiency, environmentally responsible behaviour and environmentally responsible purchasing, they can be encouraged to become involved in these issues.

Chapter 3

The Croatian Climate

Chapter 3 Summary

The Croatian Climate

Climate conditions are directly linked to human development and the way a society develops. Over the last century, emissions of greenhouse gases (GHGs) caused by human activity have already led to an impact on the climate system. Three direct characteristics of the climate, and changes to those characteristics, can have an impact on human development:

- **Temperatures**, which appear to be increasing in Croatia
- **Precipitation**, which appears to be decreasing in Croatia – especially during certain seasons
- **Extreme weather events**, such as storms, heat waves and droughts – which are already having significant impacts on human development

In Croatia during the 20th century, most regions had a decrease in precipitation and an increase in temperature in almost every season. It has not been possible to distinguish how much of this is due to natural climate fluctuations or to human influence, but climate models for Croatia point to significant future changes in climatic conditions especially if emissions are not cut dramatically.

In the future, Croatia is expected to be hotter and drier – especially in the summer. Increased temperatures nationwide are expected to have considerable impacts: increase of water temperature in the sea and in inland bodies of water, soil temperature increase, groundwater temperature increase which may lead to higher rates of evaporation and a decrease in the groundwater table, a decrease of lake and river levels, decreases in soil moisture leading to droughts, more heat waves that affect health, and numerous other impacts.

Though the State Hydrometeorogical Service – DHMZ – has been developing good cooperation with the end users of its services and with regional partners, more progress will be necessary to integrate climate information into short-term emergency preparedness, seasonal preparedness, and long-term climate forecasting in Croatia.

3.1. Introduction

When examining the vulnerability of Croatia to climate change it is necessary to have a basic understanding of the current climatic conditions within the country, as well as predictions for the future under various climate change scenarios. Climate is directly linked to human development and the way a society develops. Humanity is already having an impact on climate. (For a basic description of how climate change occurs due to human influence, see Box 3-1.) Climate also affects humanity. Three characteristics of the climate can affect human development:

- **Temperatures**, which appear to be increasing;
- **Precipitation**, which appears to be decreasing, although in a less pronounced way;
- **Extreme weather events**, such as storms, heat waves and droughts, which have been increasing in frequency and intensity in recent years.

Temperature affects both human health and economic development. Average temperatures and precipitation are critical to several Croatian industries. For example, climate conditions, such as plentiful rain, have made agricultural practices possible – often without irrigation. The tourism season is also determined by climate. Therefore, increases in temperature and changes in precipitation will affect numerous sectors.

Precipitation affects economic development in several ways. Clean, abundant, and affordable drinking water is essential for human health. Water in general is an essential factor in certain industries such as agriculture, hydro-power, tourism, fisheries, and more. Decreases in precipitation and changes in precipitation patterns may lead to reductions in the availability of water, which will affect many sectors of the economy. Drought can also lead to an increase in wildfires, which may cause significant damages to human health, the environment and the economy.

Extreme weather events such as droughts, heat waves, storms and floods can also lead to property damage and can threaten human health and well-being.

This chapter examines the current climate conditions in different parts of Croatia during different seasons. It also looks at the existing information available from climate models for future climate conditions in various parts of Croatia during the various seasons. Finally, it will examine what is needed to fill the gaps to be able to understand the likely future climate in Croatia.

"Increases in temperature and changes in precipitation will affect numerous sectors"

Figure 3-1: Severe bora in Senj on 14 November 2004.

Source: Damir Šenčar, HINA.

Box 3-1: The greenhouse effect and the carbon cycle: Too much of a good thing. Source: UNFCCC 2008

Life on earth is made possible by energy from the sun, which arrives mainly in the form of visible light. About 30 per cent of sunlight is scattered back into space by the outer atmosphere, but the rest reaches the earth's surface, which reflects it in the form of a calmer, more slow-moving type of energy called infrared radiation. (This is the sort of heat thrown off by an electric grill before the bars begin to grow red.) Infrared radiation is carried slowly aloft by air currents, and its eventual escape into space is delayed by **greenhouse gases** such as water vapour, carbon dioxide, ozone, and methane.

Greenhouse gases make up only about 1 per cent of the atmosphere, but they act like a blanket around the earth, or like the glass roof of a greenhouse -- they trap heat and keep the planet some 30 degrees C warmer than it would be otherwise.

Human activities are making the blanket "thicker" -- the natural levels of these gases are being supplemented by emissions of carbon dioxide from the burning of coal, oil, and natural gas; by additional methane and nitrous oxide produced by farming activities and changes in land use; and by several long-lived industrial gases that do not occur naturally.

These changes are happening at unprecedented speed. If emissions continue to grow at current rates, it is almost certain that atmospheric levels of carbon dioxide will double from pre-industrial levels during the 21st century. It is possible they will triple.

The result, known as the "enhanced greenhouse effect," is a warming of the earth's surface and lower atmosphere. The IPCC assesses with very high confidence that the globally averaged net effect of human activities since 1750 has been one of warming. The 'best case' computer climate models estimate that the average global temperature will rise by 1.8° C to 4.0° C by the year 2100. A temperature increase of 0.7° C occurred last century and for the next two decades a warming of about 0.2° C per decade is projected, should greenhouse gas emissions continue to rise at their current pace and are allowed to double from their pre-industrial level.

A rise in temperature will be accompanied by changes in climate -- such as cloud cover, precipitation, wind patterns, and the duration of seasons. In its Fourth Assessment Report, the IPCC projects that heat waves and heavy precipitation events are very likely to increase in frequency in the 21st century. In a world that is crowded and under stress, millions of people depend on weather patterns, such as monsoon rains, to continue as they have in the past. Changes, at a minimum, will be difficult and disruptive.

Carbon dioxide is responsible for over 60 per cent of the "enhanced greenhouse effect." Humans are burning coal, oil, and natural gas at a rate that is much, much faster than the speed at which these fossil fuels were created. This is releasing the carbon stored in the fuels into the atmosphere and upsetting the carbon cycle, the millennia-old, precisely balanced system by which carbon is exchanged between the air, the oceans, and land vegetation. Currently, atmospheric levels of carbon dioxide are rising by over 10 per cent every 20 years.

Climate change is inevitable because of past and current emissions. The climate does not respond immediately to external changes, but after 150 years of industrialization, global warming has gained momentum, and it will continue to affect the earth's natural systems for hundreds of years, even if greenhouse gas emissions are reduced and atmospheric levels stop rising.

3.2. General characteristics of the Croatian climate

Croatia's climate is determined by its geographic location in the North mid-latitudes, modified by its topography and the influence of the Adriatic and the Mediterranean Seas. For this analysis, the country's geographic areas are divided into the Northern coastal area (Istria and Hrvatsko Primorje), the Southern Adriatic coastal area (Dalmatia), the mountainous area (the Dinarides mountain belt), the Panhonnian Plain (Slavonia) and the Zagreb urban area. Examining the recordings from weather stations in these areas can provide basic information about the climate in various Croatian regions in various seasons. It is important that the data used in this analysis represent seasonal averages and therefore do not capture extreme weather events such as heat waves or heavy rainfall. An analysis of the climate conditions in Croatia over the baseline period 1961-1990 shows that temperatures are mildly warm in the summer and not terribly cold during the winter, though there are defined seasons.

Climate parameters are highly variable from year to year, so data must be taken over long periods of time (100 years) to spot trends. During the 20th century, there has been a decreasing trend in precipitation and an increasing trend in temperature for most places, during most seasons. It is not possible to distinguish how much of this is due to natural climate fluctuations or human influence, but models of the climate future for Croatia point to significant changes in the climatic conditions. Actual seasonal temperatures and precipitation for the various regions can be found in Figure 3-6 and Figure 3-7, which examine current characteristics compared to projected future changes to the end of the 21st century.

3.3. Anticipated changes to the Croatian climate in the future

Although there are limited studies specifically covering Croatia, it has been included in a number of wider studies. As climate models have different strengths and weaknesses, one climate model cannot be expected to 'predict' the future. Additionally, climate is dependent on the amount of GHG emissions released into the air (See Annex 3). Finally, there are two basic types of models – global climate models (GCMs) and regional downscaled climate models (RCMs), which provide more geographic detail. Annex 3 has a detailed discussion of these different types of models. By looking at various models we can see the probable outcomes of climate change trends. The two main aspects of climate - temperature, measured at two metres above the ground, and precipitation (mostly rainfall and snow) - are analysed below.

For the purposes of this Report, a combination of a number of models – including a number of downscaled regional models – have been analysed in order to show predictive climate trends in Croatia. The analysis is divided into the near term (until 2025) the medium term (from 2041- 2070) and the long term (from 2080 until the end of the century).

2025

For the near future, there seems to be only one study which includes Croatia.[I] This study predicts that average temperatures in Croatia in 2025 will have increased

[I] A group of authors (Coşkun, Demir, and Kiliç 2008) from the Turkish State Meteorological Service, Department of Research and Data Processing, Kalaba, Ankara, has performed a climate change study based on the B1 emission scenario for projections until 2025 using a Regional Climate Model.

by a maximum of 1°C (winter, summer and autumn), while spring temperatures will remain the same. No significant differences in precipitation are expected in most regions (with a maximum change of -2.5% along the coast in autumn). It is important to note that these are projections for a scenario of relatively low emissions growth and are only forecast until 2025.

2041-2070

In estimating the likely climate change for Croatia from the period 2041-2070, the Meteorological and Hydrological Service of Croatia (DHMZ) predictions are presented in Table 3-1. Maps that indicate these changes are included in Figure 3-2, Figure 3-3, Figure 3-4, and Figure 3-5: [II]

Table 3-1: Results of the DHMZ climate model for 2040-2070.

Season	Impacts and Changes	Notes
Winter	- Northern Croatia will experience a warming of 2.5°C while the rest of Croatia will warm by between 2° and 2.5°C. - This will be more important for inland rather than coastal Croatia.	- Winter is the only season which does not show a difference in precipitation, though there may be a slight increase in the north and a slight decrease in the south. - Surface snow in northern Croatia will become uncertain. Snow is important for soil moisture - affecting the availability of soil moisture required for the subsequent growing season.
Spring	- Croatia will be 1.5°C warmer throughout the country and at sea. - A slight drying trend is expected in southern and western Croatia during spring (-0.1 mm per day – which means 9 mm less for the season).	- A statistically significant reduction in soil moisture in the spring (March, April and May) is expected throughout Croatia. In addition, inter-annual variation in soil moisture will increase.
Summer	- Temperatures will increase by 3.5°C in the northern Adriatic and in other parts the temperature will increase between 3° and 3.5°C. - During summer, there will be 9 mm less rain per month in the east (27 mm for the season). This represents a more than 10% drop. In the rest of the country, there will be a drop of 0.2 mm/day in precipitation (18 mm less for the season).	- There will probably be more heat waves.[III] - These expected changes in temperature will be similar for all years - This model predicts a reduction in the summer convective precipitation (downpours) over many parts of Croatia; this amounts to about one third to one half of the reduction in total precipitation.
Autumn	- Temperatures will increase by 2.5°C mostly uniformly throughout Croatia. - Precipitation levels will drop 27 mm for the season in the south on the coast, Moving northward along the coast, the reduction will be 18 mm for the season - In the northern part of the country (including Istria and most of the eastern part of Croatia) the reductions will be 9 mm for the season	

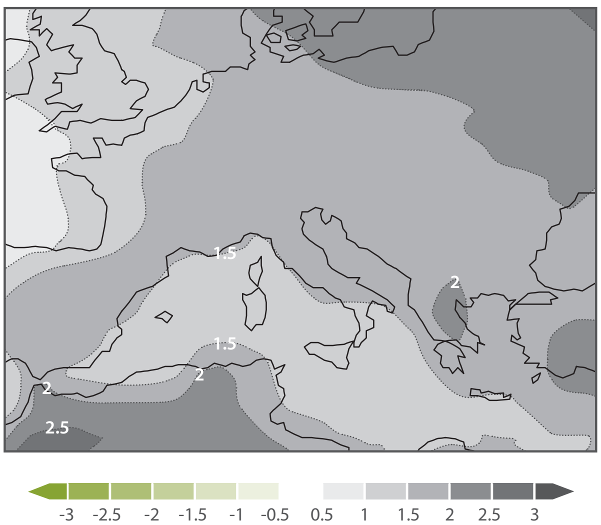
[II] Branković, Patarčić, and Srnec 2008. The results are derived from the three-member ensemble integrations of the global EH5OM model, from the Max-Planck Institute for Meteorology, Hamburg, Germany. The horizontal resolution is approximately 200 km. The period 1961-1990 (the "present" climate) and the period 2041-2070 (the future climate) under the IPCC A2 scenario are analysed and compared.

[III] See, for example, the results from Barnett et al. 2006, Clark et al. 2006, Tebaldi et al. 2006

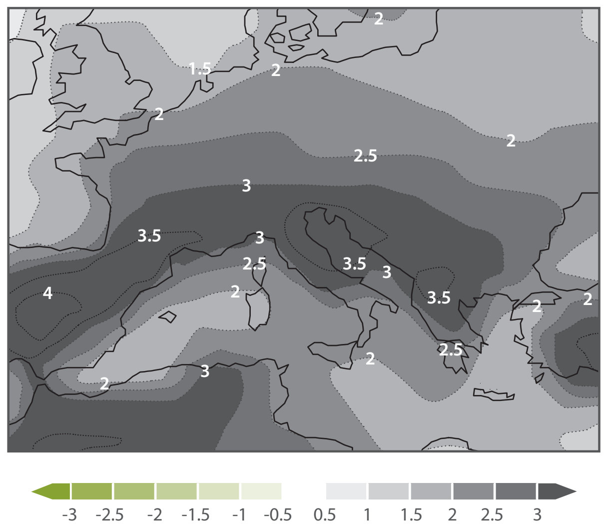
In addition to the general trends that are highlighted in Table 3-1, it is important to note that convective precipitation (from storms) is important for the supply of water and (soil) moisture, in particular in summer. Summer convective precipitation is usually associated with rapidly moving fronts passing over Croatia or with the development of local instabilities and storms. In the event of storms, intense precipitation coupled with strong winds can cause economic damage. The change expected in convective precipitation is statistically significant. Since convective precipitation in summer is mostly associated with relatively short-lived showers, some parts of Croatia (in particular the coastal regions) will, in the future climate, be deprived of these sporadic replenishments of their water resources.

Figure 3-2: Maps detailing the comparative change in average temperature for the periods 1961-1990 and 2041-2070

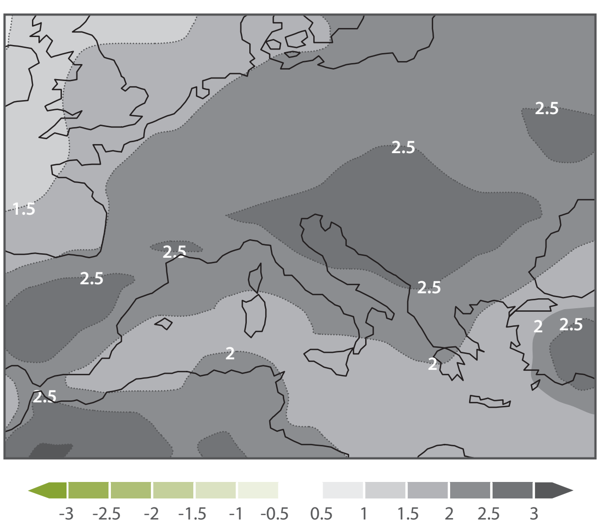
Spring



Summer



Autumn



Winter

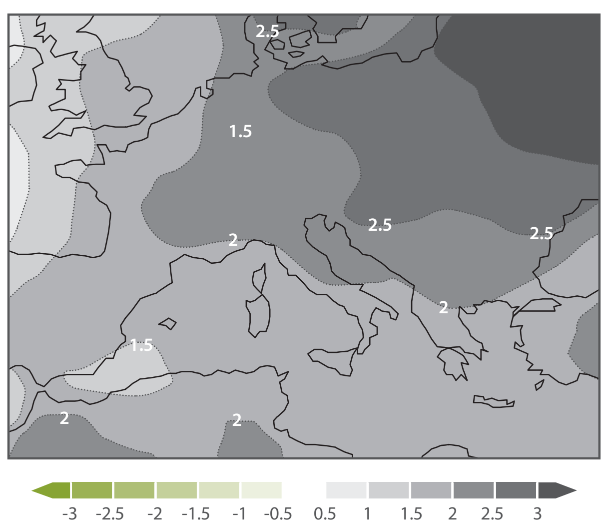


Figure 3-3: Maps detailing the comparative change in average precipitation for the period 1961-1990 and 2041-2070 (mm/day)

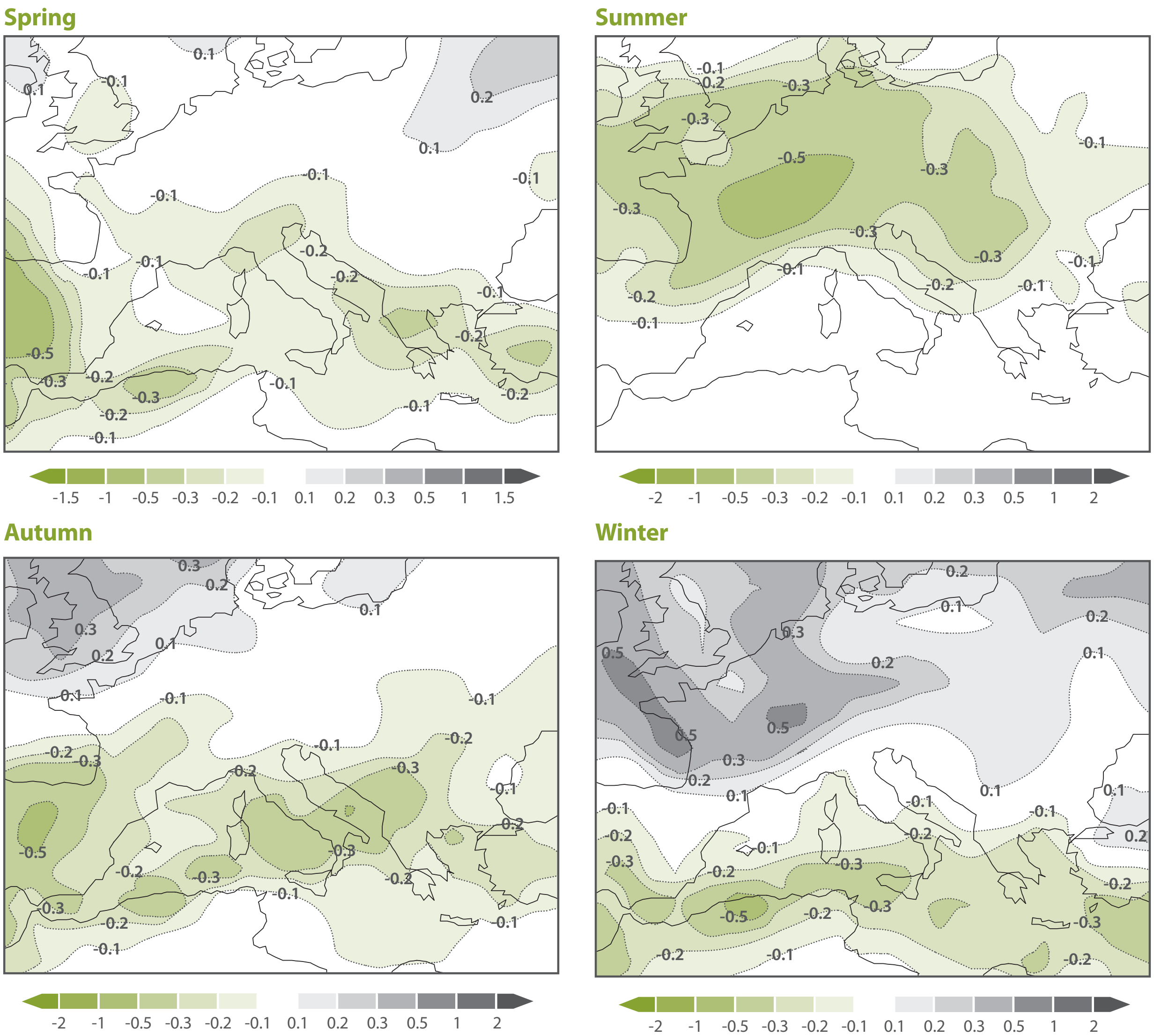


Figure 3-4: Map detailing the expected changes in summer convective precipitation for the period 2040-2070 (mm/day)

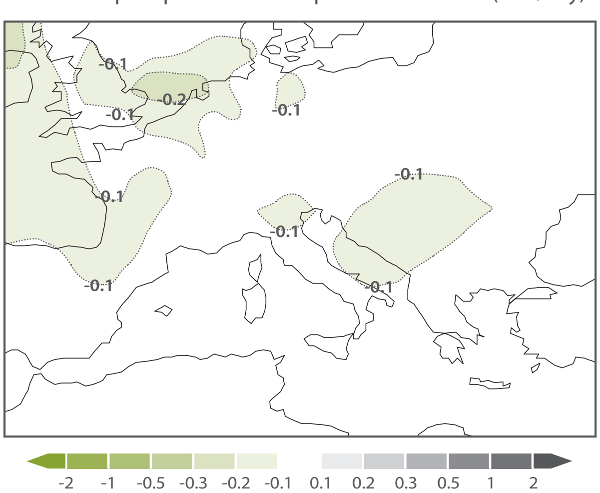
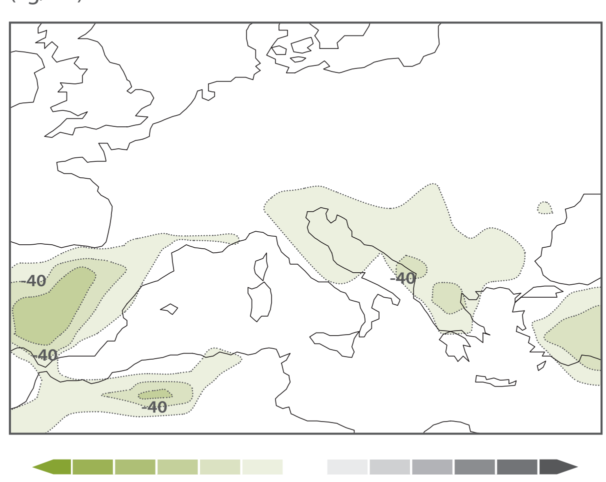


Figure 3-5: Changes in spring soil moisture for 2040-2070 (kg/m^2)



2080-2100

The results from a number of models were averaged in order to estimate the potential changes in climate statistics in various regions during various seasons for 2080-2100.[IV] It is important to note again that one model and one emissions scenario is not enough to give a real picture of what the Croatian climate will be like. Overall, according to the IPCC's Fourth Assessment Report,[1] annual average temperatures are expected to increase between 1.9° and 6.1°C, depending on the emissions scenario.[V] These numbers, however, do not indicate differences in regions or differences in seasons. Because Croatia is a small country with significant geographic and therefore climatic differentiation, down-scaled regional models are necessary to estimate changes in climate.

Having analysed these down-scaled models for various regions in Croatia, Figure 3-6 and Figure 3-7 were developed to present how future climate averages might compare to current climate averages. However, these studies do not represent a full range of emissions scenarios, nor were they focused on Croatia. Therefore, the future averages presented are for illustrative value only – they represent likely trends, but the numbers themselves are not predictive.

According to these models, the temperature increase will be the most noticeable in summer in the coastal and mountainous areas. Winters will be milder and summers will be hotter. Heat-waves will increase in summer in terms of frequency and duration. An increase in the frequency of other extreme events (storms, cyclones, etc.) is also probable. Increased temperatures are likely to drastically reduce snowfall and it may possibly cease altogether in the lower altitudes. Additionally, areas with snow accumulation will start melting earlier in the year. Precipitation projections suggest that, in terms of quantity, most rainfall will occur in winter. The driest parts of the country remain the coastal zone and islands, followed by eastern continental Croatia. The wettest parts will be the farthest north-western parts of Croatia (part of northern Istria, Gorski Kotar and far western parts of central Croatia). Overall annual precipitation will decrease.

The following suppositions are of particular importance:

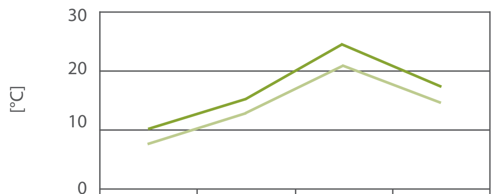
- The summer temperatures on the coast are expected to rise significantly. This could severely impact the levels of comfort for tourists as well as the water needs for agricultural services in those regions.
- Summer average temperatures in the Pannonian Plain are also expected to rise. This could have a detrimental impact on agricultural production (See Chapter 8).
- Winter average temperatures in the mountains are expected to be above freezing, which may have a significant impact on snow formation.
- Precipitation levels are expected to drop significantly, especially during the summer around Croatia. This could have significant impacts on agriculture and hydro-electrical power production,.

[IV] The studies analysed include Coşkun, Demir, and Kiliç 2008, Bruci 2008, STARDEX 2005, PRUDENCE 2008, and MICE 2005.

[V] A1 emissions scenario: 2.2° to 5.1°C; A2 emissions scenario: 3.2° to 6.1°C; B1 scenario: 1.9°C to 3.8°C.

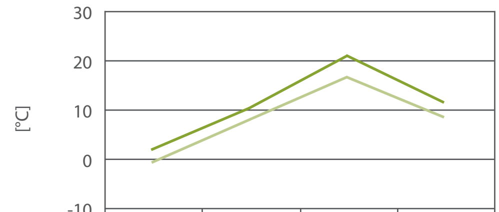
Figure 3-6: Projected temperature changes for various regions of Croatia

Northern Adriatic coastal area



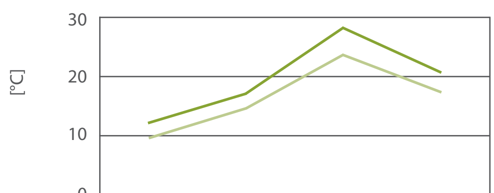
	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Temperature Averages (1961 - 1990)	6.5	12.5	22.2	14.9
Future temperature (2080 - 2100)	9.2	15.5	26.4	18.1

Mountainous area



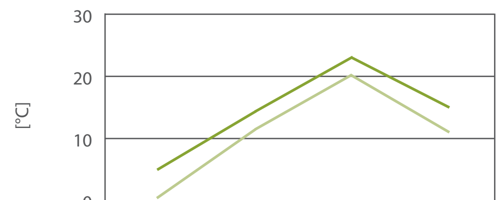
	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Temperature Averages (1961 - 1990)	-0.6	8.2	17.1	8.9
Future temperature (2080 - 2100)	2.1	10.9	21.7	12

Dalmatian coastal area



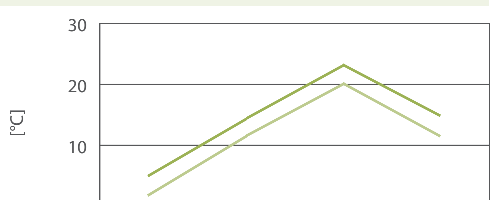
	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Temperature Averages (1961 - 1990)	9.5	14.5	23.7	17.6
Future temperature (2080 - 2100)	12.2	17.2	28.3	20.7

Pannonian area



	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Temperature Averages (1961 - 1990)	0.4	11.3	20.3	11.1
Future temperature (2080 - 2100)	5	14.5	23.5	15.1

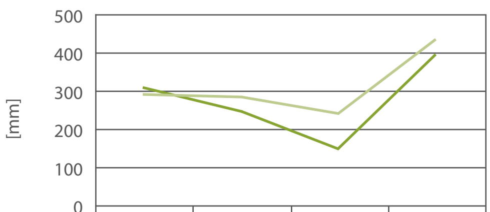
Zagreb for present, Central Croatia for the future



	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Temperature Averages (1961 - 1990)	1.9	11.8	20.4	11.8
Future temperature (2080 - 2100)	5	14.5	23.5	15.1

Figure 3-7: Precipitation changes projected for various Croatian regions

Northern Adriatic coastal area



	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Precipitation Averages (Present 1961 - 1990) (mm)	290.5	283.7	237.5	434.1
Future Averages (2080 - 2100)	306.8	245.1	144.7	392.4

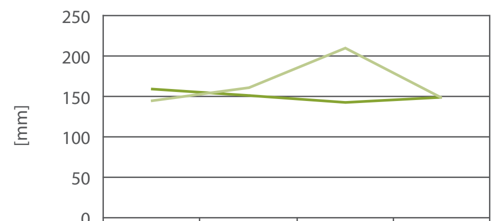
Mountainous area

	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Precipitation Averages (Present 1961 - 1990) (mm)	360.2	319.3	259	433.6
Future Averages (2080 - 2100)	381.5	283.9	159.8	413.7

Dalmatian coastal area

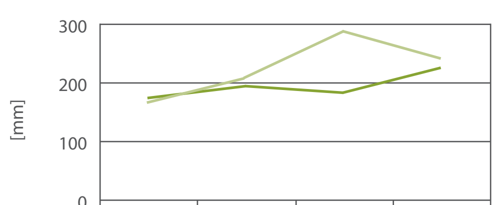
	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Precipitation Averages (Present 1961 - 1990) (mm)	233.8	165.5	105.8	224.4
Future Averages (2080 - 2100)	252.3	151.3	66.9	202.9

Pannonian area



	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Precipitation Averages (Present 1961 - 1990) (mm)	138.5	157.1	211.2	143.4
Future Averages (2080 - 2100)	155	146	135.6	143.5

Zagreb for present, Central Croatia for the future



	Winter (Dec - Feb)	Spring (Mar - May)	Summer (Jun - Aug)	Autumn (Sep - Nov)
Precipitation Averages (Present 1961 - 1990) (mm)	162.8	205.7	279.6	235.6
Future Averages (2080 - 2100)	172.4	191.1	179.5	221.2

"While there is fairly good information sharing, the warning system could be improved among the different countries of the region and within Croatia to successfully manage extreme events"

In the more distant future, regional climate models providing specific information on Croatia will be necessary"

3.4. Building capacity to predict climate and to incorporate this knowledge in decision-making

The predictions for the future climate are based on global and regional climate models. However more work is necessary so that this climate information can become a useful resource for decision-makers, including farmers, policy-makers, tourism investors, energy system managers, etc. Several types of climate change prediction would be useful for decision-makers and should be incorporated into the decision-making process, such as:

- Short-term forecasting – especially oriented towards extreme weather events,
- Seasonal forecasting – to help actors predict variables for upcoming seasons, and
- Longer-term climate modelling – to help with estimating climate change impacts.

Currently, the DHMZ is actively involved in sharing information about short-term weather events – both with specific users as well as the general public. This weather forecast information is distributed through many avenues to the public, decision-makers, disaster management teams, etc. Ongoing inter-country co-operation with other regional meteorological services regarding data sharing also exists. However, as yet no standardised warning system exists among countries to provide warnings on current or future extreme events. This means that, while there is fairly good information sharing, the warning system could be improved among the different countries of the region and within Croatia to successfully manage extreme events.[2]

Seasonal forecasting can also be helpful in predicting climate variables for upcoming seasons. This could be helpful in several sectors, especially agriculture. For example, if the predictions are for drought or heat waves at certain times of the season, there may be more incentive to change management practices. The science of seasonal forecasting is still evolving and may not yet be completely reliable for management decisions, but it could be extremely helpful in the near future. The DHMZ is becoming more active in this process, hosting the Southeastern European Regional Climate Outlook Forum in June of 2008.[VI] This sort of regional participation and increased communication amongst hydrometeorological organizations can be very helpful for increasing coordination amongst various researchers.

In the more distant future, regional climate models providing specific information on Croatia will be necessary. While the DHMZ is developing such a model (aided by funding from the World Bank), it is only initially planning to develop one scenario for one model. While this is a good step forward, more models with more emissions scenarios would be helpful to develop a better picture of what the future climate is likely to be. Since Croatia is a relatively small country, it could share climate information with numerous other countries – such a Bosnia & Herzegovina, Slovenia, Serbia, Montenegro and Albania (among others). Regionally downscaled models could be developed by each country using different global models and using different scenarios. This way, the coverage would be better, and the amount of work (and cost) for each hydrometeorological office would be less. In practice, this may already be occurring, but there seems to be no coordination of data sets, variables that are examined, and time periods analysed. A common agreement should be reached between the different hydrometeorological services to determine the responsibilities of each office in this regard. As will be seen in the analysis of vulnerability and adaptation in Section 2 of the Report, this information is important for understanding the economic impacts of climate change in Croatia.

VI For more information on this event, go to http://meteo.hr/SEECOF08/index.html.

Section 2

What Would Climate Change Affect in Croatia?

2

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What Would Climate Change Affect in Croatia?

Human development is the process of enlarging people's choices, which allows them to exercise greater control over their lives – resulting in longer, healthier and more creative lives. The impacts of climate change have the potential not only to restrict these choices, but also to force many unwanted choices on individuals and society. For example, it is expected that rising temperatures and reduced rainfall will negatively impact some farmers and reduce local supplies of fresh water. Increases in the frequency and intensity of extreme weather events (such as heat waves, hail storms, etc.), rising sea levels, and more intense storm surges, may not only threaten lives, but also individual livelihoods. Furthermore, these events may force society to divert more of its resources towards the protection of property and lives and disaster interventions.

The physical impacts of climate change will be incredibly diverse in nature, in their variability across sectors and in their magnitude. It is easy to give examples of potential economic impacts due to climate change. In the agricultural sector, climate change can reduce crop yields because of hotter temperatures and reduced precipitation. If farmers do nothing to avoid these lower yields, their net incomes will fall. The same principles are true for tourism. If the temperature increases at a beachside resort, so that it is literally unbearable to go outside for more than a few hours every day and the sea water is warm, many tourists may not be interested in visiting Croatia during the peak summer holiday season. How do we know? Because we can see from existing data that tourists already avoid such places and are willing to pay more money to travel to places that have a more desirable temperature. On the other hand, changes in the climate in Croatia, which make summers less attractive, may result in spring and autumn becoming more favourable for tourists. Similar examples of potential impacts exist in other sectors such as the health sector, the energy sector, and the fisheries/ mariculture sector. In general, human development impacts will often be determined by local factors that are highly variable. How can we make meaningful comparisons about the impacts of climate change on human well-being and how they restrict our choices and thus affect the quality of our lives?

While there are a number of answers to these questions, one approach uses economics to measure the damage caused by climate change and the benefits of avoiding this damage by adaptation. The main idea behind this approach is that climate change can cause "damage" to the production and consumption of market goods and services. When damage occurs, it can reduce profits or reduce the return on investment. Alternatively, climate change can cause prices to rise, which can damage ordinary people – especially vulnerable groups. However, some impacts can be positive, such as increased growing seasons for crops, a reduced number of deaths resulting from cold weather, an extended tourist season, etc.

The impacts on specific sectors can have wider effects on the economy as a whole. For example, the loss of income by farmers and the higher cost of food would affect through the larger economy. The same is true for tourism. If foreign and domestic tourists do not visit the Adriatic coast because the days are too hot, hotels, restaurants, supermarkets and vacation apartment owners will initially be hardest hit by the resulting drop in tourist expenditures. This will almost certainly be followed by the larger local, regional, and national economies. The assessment of the likely impacts from climate change can be described as "assessing vulnerability."

There are many reasons why both the public and private sectors need information about the physical and economic impacts of climate change - why assessing vulnerability is necessary. The most general of these is that it is necessary to know what may happen in order to plan and minimise the impacts of climate change through adaptation. Without being able to quantify these impacts, the only examples that are available are hypothetical, such as the ones above. Without knowing the costs and benefits of adaptation, it will be hard to make intelligent decisions about how governments should react to climate change. It will also be difficult to know how much governments will need to do to help the private sector adapt, if at all. Finally, climate change is likely to impact how governments address existing climate variability – by planning reservoirs, protecting wetlands, protecting against floods, droughts and other natural disasters. Governments will have to plan responses to changes in climate variability and determine the extent to which planning and coping with climate change will affect public spending and taxation. This planning also includes developing a better response to existing climate variability, which is already having an impact on Croatia.

There are various ways to adapt to the existing climate and future climate change. Autonomous adaptation relates to actions taken by private actors, such as farmers and businesses, in response to actual or expected climate change, regardless of state intervention. Policy-driven adaptation is the deliberate decision taken by public agencies to introduce various legislative, economic or informative policy measures, which either halt adverse practices or encourage the adoption of favourable practices. Both private and public/policy-driven adaptation measures can be undertaken either in anticipation of climate change or as a reaction to current climate variability. Anticipated measures that are planned and implemented well ahead of time have many advantages over ad-hoc reactive measures. Although building adaptive capacities and taking adaptive actions are complementary processes, adaptive actions usually follow later, once adaptive capacity has been developed. This is the route that Croatia should take.

This section also seeks to explore some "no regrets" options for adaptation. "No regrets" measures involve actions to improve economic efficiency or improve the way in which the sector copes with existing pressures, like climate, population changes, economic growth, and environmental quality. These actions will also help to reduce climate change damages. Adaptation options that satisfy these conditions are "no regrets" because even if the climate does not change, implementing these measures will create net social and economic benefits.

The main and most pressing problem right now, for both the public and private sectors in Croatia, is that very little is known about how climate change will affect Croatia. This is by no means because Croatia lacks highly-educated physical, natural and social scientists

Box 1: Adaptation capacity versus sensitivity and vulnerability

The extent to which the private and public sectors can adapt to climate change is often referred to as the adaptation capacity of a country. This term should not be confused with the sensitivity of a country to climate change. The sensitivity of a country refers to the magnitude of the climate change damages that will occur in a country.

Adaptation capacity refers to the extent to which these damages can be avoided, so that the damages – after adaptation – are relatively small. Thus a country could experience very large climate change damages – and thus be very sensitive to climate change - but also have the capacity to avoid many of these damages. On the other hand, a country could have very limited climate change damages, but not have the capacity to reduce them very much. Thus one needs to measure both the sensitivity of a country as well as its adaptive capacity.

The total vulnerability of a system – be it an economic system or an environmental system – is therefore a result of the exposure to current climate variability, the sensitivity to future climate change, and the adaptive capacity (or lack thereof) of that system.

that are able to project and analyse the impacts of climate change. "Climate science" in general is a new field that requires the development of analytical tools, databases and the ability to combine them to conduct integrated environmental-economic assessments of climate change. It has taken scientists in North America and the EU more than 30 years to develop the capacity to conduct integrated assessments of climate change that remain far from ideal and are continually being refined. Given the political, social and economic experience and the rapidly changing Governmental priorities of Croatia since independence, it is not surprising that the current level of Croatian climate science needs development.

In this general context, the objectives of this section of the Report are to:

1. Indicate the scale of potential climate change impacts and establish some very rough estimates for evaluating these impacts with existing information, including information on existing impacts from climate variability that may be partly due to climate change.
2. Give some indication of the current capacity to evaluate and adapt to the threats posed by climate change.
3. Outline recommendations for future institutional/ policy/technical needs including potential adaptation measures.

To accomplish these objectives this section delves more deeply into the current damages and future vulnerability due to climate in certain key sectors. It will also evaluate Croatia's capacity to project the physical impacts of climate change and place an economic value on the damages caused by these impacts. The section includes six sectors:

- Tourism
- Coastal resources – especially related to sea-level rise
- Health
- Fresh-water resources
- Agriculture
- Fisheries/ mariculture

These sectors were chosen based on three factors. First, they are likely to be affected by climate change. This is based on what we know about how the climate is expected to change in Croatia and impact assessments from other countries. Second, these sectors are important to the Croatian economy and/or to human development in Croatia (including vulnerable groups). Finally, most of these sectors have some level of data and analysis available to quantify the impacts of climate change, to make an initial calculation about the economic value of the damages caused by these impacts (or some aspect of the economic value of the damages), and to analyse the possible adaptation responses to these impacts. It should be noted that issues related to the climate impacts on biodiversity, while dealt with superficially throughout the section, are not quantified. Climate change will naturally have a significant impact on biodiversity, which is an important resource in Croatia. However, due to a lack of data to quantify this impact, in terms of its effect on human development, it was impossible to analyse this separately.

Box 2: Biodiversity of Croatia – an important driver of national development and under risk from climate change

There is global consensus that biodiversity is an intrinsic component of sustainable development. Biodiversity protection and conservation is high on the agenda of international and national policy. However, the importance of biodiversity as an economic resource and driver of development is not yet fully understood. The same is true for the impacts of climate change on biodiversity. Biodiversity is a cross-cutting component of many national industries, especially in such key sectors as tourism, agriculture and fisheries, public health, pharmaceuticals, hunting and recreational fishing.

The United Nations Environment Programme/Mediterranean Action Plan - Regional Activity Centre/Specially Protected Areas (UNEP/MAP-RAC/SPA) is currently carrying out activities related to the Strategic Action Plan for the Conservation and Protection of Biodiversity in the Mediterranean Region (SAP/BIO). The activities aim to update information and knowledge on the impacts of climate change on biodiversity in various national coastal and marine areas. This includes identifying vulnerable and critical areas, national needs, and making recommendations for immediate and mid/long-term actions.

The analysis clearly indicates that coastal Croatia, with its extremely rich biodiversity, will be the area most affected by climate change. The Adriatic's long and very indented coastline contains a great number of islands and vulnerable habitats like lagoons, estuaries, small Mediterranean wetlands, salinas, karstic rivers and subterranean hydrological systems, providing habitat that supports incredible biodiversity. The expectation is that low-lying coastal and shallow marine habitats will be exposed to sea-level rise and lack freshwater due to predicted increases in droughts. Many species may be affected because of the loss of suitable habitats and because of new conditions in marine waters, like changes of temperature, salinity and sea level and the invasion of non-native species better adapted to climate changes. The abundant native species in the coastal part of Croatia are expected to become threatened – especially those connected to Adriatic rivers, subterranean habitats (caves), islands, and coastal mountains.

Migratory birds and other migratory species will have to adapt their life-cycles to new climate conditions and find new, suitable stopover sites during migration. Some predatory marine and terrestrial species may be threatened by changes in the quantity and distribution of their prey. The rich genetic diversity in agriculture along the Croatian coast, including a great number of native varieties of grapes, olives, cherries and other cultures might be affected, but it is still difficult to predict the exact consequences. Many important protected sites, like national and nature parks, that conserve biodiversity and are valuable tourist destinations and sources of national income, may also be vulnerable to climate change.

Though experts in Croatia have predicted the vulnerability of biodiversity to climate change, the issue has yet to be recognized as an important issue at the national policy level, which should be incorporated into strategy documents or action plans. No specific monitoring or physical impact study programmes regarding climate change impacts on biodiversity have been undertaken, even though on-going research activities could have significant results and serve as a basis for future systematic monitoring and actions.

It is important to raise the issue of climate change and its effect on biodiversity to the policy level, both to protect nature and because biodiversity is an important resource for a number of economic sectors like tourism, agriculture, forestry, fishery and others. Additionally, biodiversity is responsible for a number of ecological functions, which are critical for the survival and development of human society.

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Arsen Pavasović, International Consultant

Chapter 4

Tourism

Chapter 4 Summary

Tourism

Tourism has long been important in Croatia. In 2007 alone, tourists stayed for a total of 56 million overnights and spent EUR 6.7 billion. Tourism generates about 20% of GDP and 28.7% of total employment (336,000 jobs). Thus, the tourism industry contributes significantly to human development in Croatia through the jobs and incomes that it creates for its people. By 2018, one-third of total employment is expected to occur in the tourist sector. In addition to those directly working in the tourist industry, there are many people working in related industries that are directly impacted. Tens of thousands of families rely on tourism income in the grey economy and they supplement their incomes through tourism (unregistered apartment rentals, unregistered sales of agricultural, aquaculture or fishery products, etc.). The value of unregistered accommodation alone is equal to almost 1% of the entire country's GDP.

Most projections of tourism in the EU show that by the end of the century, because of climate change, hotter day time temperatures along the Adriatic coast will cause many beach tourists to avoid these destinations in favour of cooler locations to the north. This could have serious adverse consequences on many local communities and, given the important role of beach tourism, the national economy. Hotter, drier summers with more extreme weather events and a rising sea level, may put human and economic development gains at risk. Additionally, specific natural sites may be at risk due to climate change, though further study is required regarding the probable physical impacts of climate change on specific areas.

Because of the lack of knowledge about the actual physical impacts on specific tourist sites, as well as the probable changes in tourism trends, recommendations for adaptation are limited. However, the following "no regrets" steps can be taken to address climate change and human development in the tourism sector:

- Continue to focus on "climate-proofing" tourism in Croatia – including extending the tourist season and enhancing the service capacities and products offered within the industry.
- Encourage measures to increase the energy efficiency of hotels and other buildings – including improving the ability to keep buildings cool in hot weather. This will also have impacts on emissions reductions.
- Ensure that information on the tourism industry, provided by Government-funded research, is user-friendly and can be easily accessed by the public and stakeholders.

In addition to "no regrets" options, other steps can be taken to address vulnerability in the tourism industry.

- Develop and provide better information for decision-makers (including the Government and investors) about future climate change and its potential impact on the natural systems that impact the tourism sector. This is already taking place to some extent, though activities need to be coordinated.
- Develop the capacity to better evaluate and simulate the impacts of climate change on tourism and assess the impacts on the local and national economies.
- Develop the capacity of the public sector to develop policies and measures that facilitate private sector adaptation to climate change.

4.1. Introduction

Tourism in Croatia is primarily focused on the Adriatic coast, with a smaller amount in natural areas inland. Tourists stayed for a total of 56 million overnights in Croatia in 2007 alone, spending EUR 6.7 billion. Overall, tourism generates about 20% of GDP and 336,000 jobs. Most projections on tourism flows in the EU show that by the end of the century, warmer daytime temperatures along the Adriatic coast will cause a large number of beach tourists to avoid coastal destinations in favour of cooler locations to the north. This could have serious, adverse consequences on many local communities, and the national economy. This chapter illustrates how tourism affects human development and points out the potential risks and opportunities that may occur as a result of climate change. It also discusses the general capacity to project the impacts of climate change and to estimate the costs and benefits of avoiding damages through adaptation. Finally, it highlights some potential adaptation measures that may be considered for making the tourism sector less vulnerable to climate change as well as needs for further research and discussion.

4.2. The importance of tourism in Croatia

4.2.1. The history of tourism in Croatia

Tourism has a long tradition in Croatia. It is focused on the coast and oriented towards relaxation, with 62% of tourists coming for "passive rest and relaxation."[1] Almost all of the tourism destinations are in Adriatic coastal areas, while the city of Zagreb is the other major area visited. In 2007, almost 90% of all tourists visited coastal counties (though this also includes Plitvice Lakes National Park – which is inland), while 6% visited Zagreb.[2] The political and economic decentralization of 1965 (which emphasised building an open economy) stimulated the growth of the industry.[3]

Before the war in Croatia, from 1991 to 1995, the tourism industry had a strong influence on establishing a middle class at the coast. Income growth from tourism was much faster and larger than in the fishing industry, traditional boat building industry or agriculture and the employment structure began to change. Coastal communities became areas oriented towards apart-

"Almost all of the tourism destinations are in Adriatic coastal areas, while the city of Zagreb is the other major area visited"

Figure 4-1: The Island of Mljet.

Source: Croatian National Tourist Board.

ment rental and restaurants and, as a result, became far less dependent on coastal natural resources and more dependent on the revenue obtained from the two to three month tourist season - which sustained them for the rest of the year.

During the war the infrastructure of many tourist destinations was severely damaged. Some of the most important destination cities, like Dubrovnik, were subjected to sustained shelling and nearly half the hotels were damaged.[4] Tourist visits fell to 20% of pre-war levels and, partly as a result of this decreased tourism, Croatia's overall GDP fell by more than a third during the period 1989-1993.

The dramatic decline in the number of tourists during the 1990s illustrated the vulnerability of the tourism industry. This created an opportunity for public and private sector decision-makers to consider a new approach for the industry's development. Before the 1990s the predominant attraction of tourist destinations was the sea and the beach. The goal at that time was seaside "mass tourism," targeting the working class in Eastern Europe, Germany and Italy. Because of the low prices and limited products targeting lower income tourists, it was difficult for those providing goods and services to tourists to increase their incomes. After the war, a new concept of tourism development emerged, that would contribute more to national incomes. The national strategy expanded to include the development of inland tourist destinations, rural tourist destinations, ecotourism and the introduction of new products geared towards higher income tourists.[5] However, resting and relaxing by the seaside is still the most important tourist activity in Croatia.

4.2.2. Role of tourism in the Croatian economy

Following the end of the war in 1995, tourism and Croatia's economy slowly began to recover. Finally, in 2000, the tourism sector quickly started to rebound and the numbers of day and overnight tourists increased rapidly. In the year 2007 tourist numbers rose substantially and surpassed pre-1991 numbers for the first time.[6] At the same time, Croatia started to build a new motorway network, which has made it easier for tourists to get to some cities and areas on the coast. This has had a significant impact on some areas. For example, the city of Zadar and adjacent areas were severely devastated by the war in the 1990s, but since the motorway was built, it has become one of the most dynamic areas of growth on the coast.

The percentage of foreign tourists is still much greater than local tourists, both for day-tourists (83.4 % foreign versus 16.6% domestic) and overnight tourists (88.5 % foreign versus 11.5% domestic).[7] The estimated income from tourism for 2007 was almost 20% of Croatia's GDP and is expected to grow dramatically in the coming decade (Table 4-1, Figure 4-2).[8]

4.2.3. Tourism's impact on employment

The tourism industry contributes significantly to human development in Croatia through the jobs and incomes that it creates for Croatians. The travel and tourism economy currently (2008) provides 336,000 jobs or almost a third of total employment and is expected to grow.[10]

Table 4-1: Number of visitors, overnights, GDP and income from tourism 2001-2007

Year	2001	2002	2003	2004	2005	2006	2007	Projected for 2018[9]
Number of visitors (in million)	7.9	8.3	8.9	9.4	10	10.4	11.2	
Overnights (in million)	43.4	44.7	46.6	47.8	51.4	53	56	
Income from tourism (in billion EUR)	3.7	4	5.6	5.5	6	6.3	6.7	26.1
GDP (in billion EUR)	22.2	24.5	26.2	28.7	31.3	34.2	37.4	
Share of tourism in GDP (%)	16.9	16.2	21.2	19.2	19.2	18.4	18	32.7

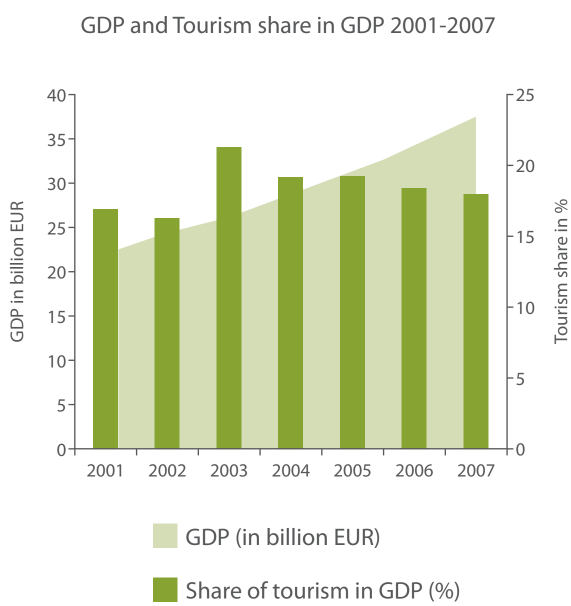
About 6% of the working population in Croatia works in the tourism hospitality and restaurants sector alone.[11] In 2007, that accounted for approximately 86,000 people. As these people probably support other members of the family, the number of people that could be affected by changes in the tourism sector would be much bigger. In 2007 almost 16,000 seasonal workers were employed,[I] yet there were still many vacancies unfilled. The hospitality and restaurant sector represents the third largest employment sector accounting for 13.8% of the total national demand for workers.[II]

Most of the seasonal workforce comprises Croatians under the age of 35 and with high-school or elementary school education (with no official qualifications under Croatian law). Meanwhile, the tourism industry requires more and more qualified personnel, even for basic jobs. This may mean that in the future there will be an even greater shortage of qualified workers.

In addition to those working directly in the tourist industry, there are many people working in related industries that are directly impacted by tourism. People working in agriculture, fishing or mariculture, transportation personnel, services oriented to tourists (such as tour-operators, grocery markets, bakeries, ice-cream shops, hair salons, and wellness centres) and unregistered apartment rentals, are all directly affected by tourism. Tens of thousands of families rely on tourism incomes in the grey economy to supplement their household budgets (unregistered apartment rentals, unregistered sales of agricultural products, etc.). The value of unregistered tourist overnights alone is equal to almost 1% of the entire country's GDP. According to some estimates, approximately 50% of overnights are unregistered, and no State duties are paid for them.[12] Probably because of the seasonal nature of tourism and the grey economy, five of the seven coastal counties actually have higher levels of official unemployment than the national average (see Figure 4-3).

> "In addition to those working directly in the tourist industry, there are many people working in related industries that are directly impacted by tourism"

Figure 4-2: GDP and tourism share in GDP 2001-2007. Sources: CBS; Ministry of Tourism.



4.2.4. Barriers to human development in employment in the tourism sector

While a tremendous number of jobs are created by the tourism sector, there are structural employment problems within it which make the workers quite vulnerable. This is due largely to the seasonal nature of the employment, and the fixed and short-term contracts common in this sector, which provide no job security.

- Low pay cheques and an unofficial "grey economy" workforce are widespread. In spite of the high demand for workers in the tourism sector, wages are 13-16% lower than the average wages in other sectors in Croatia. Grey economy employment lowers the salary average due to the unfair competition it creates with legal jobs, where State duties and minimum employee qualifications must be met.
- There is inadequate professional (vocational) education and a lack of programmes for life-long learning and improvement.
- There are inadequate public-private partnerships, such as privately-funded scholarships for students of higher education (businesses paying for education for their future employees).

[I] This included sales personnel (approx. 1800 people), wait staff (approx. 1700 people), service personnel for rooms (approx. 1500 people), cooks (approx. 1300 people), kitchen personnel (approx. 1100 people) and custodians (approx. 1000 people).

[II] After the processing industry 21.4% and sales 18.2%.

- There is often an absence of workplace standards. This is especially prevalent in foreign-owned establishments, where unrealistic requirements for staff mean that domestic personnel are unable to meet the requirements and are consequently not paid as well as expected. [13]

These are only a few of the areas of concern. In order to ensure that the tourism sector aids human development, policies for encouraging the professional development of seasonal workers within the tourism sector could be very effective. These conditions are fairly typical of worldwide trends, even in other social-democratic EU countries. The World Tourism Organisation has recognised many of the issues above and has tried to incorporate them into the Tourism Code of Ethics[14] to promote the principles of the modern tourism industry worldwide to benefit tourists and hosts equally.

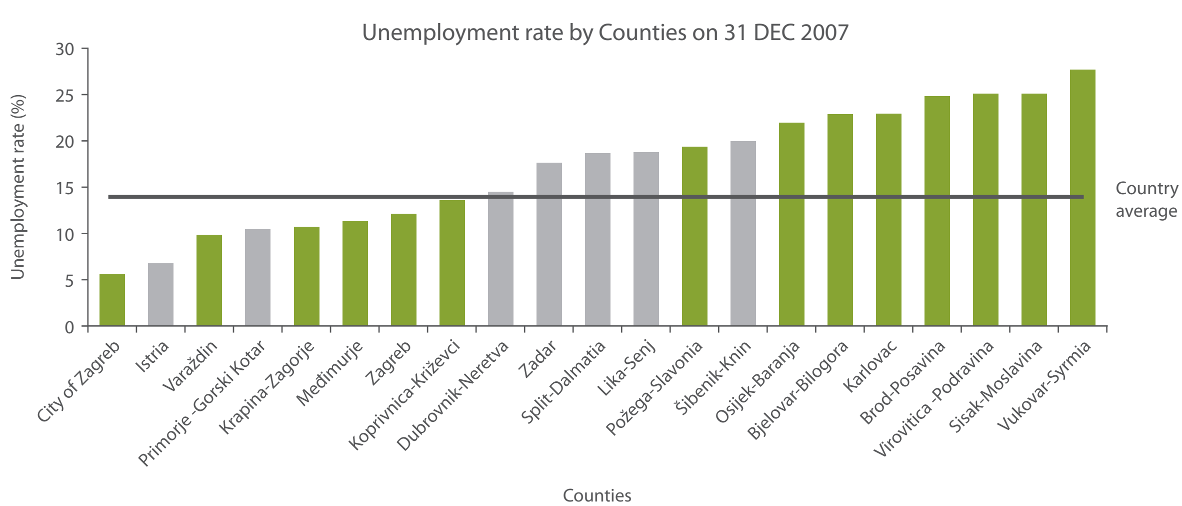
4.3. Climate risks and vulnerability to climate change

There is a growing body of literature seeking to explain how climate influences the supply of and demand for recreation and how changes in climate will affect tourism flows.[15] In Croatia, the climate is especially important for tourism. Summers are characterized by mild heat, with very little rain on the coast, a lot of sunshine, and infrequent extreme weather events. The characteristics of the Adriatic in terms of temperature and water quality make it an ideal place for enjoying the sea. The water is clear and warm during the major European vacation season of June, July and August. Most tourism takes place outdoors and tourists can rely on a number of days of sun during their vacation that are not unbearably hot. Inland attractions are also related to outdoor activities – including a substantial amount of ecotourism in Plitvice National Park and other national and nature reserve parks. All these characteristics, which create favourable tourist destinations, are vulnerable to climate change. Temperature and precipitation changes alone could lead to negative impacts on the tourism industry. While this is not specific to Croatia, it may have more significant consequences for Croatia.

4.3.1. Potential impacts of climate change on tourism in Croatia

There are various categories of potential impacts on the tourism sector due to climate change.[16] In Croatia, the two most important categories are:

Figure 4-3: Registered unemployment rate by County on 31 December 2007. Out of seven coastal - tourist - counties (grey columns), five of them have higher unemployment rates than the country average. Source: CBS 2007.



- **Direct impacts of climate change** - studies have shown that changes in climate will change people's choice of destination because they will enjoy the destination less and not be willing to pay as much to visit it.
- **Indirect environmental change impacts** - the natural environment and related ecosystems are a critical resource for tourism and therefore climate-induced environmental changes will affect tourist destinations.

Table 4-2 summarises the physical impacts of climate change and their implications for Croatia, but is by no means comprehensive. It should be noted that this chapter does not address issues related to sea-level rise, which is discussed more thoroughly in Chapter 5. However, sea-level rise may have important consequences for the tourism sector.

4.3.2. Direct climatic impacts – temperature and rainfall

Changes in temperature, along with changes in precipitation and water temperature will probably have the most impact on beach tourism in Croatia, although changes in the frequency and intensity of extreme events cannot be ruled out. Two methods are currently used to simulate the impact of climate change on tourism: the Hamburg Tourism Model (HTM)[17] and the Tourism Climate Index (TCI). Further details on these approaches are detailed in Box 4-1 (below).

The HTM model was used in one study[18] covering 16 world regions and a number of individual countries. The analysis revealed that, in total, global tourism fell by approximately 10% relative to the base case (without climate change), as more people stayed at home. The study also showed a gradual decline in tourism in warmer countries, which was partially offset by increasing tourism in northern countries. A study of Mediterranean countries using the HTM showed similar results. Countries on the southern coast lost tourists and countries on the northern coast gained tourists. In this study, the projections for Croatia were mixed: in 2100, while domestic holiday visits increased by 25%, the number of foreign tourists fell by about 8%, whilst holiday expenditures increased by about 8%. However, for the purposes of this Report, the HTM could not be utilised to project economic impacts from changes in tourist flows to Croatia because the data available for Croatia within this model was insufficient.

There are several studies associated with TCI research.[19] The PESETA project (Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis)[20] is an early effort by the EU to conduct a multi-sectoral assessment of the short- and long-term impacts of climate change. One of the sectors included in this project was the tourism sector.

The study included Croatia within its geographic and national scope. It projected the effects of the IPCC SRES-A2 scenario (high population growth with regionally oriented economic development) on the summer-time values of the TCI. The results are shown for the period 1961-1990 in Figure 4-5 and an average for the period 2071-2100 in Figure 4-6.

Comparing the two figures, there is a substantial shift in the relative attractiveness of different regions for summer recreation. The majority of locations on the Mediterranean and Adriatic, which registered very good to excellent on the TCI scale in the period 1961-1990 become acceptable or unfavourable under the climate change scenario by 2071-2100. This appears to be true for the Croatian coast. In the interior of the country, the changes are more mixed, but they still involve declines in the TCI index category. However, despite these declines in the summer TCI scores, the spring and autumn scores (not shown here) are generally expected to increase throughout Europe.

This methodology has a number of limitations.

- The results are shown for only one emissions scenario (the A2 scenario).
- The approach is based on average monthly climate data, and does not take into account extreme weather events, which are a part of the TCI index and which may be important for tourism.
- The TCI index has not been validated in the EU through any correlation with actual data on the levels of visitation.
- Finally, the TCI index only includes meteorological variables, and does not include other site characteristics that influence tourism participation and which may be sensitive to climate change, such as the natural environment, biodiversity, etc.

Table 4-2: Summary of potential impacts and effects of climate change on tourism and recreation

Source of Impact to Tourism	Type of Impact	Potential Impacts…
General changes in climate and weather	DIRECT	- The attractiveness (i.e., benefits) of a location for tourists and recreators in complex ways (e.g. too hot, bad or unpredictable weather).
	INDIRECT	- Specific environmental characteristics of locations, including vegetation, animal populations, and scenery, which also influence tourism and recreation opportunities (e.g. beaches washed away). - Damaged tourist infrastructure due to extreme weather events – also the psychological impact to tourists (fires, tornadoes, floods, etc). - Climate change-related health issues (from heat waves mortality/ sicknesses, vector born disease occurrence).
Precipitation and temperature induced changes in the discharge of streams and lake levels	INDIRECT	- The attractiveness of a location (e.g. rivers: such as Cetina, Lika, Gacka, and others; the waterfalls of Plitvice National Park, lakes: Vrana (Cres and Dalmatia), Sabljak, others; other fishing and recreational ponds - Aquatic ecosystems and habitats that influence supplies of environmental services enjoyed by tourists and recreators (this could affect 'Plitvice Lakes' and 'Lonjsko polje' ecosystems, and/ or many others) - Water availability for drinking and other uses
Precipitation and temperature-induced changes in freshwater quality	INDIRECT	- The attractiveness of a location for tourists and for recreational purposes - Aquatic ecosystems and habitats that influence supplies of environmental services (e.g. waters of Kopački Rit National Park, Lonjsko Polje Nature Reserve and Plitvice National Park)
Temperature induced changes in freshwater or sea water temperatures	INDIRECT	- The attractiveness of a location (e.g. induced algal blooms, increase of alien species destroying aquatic ecosystems) - Aquatic ecosystems and habitats that influence the supplies of environmental services enjoyed by tourists
Reduction in snow-pack	DIRECT	- Affects overall snow related tourism (Platak, Bjelolasica, Sljeme, Begovo Razdolje, Čelimbaša, Tršće).
	INDIRECT	- Tourism infrastructure - for example by pressures on freshwater sources due to artificial snow making or lack of snow melt.
Changes/ destruction of "scarce" ecosystems and biodiversity	DIRECT	- Affects national parks tourism, eco-tourism (bird watching, eco-trails, etc.).
	INDIRECT	- Affects nature related tourism (scenic ecosystems lose value).
Impacts due to Sea-level Rise	To be addressed in Chapter 5	

Box 4-1: Information about models dealing with climate variables and tourism

Hamburg Tourism Model (HTM)

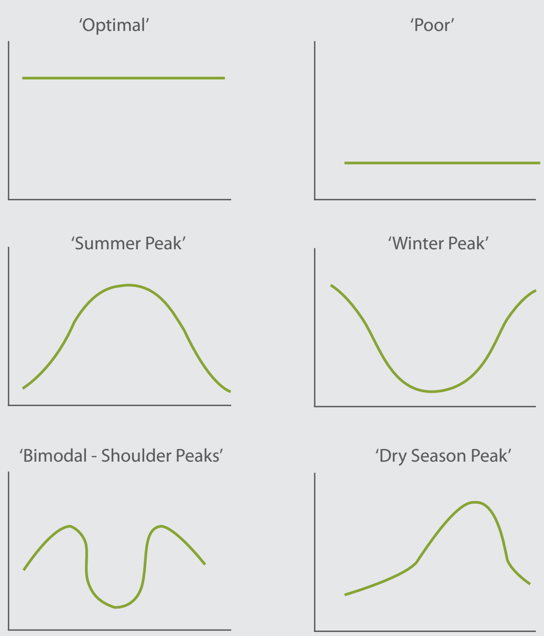
The Hamburg Tourism Model (HTM) can be used to estimate changes in global tourism flows due to climate change. This approach involves, first, using aggregate data to develop an empirical model of the relationship between a measurement of tourist participation (such as overnights or arrivals or departures) and a number of explanatory variables, among which are climate variables. The empirical model is then used to simulate the effects of changes in the climate variables on tourist participation. The HTM and models like it tend to be relatively crude instruments for simulating the effects of climate change on recreation demand. This is because they use aggregate data on tourism and climate variables; they often do not discriminate between different types of recreation or tourism, and fail to take into account important trade-offs caused by changes in the desirability of the climate at different sites relative to the costs of travelling to those sites. These effects can be captured much better through the use of travel cost models. Travel cost models are similar to participation models with one critical difference: they include not only climate among the explanatory variables, but also the travel costs between origins and destinations. Models of this type have been developed to look at the determinants of the travel behaviour of UK[21] and Dutch[22] residents. However, these particular models were not developed to simulate the effects of climate change on destination choice in the EU.

Tourism Climate Index (TCI)

A second way of incorporating climate as a variable for tourists is through the use of a Tourism Climate Index (TCI). The TCI indicates the desirability of a tourist site based on local climate features, consisting of maximum and minimum daily temperatures, mean daily temperature, mean and minimum daily relative humidity, total precipitation, total hours of sunshine, and average wind speed.[23] These variables are used to construct three "comfort indexes" whose weighted sum constitutes the TCI. The TCI, as such, provides a method to systematically rate the tourist locations around the world, using a scale from -20 to 100. The scale is divided into 11 categories, where 50-59 is "acceptable" as a tourism climate, 80-89 is "excellent," and 90-100 is "ideal."

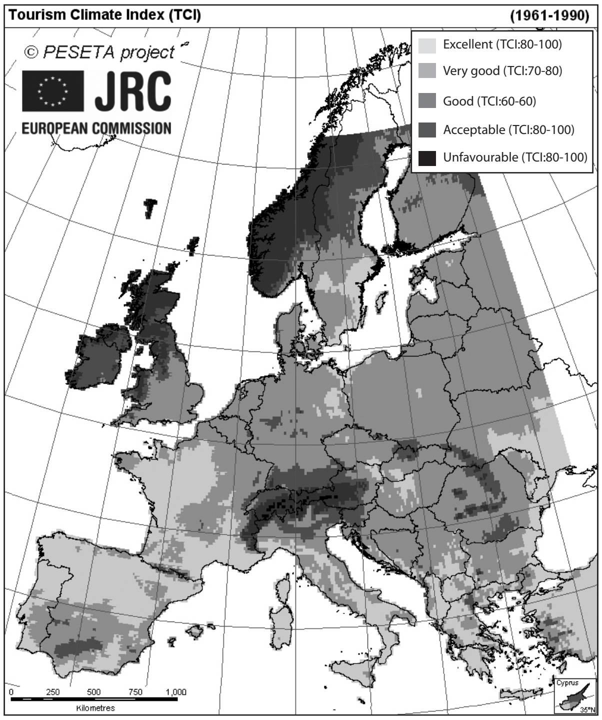
The TCI can be used to identify six different "representative" TCI distribution shapes (Figure 4-4). A location with year-round tourism and a consistently favourable climate would be called "optimal" and would have a TCI rating of 80 or above all year, while a country with "poor" tourism would have a TCI rating below 40 throughout the year. A location that is more attractive for summer tourism (such as Croatia) will have higher TCI values during the summer months (summer peak) while a location with more winter tourism will have higher TCI values during the winter (winter peak). Locations where climate is attractive for tourism in both the spring and autumn months will have higher TCI values during those months (bimodal shoulder peaks), while areas with distinct wet and dry seasons will generally have the highest TCI values during the dry season (dry season peak).[24] This implies that in the future, tourists will be most likely to visit countries during the times with the highest TCI values.

Figure 4-4: Conceptual tourism climate distributions according to TCI. Source: Scott and McBoyle 2001.



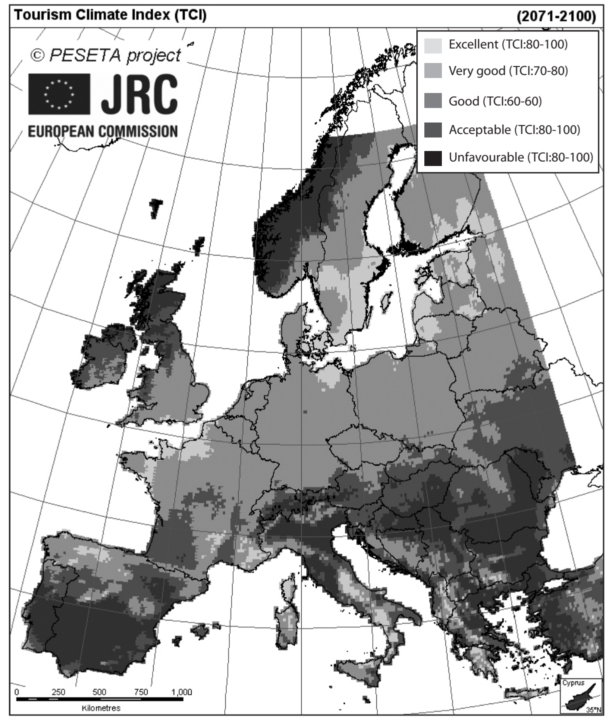
"In general, what both studies show is the potential for a shift in summer tourism from southern to northern coastlines, and the possibility that these summer tourism losses can be offset by spring/ autumn tourism gains (if tourists can adjust their vacation periods)"

Figure 4-5: Simulated conditions for summer tourism in Europe for 1961-1990.



Source: PESETA project 2007.

Figure 4-6: Simulated conditions for summer tourism in Europe for 2071-2100 according to High-Emission Scenario (IPCC A2).



Source: PESETA project 2007.

A previous study[25] used the climate results associated with two emissions scenarios (SRES scenarios A1F and B1A)[III] to examine the impacts of climate change on the TCI. The study showed the importance of the seasonal impacts of climate change and the importance of adjusting to them. In the summer months, the TCI ratings fell along the Mediterranean and Aegean coastlines but increased in the north, along the Baltic and North Atlantic coasts. Conversely, the conditions for tourism along the Mediterranean and Aegean coastlines improved particularly in the spring and, to a lesser extent, the autumn. The results for Croatia in this study are similar to those in PESETA's A2 scenario and are typical of coastal areas along the Mediterranean and Aegean seas. Meanwhile, drier summers in the interior of Croatia may help to attract more tourists, although water scarcity might become a problem.

In general, what both studies show is the potential for a shift in summer tourism from southern to northern coastlines, and the possibility that these summer tourism losses can be offset by spring/autumn tourism gains (if tourists can adjust their vacation periods). It should be kept in mind that changes in the TCI do not tell the whole story. There are a number of other determinants of tourism flows that cannot be captured solely by the climate indicators of the TCI. In this regard, the PESETA tourism study is currently analysing the effects of changes in TCI, due to climate change, on visitation and subsequently on tourist expenditures. However, this part of the assessment has not yet been finalized.

4.3.3. Direct impacts of climate change - extreme weather events.

Coastal and interior Croatia could also be vulnerable to increases in the frequency and/or intensity of extreme events. Increases in surface water temperatures in the Adriatic have the potential to increase the in-

[III] For complete and extensive description of various IPCC SRES scenarios please refer to Annex 3.

tensity of storms, including those that produce high winds, waterspouts and even tornadoes. There may also be an increase in both the frequency and intensity of droughts. Increased storm intensity brings the possibility of increased flooding – particularly coastal and inland flash floods. In addition, the predicted temperature increase in Croatia may produce heat waves and these higher temperatures can be associated with higher health risks (including heat stroke and even death), especially among the elderly, who make up a substantial portion of the tourist population.[IV]

At the current time, the necessary information to model and simulate the effects of greenhouse gas emissions on forming and frequency of occurence of "extreme events" are simply not sufficient. Avaible data are limited and sufficient only to research and model so-called ENSO-phenomena, (El Niño Southern Oscillation phenomena such as El Niño and La Niña events), so the conclusions about climate change in this area are still not certain. At the same time, our knowledge about the impact of extreme events on tourism is very limited, although there is every reason to believe that tourists do consider such factors when they plan their vacations and would prefer to avoid extreme events rather than experience them. Thus, increases in floods, droughts, severe storms, and heat-waves – if they do occur in Croatia – will probably make tourists avoid the country. For tourists who visit anyway (and for domestic tourists), the development of advanced medical and disaster relief plans may become more important.

Another result of extreme weather conditions could be the higher occurrence of forest fires due to hotter, drier summers.[26] In France, during the extreme heat-wave of 2003, the cost of fighting forest fires increased almost 50% compared to normal years.[27] The total damage from forest fires in Croatia for 2007 was approximately EUR 113 million, according to the Croatian Forests company data. The estimated damage from the karstic areas (mostly coastal) was approximately EUR 108 million and on the continent amounted to approximately EUR 5 million.[28] Most of these fires occured along the coast near primary tourist areas. For example, in 2007, forest fires near Dubrovnik almost forced the evacuation of part of the city during the peak tourist month of August.[29]

4.3.4. Indirect climate impacts

Less attractive marine ecosystems

In addition to its climate, tourists are attracted to a location by the availability of participatory activities, goods and services, and the natural beauty there – all indirectly influenced by climate change. Warmer temperatures can lead to a variety of changes in coastal and inland ecosystems, such as changing the species composition of ecosystems, and the levels of algae (which cloud the water). In particular, it is possible that seawater could become less attractive (due to higher nutrient concentrations, a loss of biodiversity and decreases in transparency), which could negatively impact tourism.

Occasional plankton algae (phytoplankton) blooms already cause tourists to avoid affected areas.[30] Algae blooms can also cause damage to the fishing industry (with indirect damage to tourism because of less seafood). Last year in Istria, algal blooms in the sea caused fishermen approximately EUR 127,000 in damage (in terms of lost fish).[31] While the quality of Croatian seawater is currently among the highest in the world, it is also vulnerable to multiple types of stress. These include warmer water temperatures and pollution from municipal, industrial, agricultural and marine transportation. Various pollutants combined with warm water can lead to a state of eutrophication and algal blooms which can become "dead zones" that have very little oxygen content. Also, alien species may become prevalent while indigenous species die out due to changes to the seawater. For example, the seawater may become warmer and thus more suitable for tropical species and less suitable for native species (see Chapter 9 for more on the role of sea temperature and fish species).[32] Atmospheric CO_2 concentration increases can also lead to the increased acidity of seawater, and the possible effects of this on marine eco-

[IV] More about importance of climate change on human health can be found in Chapter 9.

Figure 4-7: The Croatian coast during the tourist season.

Source: Ivan Bura

systems are not yet completely understood. The ecology of a marine area is a finely tuned mechanism and abrupt changes caused by climate change will have a great influence on it. These changes can affect the Croatian tourism sector as well as it relies so heavily on the attractiveness of the ecosystem.

Less attractive inland areas

Another potentially important climate-related impact on tourism is related to the effect of climate change on river discharges, lake water levels, fresh water quality and water temperatures, all of which can influence the natural and man-made environment. According to the recent TOMAS survey,[33] the natural beauty of the country is the third most important reason why tourists come to Croatia. For example, Plitvice Lakes National Park received over 927,000 visitors in 2007 (including 840,000 foreign visitors), which accounts for almost 10% of all visitors to Croatia.[34] Continental tourism currently represents 5% of tourism income and, as such, its development has been prioritised in the Tourism Strategy Report 'Croatian Tourism Development by 2010'.[35] Continental tourism includes village tourism, animal watching, fishing, hunting, and environmental trails, all of which rely on climate as an important factor (directly or indirectly).

Less water available

Change in the availability of water is another potential indirect impact. Climate models predict that summers will be drier and hotter, which will mean an increase in the demand for water coupled with a decrease in water supply. Fresh water availability is already an issue on some Croatian islands, where water must be pumped from the mainland, especially during the tourist season. Only 25% of island residents believe they have solved the water availability problem.[36] Another example where freshwater availability may be threatened is the freshwater storage of Vrana Lake, where seawater intrusion would immediately and severely affect the islands of Cres and Lošinj, which are dependent on this water source.[37]

Biodiversity loss and other issues

Biodiversity loss could severely undermine eco-tourist attractions. A collapse of the fragile biodiversity of the karst system would lead to fewer visits by "nature lovers". Additionally, changes in the amount of mosquitoes and other pests could mean that some areas featuring biodiversity and natural attractions lose their attractiveness.

The visual appeal of some sites may also be reduced. For example, changes in environmental conditions in and around Plitvice Lakes (e.g. organic pollution of water), due to a considerable increase in air pollution (CO_2 concentrations), could result in the formation of travertine, which would eventually destroy the cascades of the sixteen lakes. The resulting end of tourism in the area would also mean an end of revenue.[38] While no physical impact studies have been carried out to explore this scenario, it is theoretically possible.

Altered agricultural production could also have impacts on food and wine tourism. Food and wine are ranked as the fifth reason why foreign tourists travel to Croatia.[39]

Additionally, sea-level rise, coastal erosion, and inundation could lead to the failure of various infrastructure systems - from beaches to sewers, to marinas and berths (see Chapter 5).

Finally, with a shift of climatic regions there may be an increase in epidemics (such as cholera and typhoid) and vector-borne diseases (such as malaria and dengue fever).[40]

A loss of snow

In addition to the impacts on summer tourism, winter tourism may also be affected by the reduction in snow pack. An increase of only 1°C (which is expected) could result in the serious decline or even the complete failure of the small snow-related tourism sector in Croatia. The average winter temperature for mountainous areas is -0.6° C and has been steadily rising (see Chapter 3), thus resulting in a decrease in snow pack in recent decades.[41]

4.3.5. Multiplier effects of local impacts

Income and job losses in local tourism-centred communities have the potential to spread throughout the economy as the flow of goods and services between the tourist sector and other parts of the economy would be affected. Croatia's long-term development strategy of relying on tourism as one of the primary sources of national income may be at risk. Croatia generates approximately 20% of its GDP from tourism, which is characteristic of economically undeveloped countries.[42] Most developed countries have a relatively small share of tourism in GDP, such as Italy and Austria (6%).[43] Even 'famous' and branded non-European holiday countries such as Australia, Malaysia, Thailand or Singapore do not rely on tourism substantially. Singapore lowered its percentage of GDP from the tourism sector roughly from 14% to 5 % from 1990 to 2005.[44] While there are no macro-economic models of the Croatian economy that can measure what the impact of a drop in tourism would mean for the economy, it is apparent that the entire economy is vulnerable if tourism should falter.

The impact climate change on specific groups of people is not clear. A potential multiplier effect would be on the seasonal workforce. In the case of minimal warming (up to 1°C), the tourist season may start earlier and close later and, as a result, the number of working months will increase.[45] On the other hand, the seasonal workforce may suffer if unfavourable climatic conditions (frequent extreme events, for example) harm the tourism sector and tourist numbers fall.

Figure 4-8: Cartoon on the dependence of Croatia on tourism (Croatian text: "Are you one of those countries they write about that completely leans on tourists… More than Banana Republics on bananas!").

Source: Puntarić 2008.

In addition, changes in the number of tourist visits could dramatically affect numerous middle-class entrepreneurs who are dependant on tourist revenue (rental apartment owners, family restaurant owners, etc.), particularly during the peak summer season. Private accommodation and campsites make up 67% of all visitors capacity for hosting to Croatia.[46] This group does not have as much capital available for adapting to climate change as do the larger hotels and hosts. If climate change lengthens the tourist season, but total tourist visits remain constant, larger hotels may earn more while secondary, less-attractive rentals suffer because of a drop in the peak months. If, on the other hand, the peak flows are expanded and

"Changes in the number of tourist visits could dramatically affect numerous middle-class entrepreneurs who are dependant on tourist revenue (rental apartment owners, family restaurant owners, etc.), particularly during the peak summer season" smaller scale entrepreneurs can capitalize on tourist visits, the outcome is more positive for middle-class entrepreneurs. If the climate becomes an extremely adverse factor and tourists stop coming in large numbers, certainly those on the fringe of the industry will suffer the most. This could impact not only room renters, but other people who sell goods and services to tourists.

Finally, changes in climate – especially related to an increased frequency of natural disasters – could have a significant impact on the financial sector and the insurance industry covering tourism and tourist destinations. See Box 4-2 for more information about the global situation regarding the risks to tourist destinations from climate change.

Box 4-2: Financial risks and climate change.

Within the financial sector, climate change risks are being taken very seriously - especially in the insurance industry. This is important to tourism because of the number of buildings that may be vulnerable to climate impacts (flooding, forest fires, strong winds and storms, etc.). Insurance companies have been responding very quickly in understanding climate change issues. Practically all major insurance houses have already initiated their own research and taken steps towards addressing climate change issues.[47] The insurance industry perceives climate change as a potential risk, an opportunity and somewhere in between. Most often, insurance related to climate change deals with property insurance. Extreme weather events of recent years such as hurricanes have led large insurance companies to impose higher policy rates or simply refuse to provide coverage altogether.[48] For example, faced with high losses in 2005, insurers in the USA Gulf area cancelled more than 600,000 homeowners' policies or refused to renew them. Many commercial businesses could not find property insurance at any price. On the other hand, insurers who continued to issue policies at higher rates earned enormous profits, as there were no major hurricanes in the area in 2006 and 2007.[49]

For the banking sector, climate change does not yet seem to be of great concern. Following the massive damages to infrastructure in Europe (floods in 2005) and the US (hurricane Katrina in 2005), the situation is changing, but banks are still protected. However, losses due to natural disasters may overwhelm insurance and banking markets. One scenario estimates that disaster losses could reach over EUR 640 billion in a single year by 2040.[50] The impacts will be worse in developing countries where the capacity to manage climate related disasters is much lower. In Croatia, the large majority of hotels and other registered apartment renting facilities do have "fire insurance" – which, in addition to fires, covers extreme weather events. There is a long tradition of insuring business assets (in this case buildings) in Croatia, which may be the reason why a higher demand for insurance due to increased natural disasters has not been seen.

The UNEP FI CCWG (2006) report presents key recommendations for the financial sector:

- Recognise the reality of climate change and mainstream it into all business processes. It is a decision factor for business planning and strategies, portfolio management, and at the individual transaction level.
- Develop and supply products and services for the new markets that will emerge with integrated adaptation; e.g. at the micro-level in developing countries, and in the area of ecological services.
- Work with policy-makers to undertake a transition to integrated adaptation.
- Ensure that contingency plans consider "worst case" disasters.

4.4. Assessing vulnerability and adapting to climate change in the tourism sector

As has been demonstrated, the tourism sector has a significant impact on human development in Croatia and is potentially vulnerable to climate change. The probable effects on tourism resulting from climate change need far more research and analysis.

4.4.1. Information availability for decision-makers to assess vulnerability and adapt to climate conditions and climate change

Both the public and private sector need more information about the impacts of climate change, the magnitude of the resultant economic losses, the options available to avoid or offset these losses and the benefits and costs of undertaking them.

The first issue to be addressed – and this applies broadly to all of the sectors – is the need to develop the capability to downscale global climate change models to a finer grid scale, focused specifically on the region. Once developed, these models will be used to make climate projections of a much finer scale and to generate climate and weather data, such as the number of rainy days, number of very hot days, etc. At the same time, Croatia needs to be able to develop the capacity to project how climate change will influence extreme events, such as floods and droughts. Since the coastal climate is quite different from the interior climate, this is especially important in the tourism sector.

Currently, there is very little information about the impacts of climate variability, either directly or indirectly, on the behaviour of overseas tourists who visit Croatia, or domestic tourists. As discussed earlier, the vacation destinations of foreign and domestic tourists will be influenced by changes in climate both where they live and where they choose to vacation. This includes the effects of climate change on the environmental characteristics of these places. Information about the effects of climate change on the environmental attractiveness of tourist sites requires new research. For example, if runoff in Plitvice National Park is greatly reduced, the numerous waterfalls may be reduced to trickles of water and the pools beneath them may become stagnant, making it an unlikely tourist destination, despite the attractiveness of the area's other characteristics.

More detailed and accurate information regarding probable changes in climate, extreme events, and changes in environmental characteristics resulting from climate change is essential. Only then can research be carried out to analyse how these changes in climate will influence the choice of tourists' travel destinations, the impact of these choices on local expenditures at tourist destinations and on the Croatian economy as a whole. See Box 4-3 for more information on the type of research that may be helpful.

"More detailed and accurate information regarding probable changes in climate, extreme events, and changes in environmental characteristics resulting from climate change is essential."

4.4.2. Resource availability for adaptation and adaptation studies and the role of institutions and decision-making authorities

The role that the Croatian National Government will play in adapting to climate change is not clear. Tourism is a market-driven activity propelled by the decisions and economic circumstances of individual tourists, most of whom do not even live in Croatia. Therefore, it may appear that there is very little that national and local governments can do to avoid the possibility of tourism losses due to climate change in coastal areas. However, this is somewhat misleading. The impact of climate change on tourism is potentially quite broad, but so is the mandate of the public sector. Looking at how local and national governments are currently involved – directly and indirectly – in the tourism sector, will help to give us a better idea of how the Government can be involved in future adaptation to climate change. The Government is already deeply involved in tourism, and Croatia plays a leading role in global institutions focused on tourism. For example, Croatia is the head of the European Commission of the UN World Tourism Organization. The current tourism-related activities of the public sector fall into six broad categories (Table 4-3).

Box 4-3: Models to estimate the changes in visitation by tourists and tourist welfare

Estimating the changes in visitation to Croatia by foreign and domestic tourists can be undertaken using participation or travel cost models, using aggregate data, as is the case with the Hamburg Tourism Model or the participation model being used in the second step of the PESETA study. Modelling of the impacts of climate change on tourism is currently institutionally fragmented in the EU. In addition, the coverage of Croatia in these models is not very good and this needs to be improved for use by Croatian policy makers. However, research institutes in other parts of Europe already have a comparative advantage in this field, both in modelling and handling the large geographic databases. Therefore, future research in this area would benefit Croatia by the collaboration between Croatian and EU researchers to improve existing or develop new aggregate participation (or travel cost) models and related databases.

While leaving the aggregate modelling of tourist behaviour to other European centres, it may also make sense for Croatian researchers to develop recreation demand models for individual sites or areas, using survey data from individual respondents. There are three reasons for this. First, economic activity in the key beach tourism sector accounts for a large share of Croatia's GDP. These kinds of models, based on individual data, tend to shed much more light on the climatic and environmental determinants of recreation demand than do aggregate models. Second, not only are these disaggregated models better at predicting tourist behaviour, they can also be tailored to the environmental nuances of specific sites, such as Plitvice and other karst-based systems, that are among Croatia's must valuable environmental assets. This enables the disaggregated recreation demand models to better manage both the direct and indirect effects of climate change on recreational demand behaviour.

Recreation demand modelling at individual sites or multiple sites using survey data on individuals, either from a target population or on-site surveys, is a fairly well developed field and quite complex. A comprehensive study of an individual site (National Park Plitvice, for example) could cost significant resources and take several years to complete. This would involve designing, administering and processing survey data, estimating the parameters of the recreation demand models, and then using them to simulate the impacts of climate change and the adaptation policies needed. However, if this sort of study were done through the university system grants programme, the costs would be significantly less, since the only major costs would be the surveys themselves and consultations/ trainings from economists abroad. The benefits of conducting such studies would be that they would provide more accurate information than provided by aggregate models, both about the impacts of climate change and possible responses to avoid these impacts.

Modelling the economic impacts of climate change

Aggregate participation models and disaggregated recreational demand models can be used to project the effects of climate change on visitation. However, additional data is needed to calculate the effects on the local economy and then to simulate the impact from changes in local revenue on the larger economy. First, Croatia probably needs to step up its efforts to systematically survey tourist expenditures at many locations, on an on-going basis, using a homogeneous approach to sampling and surveying. This data can be used in conjunction with participation data to estimate changes in tourist expenditures due to the impacts of climate change on visitation. Provided there is sufficient climate variability in the data set, this data can also be analysed to determine if the expenditures of tourists are in any way influenced by climate change (if visitation is consistent). This climate effect on expenditures can be incorporated into the above calculations. A Croatian Input-Output table or, better still, Computable General Equilibrium (CGE) model could then be used to translate these changes in local spending into their effects on national income and employment.

Table 4-3: Categories of State involvement in tourism

Category	Description
1. Planning, development and operation of public services and transport infrastructure	Providing clean water, sanitation, port facilities and services and transport links to tourist destinations.
2. Regulation of land use	Urban and suburban land use zoning, building and electrical codes, wilderness protection and natural hazard zoning. In addition to urban planning, the Croatian Government has spent significant resources building eco-tourism infrastructure, including bicycle trails.
3. Regulation of environmental quality	The development, promulgation and enforcement of regulations and measures to ensure clean air and water.
4. Promotion of economic development and tourism	The activities undertaken by the public sector to increase tourism through advertising and public relations. The Croatian Government is actively involved with the Croatian National Tourist Board in promoting the country as a summer tourist destination internationally – including paying for commercials on outlets such as CNN.
5. Planning and implementation of taxation and investment policies to promote development	Providing economic incentives to private developers and investors to overcome barriers to economic development. The Croatian Government has been active in encouraging "renovation" activities among small tourist operators, offering grants to numerous small-scale entrepreneurs. This has focused on inland rural tourism.
6. Disaster relief planning and management	Including activities to avoid the consequences of natural disasters and to provide various forms of aid and services to victims of natural disasters.

In addition to the historical involvement of the public sector in these six areas, one cannot lose sight of the much larger fact that tourism is a major industry in Croatia. To the extent that climate change and sea-level rise threaten the future of beach tourism in Croatia, the most important role of the public sector may be to develop new forms of economic activity to generate income, wages and tax revenues that are lost due to climate change. Much of this activity may come from developments in sectors other than tourism. This broader view emphasizes the interplay between (and perhaps the indivisibility of) development policy and climate change adaptation policy. It applies more broadly to the direct and indirect impacts of climate change on the economy as a whole. If we take this broader view, then the potential for public sector involvement in adaptation policy is very broad indeed.

4.4.3. Analysis of available technological options for adaptation

Based on the results of the PESETA study and the results of other modelling-based studies for the EU, the preliminary evidence is that foreign tourists and probably Croatian tourists as well, will adapt to climate change by choosing a new vacation spot and no longer visiting the Croatian coast. This would be a potentially devastating blow to many communities on the Croatian coast and to the whole Croatian economy, which is heavily dependant on beach tourism. It would result in reduced income from (and employment in) the tourism industry in Croatia. Most actors within the tourist sector in Croatia are only beginning to think about the effect that climate change may have. Efforts should begin immediately to better un-

Box 4-4: Adaptation concepts in the tourism sector.

Adaptation to climate change in the tourism sector can take a number of different forms. Tourists can adapt by changing the destinations they visit, including staying at home. They can change their activities to those that are less influenced by climate change. Depending on time constraints, they can also change when they take vacations. Finally, they can change the goods and services they consume while on vacation – for example by renting an air-conditioned room. Essentially, tourists have a fairly high capacity to adapt to climate change, depending on the ability of tourists to obtain and utilize free time, their access to information about tourism opportunities and their ability to pay.

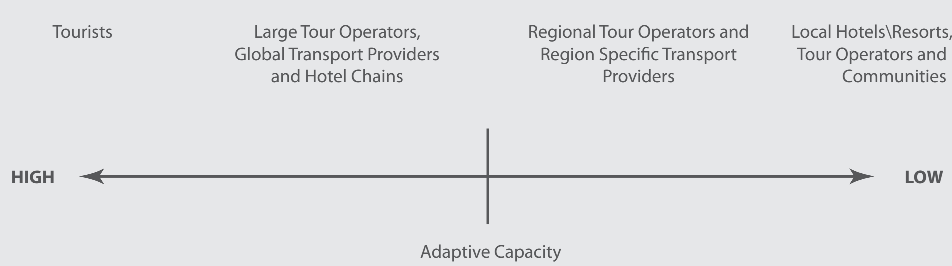
Tour operators and transportation providers are already very responsive to changes in "tastes" and also to climate variability. They have the ability to switch destinations and add or reduce flights on an annual and sometimes even a seasonal basis. They can adjust very rapidly to climate change, perhaps even acting as leaders in selecting and promoting new holiday hot spots.

For the hosts of tourists, such as hotels, local tour operators, and communities, adaptation would also mean altering their products. However, the more local the actor, the more difficult it is to adapt. Local actors are connected to the infrastructure, or the business was developed on local attractions. This range of adaptive capacity is presented in Figure 4-9.

Because local actors are less able to adapt (and most actors in the Croatian tourist economy are at the local level) this may not be good news for the Croatian tourism sector. As has been explained, there are many individuals that rent out rooms, sell agricultural goods, and provide services at the local level who would not have the ability to adapt in the same way a major cruise line would. Furthermore, larger infrastructure owners are also at a disadvantage with regard to adaptive capacity.

Croatian hotels are predominantly owned by Croatians (probably over 60% - in private or State ownership). The remainder are owned by commercial banks (25%) and Private Investment Funds (14%) the majority of which are foreign-owned. Although this is a positive factor for human development in Croatia, with most of the profits remaining in Croatia, it also means that climate change risks and the related damages will be borne by Croatian investors and the Croatian economy, rather than by foreign investors. While hotels are not the only tourist operators in Croatia, businesses associated with tourism are owned and operated locally, which limits their adaptive capacity. People cannot simply move their businesses to other locations.

Figure 4-9: Relative adaptive capacity of major tourism sub-sectors. Source: with modifications after Simpson et al. 2008.



derstand the impacts of climate change, the actions that should be taken to offset/ prevent tourism losses, and the private-public sector dialogue needed to implement actions. How can the private sector adapt to these impacts and how can the public sector facilitate this adaptation?

The private sector in both the local and national economies can be expected to adjust to losses (Box 4-4 for more information on adaptation concepts in tourism). In the short-run, this may result in the economic decline of local communities which are dependant on tourism, higher unemployment and rural-urban migration. In the long-run, these declines will be offset to some extent by investments in new and existing industries, with shifts in the industrial structure of the country. However, the public sector also has a role to play in coping with climate change, both in the short- and long-run, even if it is currently unclear what that role will be. Table 4-4 presents a general overview of the type of adjustments that might be taken by the private and public sectors to adapt to climate change in Croatia. Potential adaptations to sea-level rise may also become necessary. These are analysed further in Chapter 5.

Table 4-4: Types of adaptations to climate change in the tourism sector

Adjustments to adapt to climate change	Detailed explanation
Reducing the sensitivity of local tourism-dependant economies to climate change	Autonomous and planned adjustments by the private and public sectors in local communities – identifying alternative income-generating activities in communities that are heavily dependent upon beach-based tourism. For example, tourism promotion could include cultural activities, such as film, music and theatre festivals, food, historical sites like Dubrovnik, ancient ruins, the Pula coliseum, etc. This could also include providing indoor pools, wellness tourism, air-conditioned entertainment, and other amenities. This is already underway within the general strategic framework of tourism development in focusing on rural tourism development, but can be especially important within the context of climate change threats.
Increasing work with tourism firms and actors to enhance marketing abilities at home and abroad. This may include helping to improve capacities for management and hosting tourists.	This is already undertaken by the Croatian National Tourist Board and through private sector investment. This would involve enhancing and promoting the non-climate related characteristics of Croatia's tourism, such as levels of service, amenities and comfort, as well as the perceived level of luxury. In recent years, much of the growth in the tourism industry has relied on these sorts of improvements. In order to ensure that human development is enhanced, continued attention should be paid to the most vulnerable groups, including seasonal workers with lower qualifications, local people who have less access to capital and education, and those that are least likely to handle the risks if tourism is negatively affected.
Changing the thermal efficiency of buildings	Provide incentives for builders, building owners and lending institutions to increase the thermal efficiency of existing and new buildings, through more economically-efficient pricing of energy, programmes to encourage the financing of these measures based on life-cycle cost principles and the promulgation of voluntary and/or mandatory buildings efficiency standards. While the MEPPPC has already implemented standards for energy efficiency in new buildings, companies and individuals should be encouraged to go above and beyond the basic requirements in order to save on cooling costs and make tourist destination hotels and guest houses more comfortable.
Developing additional water supplies	Developing additional supplies, water purification and waste treatment facilities for coastal communities – especially on the islands, where water supplies are already tight.
Increasing water-use efficiency	Encouraging water conservation through higher water and energy tariffs, programmes to encourage banks to make loans for the installation of complementary energy efficient and water-saving technology based on life-cycle cost principles, or through voluntary and/or mandatory energy and water conservation standards.
Reducing risks of natural disasters in tourist areas	Increasing the focus of national and local governments in coping with climate-based risks that threaten tourist areas, such as fires, floods, storms, and heat waves, by improved disaster risk management planning and investment.
Protecting fragile, climate-sensitive ecosystems	Undertaking both active and passive measures to protect and restore ecosystems vulnerable to climate change.

4.5. Conclusions and recommendations

Because of the lack of knowledge about the actual physical impacts on specific sites, as well as the probable shift in demand by tourists, recommendations for adaptation are limited. However, the following "no regrets" steps can be taken in order to address climate change and human development in the tourism sector:

- Continue to focus on "climate-proofing" tourism in Croatia – including expanding the tourist season and enhancing the service capacities and products offered within the industry.
- Encourage measures to increase the energy efficiency and ability to keep hotels and buildings cool during the hottest months. This will also have an impact on emissions reductions.
- Ensure that information on the tourism industry, provided by Government-funded research, is user-friendly and can be easily accessed by the public and stakeholders in particular.

In addition to "no regrets" options, there are other steps that could be taken to address vulnerability in the tourism industry.

- Develop better information available for decision-makers (including the Government and investors) about future climate change and its potential impact to the natural systems that impact the tourism sector. This is already taking place to some extent through work with the DHMZ and as a part of university research. However, activities must be coordinated.
- Develop the capacity to simulate the impacts of climate change on tourism and assess the impacts on the local and national economies.
- Develop the institutional and analytical capacity in the public sector to develop policies and measures to facilitate adaptation by the private sector to climate change and to assess the benefits and costs of these policies and measures.

Chapter 5

Coastal Zone and Sea-Level Rise

5

Chapter 5 Summary

Coastal Zone and Sea-Level Rise

Global sea level is expected to rise between 9 and 88 cm by 2100. However, this estimate only represents the rise resulting from the warming of the seawater. It does not consider the impact of ice-melt / ice sheet flow or the uncertainties in climate-carbon cycle feedbacks. If significant ice-melt occurs, the sea level could rise much more and far more rapidly. Overall, considerable uncertainty exists as to the likely level of sea-level rise.

In addition to the cultural significance of the Adriatic for Croatians, most tourism occurs on the coast. Maritime transport, off-shore gas production, shipbuilding, agriculture and fishing and mariculture are all important economic activities that occur either on or near the coast. The Croatian coastal areas are also important because of the diversity of natural ecosystems. Economic development is already putting pressure on these natural ecosystems, meaning that there is a significant risk for biodiversity.

Sea-level rise has the potential to become a costly impact of climate change on the Croatian coast. However, the uncertainty about the level of sea-level rise means it is very difficult to estimate. If the level of the sea rises by half a metre or more, some areas will be particularly vulnerable in the middle to late part of this century. In particular, the Neretva Delta, the Krka River, Vrana Lake near Biograd, the island of Krapanj and numerous other locations may face significant challenges.

According to the rudimentary analysis in this Report, the total amount of land covered would be over 100 million square metres with a sea-level rise of 50 cm and over 112 million square metres with a sea-level rise of 88 cm. This would lead to a loss in land value of EUR 2.8-6.5 billion and EUR 3.2-7.2 billion respectively. While these are very rough estimates, they point to the potential for significant losses as a result of sea-level rise.

The basic options for coping with sea-level rise are to protect vulnerable areas or to retreat from them. Sea-level rise is expected to occur gradually. Therefore, there is still time to develop the best methods for coping with the problem, place by place. The role of the national and local governments in adapting to sea-level rise is currently unclear. Many laws and regulations address the protection and management of Croatia's coastal resources, but the existing body of law is largely a patchwork of legislation that is sometimes inconsistent and does not address the management of the coastal areas in a comprehensive and consistent manner.

The first step for Croatia to take in this area is to improve the institutional capacity to comprehensively plan and manage coastal resources. This is a "no regrets" measure. The second step is for coastal planners, managers and developers to take into account potential future changes in sea level in developing coastal land use regulations, disaster risk management, and when planning major infrastructure projects – such as sewerage – with planning horizons of 50 or 100 years into the future. The third step would be to improve policies, measures and projects for adapting to potential sea-level rise. This includes assessing the benefits and costs of options as well as improving access to information. More comprehensive and detailed mapping of the coastline, including physical characteristics, land use patterns and economic activities will be needed to achieve this.

Croatia should co-operate with existing organisations that are developing global/ regional databases and models for forecasting sea-level rise, the physical and economic damages, and the benefits and costs of alternative adaptation options. This will make it possible for Croatia to better forecast the physical and economic damages that may be caused by sea-level rise and the benefits and costs of avoiding these damages.

5.1. Introduction

One of the effects of climate change is sea-level rise. This chapter analyses the possible implications of sea-level rise for the Croatian coast in a human development context, the direct and indirect impacts resulting from it, and the eventual adaptation measures that may overcome foreseeable problems. It also discusses some of the issues related to coastal zone management, in general, which have some connection to climate change.

Models using the Intergovernmental Panel on Climate Change (IPCC) SRES scenarios[1] presented in the IPCC (2001) report, project a global absolute sea-level rise of between 9 cm and 88 cm by 2100. The IPCC (2007) report[2] also projects a sea-level rise of between 18 and 59 cm (depending upon emission scenario) until 2099, caused by the warming of the seawater only, without taking into consideration ice-melt/ ice sheet flow or the full effects of uncertainties in climate-carbon cycle feedbacks. According to the IPCC working report, it is not possible to assess the likelihood of certain levels of sea-level rise.[3] Some studies[4] have estimated that the Earth will be warm enough in less than 150 years (assuming no reduction in greenhouse gas emissions) to melt the Greenland Ice Sheet. This change could lead to four to six metres of sea-level rise at a rate of two to five centimetres per year.

Antarctica does not yet appear to be contributing substantially to sea-level rise, because the snow fall rate and the formation of new ice is still greater than the rate of ice-melt. This is due to increased precipitation over that region which is, ironically, caused by increased evaporation due to global atmospheric warming. In regions of coastal subsidence or high tectonic activity, which is the case with the Croatian coast, climate change-driven sea-level rise could be even faster and more pronounced and thus cause even more damage. When examining the amount and type of land that may become submerged due to sea-level rise in Croatia, it appears there may be profound impacts.

Figure 5-1: Storm surge in Rijeka.

Source: HINA.

5.2. The importance of the coast to Croatia

The Croatian territorial sea occupies an area of 31,067 km^2, which is roughly one-third of the total Croatian territory. The length of the coastline is 5835 km and there are 1246 islands and islets, of which only 47 are inhabited.[5] The Adriatic is directly responsible for the well-being of Croatians – not only those living on the coast, but also those living on the continent. In addition to its cultural significance, the coast is also the main area for tourism. Maritime transport, offshore gas production, shipbuilding, agriculture and fishing and mariculture, also occur either on or near the coast. All these sectors are extremely important to the Croatian economy, in general, and affect the well-being of hundreds of thousands of households. However, successful economic development is only one part of sustainable human development. Sustainable development includes the protection of natural resources, biodiversity and aesthetic landscapes, as well as the inclusion of the public and stakeholders in the process of planning and development.

The most recent documents[6] on this subject suggest that, despite the importance of the natural, coastal ecosystems to Croatia's economy, the actual protection measures established are not strong enough to protect them from the adverse impacts of economic development. PAP/RAC (2008) reports that the major issues in the terrestrial zones of the Croatian Adriatic area include the following (see Box 5-1):

1. Urbanisation of the coastal belt;
2. Tourism development - currently affecting the existing environmental infrastructure, the landscapes and natural qualities of coastal regions;
3. The abandonment of agriculture and conversion of farmland into housing; and
4. The conflict between nature and landscape protection and further economic development.

Since the entire Croatian coast is situated on carbonate rocks and karst habitats – which are rare and extremely vulnerable to physical changes – the management of those ecosystems (which are also connected to fresh water reservoirs) is a top priority for nature protection.

The same document suggests that the major issue in the aquatic zones of the Croatian Adriatic area is maritime traffic (private and commercial), which is becoming more and more dense – especially in the northern Adriatic (due to the port of Rijeka but also the foreign ports of Trieste, Venice and Koper). Even more traffic is expected with the opening of the Liquefied Natural Gas (LNG) terminal in Omišalj (on the island of Krk). Another great hazard to seawater quality is the lack of or insufficient wastewater treatment from the facilities and settlements along the Adriatic coast. Besides domestically produced pollution, a large contribution comes from the Italian Po River. Seawater pollution has adverse effects on water-based tourism and marine ecosystems. Fisheries management is another major issue in the Adriatic, as the decrease in fishing resources (due to over-fishing and damaged marine ecosystems) is reducing the economic opportunities for many families and consequently the contribution of the fishing sector to the country's economy (see Chapter 9).[7]

Box 5-1: Coastal zone planning and development – issues of environment and social well-being

One of the milestones in the planning and control of coastal development in Croatia was the adoption of the Coastal Decree (the Decree on the Protected Coastal Area adopted in 2004). It was a necessary response to the pressure for coastal development, mostly poor quality, second homes (including illegal buildings), which could not be controlled through regular spatial planning instruments. The impact of the Decree has become somewhat controversial. A majority of landowners saw an opportunity to sell their properties at a high price and pushed for their land to be classified for construction. Few succeeded, which has resulted in disappointment and frustration with the restrictions. Owners are not allowed to build on their land and the land cannot be sold at what they consider a just price. As a result, local communities are often divided over the situation. Others were fortunate enough to sell their land for large sums but often have not invested productively to generate future incomes and/or jobs. As a result of the strong demand for coastal property, it is common for successful businesses in the area to neglect their core activity and to try their luck in real estate development.

On the positive side the Decree clearly managed to achieve some important sustainable development objectives, including:

- curbing further sprawling development, by restricting permission to build on new land;
- stopping development on pristine coastal land; and
- ensuring that construction was set back from the coast, allowing public access

Existing county spatial plans required amendment, in order to be harmonized with the Coastal Decree, which was then repealed and almost completely integrated into the new Spatial Planning and Construction Law (in effect from the end of 2007). As a result, large tourist development zones (most pre-existing) outside of settlements, were designated or maintained. However, the planning and development of these zones will require major financing from powerful investors and thus excludes locals. Since locals are unwilling to take most of the jobs – in particular the low-wage ones – offered by tourist businesses, foreign workers are employed during the tourist season, particularly on the islands. Since an increased number of recently privatized hotels are trying to extend the tourist season, many of these workers will tend to become permanent residents. No social assessment of this process and its implications has yet been made.

Consequently, several fundamental policy issues and key questions will need to be addressed for the coastal zones, as follows:

1. What is the correct response to the strong pressure for intensive coastal urbanisation, often without the necessary infrastructure (primarily real estate development, namely secondary homes, sometimes hidden or combined with tourism development)?
2. What instruments is the Government ready to apply to ensure a more equitable distribution of the extra profit generated through land-use decisions (planning gain or increased land value when land is designated as buildable in land-use plans)?
3. How will policy ensure that locals are not excluded from future economic (mostly tourism–related) development – particularly on the islands? How is it possible to counteract severe aging, depopulation, and abandonment of the traditional economic sectors and to ensure that immigration does not have negative social consequences?

Different approaches to these issues may lead to different scenarios for the future of coastal communities. Failing to deal with intensive urbanisation may lead to future environmental degradation of the coast, inevitably associated with biodiversity and landscape diversity loss – turning the Croatian coast into something akin to Spain or Italy. Not dealing with the equitable distribution of economic development would result in further social segregation and the loss of the trust of local people in any spatial planning policy. A positive sign is the recently prepared draft Law on Agricultural Land (now in Parliament for adoption), which tackles this issue by capturing at least part of the planning gains and earmarking them for local agricultural development.

To ensure that tourism-related development does not exclude locals, a supportive environment, which includes small and medium scale investment opportunities and educational programmes, must be cultivated to enable both domestic investors and workers to participate in local tourist development. If not addressed, this issue may lead to further depopulation, uncontrolled immigration by foreigners (from more robust socio-economic environments) and the loss of the traditional local character and identity.

Finally, development planning itself is very limited. The local self-government system is overly fragmented and lacks the human and financial capacity required for the efficient decentralization of responsibilities and the formulation of sustainable development strategies. This equally applies to the local capacity for planning and implementing the complex infrastructural projects necessary to minimise the environmental impacts of new developments. Because the new Planning Law in most cases requires infrastructure to be in place before new development takes place, and given the limited local capacity to organise infrastructure construction, the result is a slowing of investment activities along the coast. However, this may not be a bad thing for local communities and the environment.

Gojko Berlengi, COAST Project Manager, UNDP - Croatia

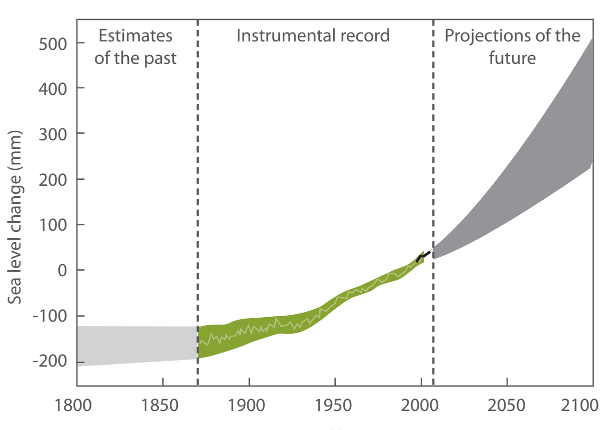
"In the long term, sea-level rise may be among the most costly impacts of climate change on the Croatian coast, along with the effects of a warmer, drier climate on tourism and an increased frequency of extreme weather events"

5.3. Potential impacts of future climate change on the coastal zone in Croatia

In the long term, sea-level rise may be among the most costly impacts of climate change on the Croatian coast, along with the effects of a warmer, drier climate on tourism and an increased frequency of extreme weather events. Sea-level is the average height of the ocean between high and low tide. Sea-level rise is the change of the average height of the ocean over a long period of time. However, a rise in sea-level is not only a rise in this average. It can also mean that storm surges, flooding, and erosion become more pronounced.

Monitoring and re-assessing historical, sea-level data has recently become more important due to the changes in sea-level triggered by climate change. Figure 5-2 shows past changes in global sea-level and projections for the future.

Figure 5-2: Time series of global mean sea-level (deviation from the 1980-1999 mean) in the past and as projected for the future. The shaded areas show the uncertainty in the estimated long-term rate of sea-level change (light grey) and the range of model projections for the SRES A1B scenario for the 21st century relative to the 1980 to 1999 mean (dark grey). Future projections have been calculated independently from the observations. The green shading denotes the range of variations from a smooth curve (light green line), which is a reconstruction of global mean sea level from tide gauges. The black line shows global mean sea-level observed from satellite altimetry. Beyond 2100, the projections are increasingly dependent on the emissions scenario. Over many centuries or millennia, sea-level could rise by several metres.



Source: Bindoff et al. 2007.

There are two basic reasons why mean sea-level rises:

- The total volume of seawater increases because of the thermal expansion of seawater due to surface warming.[8] According to the IPCC (2007a), since 1993 thermal expansion of the oceans has contributed to about 57% of sea-level rise, with decreases in glaciers and ice caps contributing to about 28% and losses from the polar ice sheets contributing to the remainder. This means thermal expansion of water is currently the number one factor in sea-level rise. Since the same report states that global temperatures are expected to continue to rise, we can surmise that sea-level rise is also highly probable. The crucial question is how much it will rise and how quickly.
- The warming of the Earth's atmosphere is causing accelerated melting of the Earth's ice sheets and alpine glaciers, contributing to an increase in the total volume of seawater.

Both these factors produce a rise in global sea-level, which affects the Adriatic Sea as well. Measurements have shown a steady rise in sea-level over the last decade. However, observations of such a small time period make it difficult to conclude whether this is part of an overall trend in sea-level rise or just a decadal variation of sea-level.

The Croatian coast is a tectonically and seismically active zone characterised by local uplifting and subsidence. Therefore, monitoring the mean sea-level should take these factors into account. The analysis of the tide gauge stations at four points along the Croatian Adriatic coast (Rovinj, Bakar, Split and Dubrovnik), over several decades (from 1956 to 1991), showed very different trends. For example, at Rovinj and Split sea-level is falling relative to the land by a rate of -0.50 mm/y and -0.82mm/y respectively, while in Bakar and Dubrovnik sea-level is rising relative to the land by a rate of +0.53mm/y and +0.96mm/y, respectively.[9]

5.3.1. Particularly vulnerable areas

A limited number of studies have been undertaken in Croatia related to present and future sea-level rise due to climate change. One of the most recent ones[10] provides both a good overview of the risks of sea-level rise along the Croatian coast and an assessment of coastal vulnerability and the adaptation options available to reduce this vulnerability. This study and the independent analysis for this Report identify a number of vulnerable areas on the Croatian Coast (Table 5-1).

Sea-level rise also remains a potential, but less significant, threat to numerous other coastal areas. Natural and climate change-related fluctuations in runoff, plus future economic development, may intensify the effects of sea-level rise all along the Croatian coast. The small island of Krapanj in the Adriatic, which is only about 1.5m above sea-level, may require complete evacuation in the case of close to 1m sea-level rise (Figure 5-4). Another potential "hot spot" for sea-level threats are coastal agricultural areas, in particular the Neretva River Delta, where significant production

Table 5-1: Areas that are likely to be vulnerable to sea level rise on the Croatian coast

West Istrian coast	Raša River
Vrana Lake on the Island of Cres (the freshwater reservoir)	Zrmanja River
Town of Nin	City of Zadar
Vrana Lake Nature Park near Biograd	The small but densely inhabited island of Krapanj
City of Split	Cetina River
Neretva River	City of Dubrovnik
City of Stari Grad on Hvar	River Krka
Areas around Šibenik	

Figure 5-3: Flood affected area of the Neretva river valley after 0.50m (light grey) and 0.88m (dark grey) sea-level rise. (Mesh means urban settlement)

Source: OIKON d.o.o.

losses could occur due to coastal flooding and salinisation of the remaining land.[I] Figure 5-3 illustrates the flooding disaster of the Neretva River Delta resulting from a 0.50 m and 0.88 m sea-level rise.

If future sea-level rise is significant, in addition to the vulnerable areas mentioned, several other problems are foreseen:

- **A number of commercial fishing ports and fixed marinas may be affected** – even if the sea-walls remain above projected sea levels, the ports can still be affected during stormy weather, by high waves (during "jugo" winds) and extreme seawater levels, which will make them vulnerable to flooding.
- **Contamination of coastal freshwater springs (salt water intrusion) affecting drinking water supply may occur** – a great number of coastal settlements in Croatia use coastal or near-coastal freshwater springs in karst terrain. Higher levels of seawater could displace the freshwater from those springs (a process called saltwater intrusion) resulting in their contamination. Moving wells to a new location or desalinising the water would require additional funds.
- **Wetlands and swamps may be damaged** – in particular, one of the most recently proclaimed Croatian Nature Park 'Vrana Lake', the only large swamp near the Mediterranean coast – could be directly threatened and potentially destroyed with a sea-level rise of 0.5 metres. Vrana Lake is a special ornithological reserve (habitat of endangered bird species) with immense biodiversity and extraordinary scientific and unique ecological value.[II] Flooding by seawater would irreversibly destroy the sensitive balance of its ecosystem.
- **Coastal erosion may speed up and a number of beaches may be destroyed or become submerged.** Although it is possible that new beaches could appear further inland and new ones may be created by erosion, artificial beach repair and replenishment of the beach gravel or sand may be necessary and will need funding. In addition sea-level rise can negatively affect many of the plants and animals of the coastal ecosystems, including forests.
- **The tourism and recreational businesses that depend upon coastal areas may be severely affected.** Since the tourism industry is predominantly seaside-oriented, sea-level rise can also have a direct and indirect impact on this sector. Table 5-2 summarises the potential direct and indirect impacts of sea-level rise on Croatian tourism. The most prominent direct impact is the threat to coastal tourist and cultural sites (hotels, historical sites). The most prominent indirect impact would be the threat to freshwater springs, water-pipes and sewerage systems.

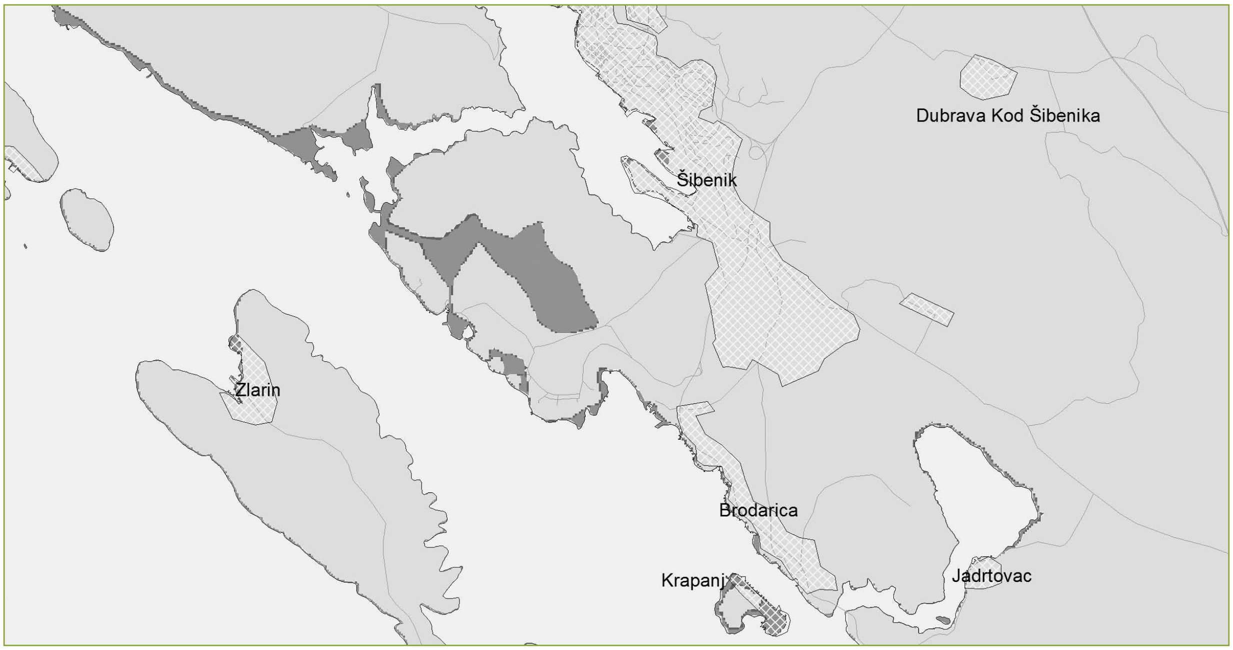
[I] Znaor (2008) estimates the value of tangerine production alone at EUR 6 million per year for the Neretva River Delta

[II] See http://vransko-jezero.hr/cms/ for more details.

Table 5-2: Potential direct and indirect impacts of sea-level rise (SLR) on the Croatian tourism industry

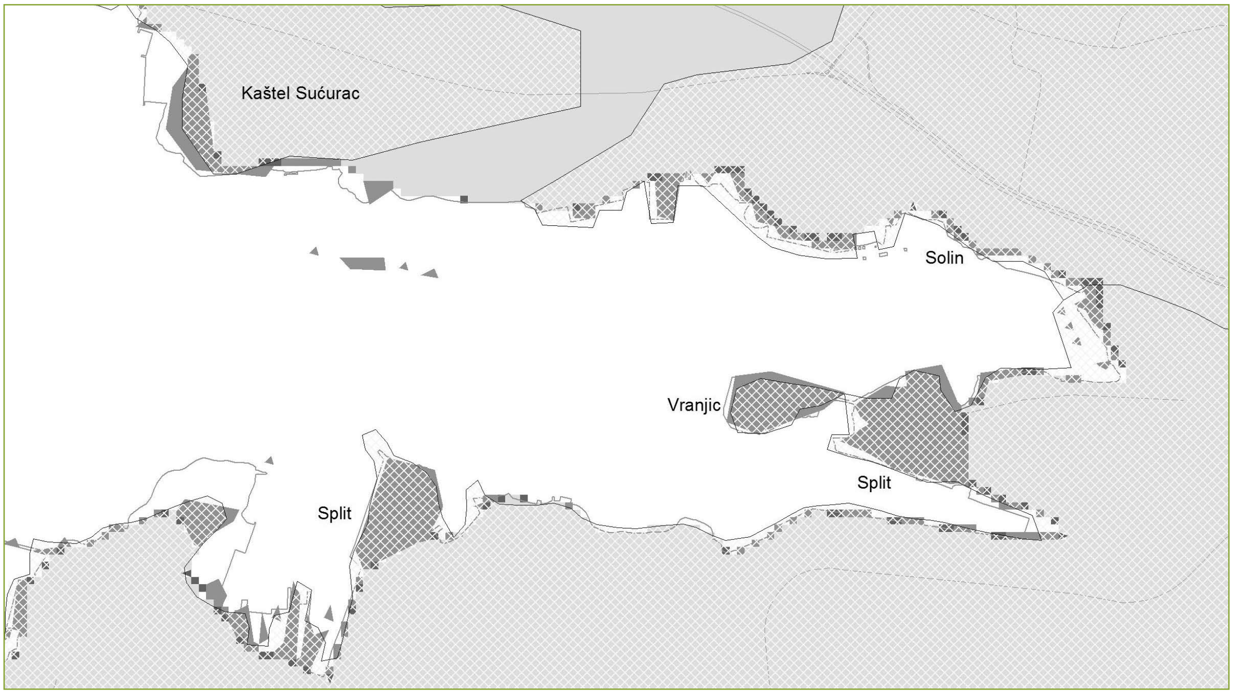
Type of Impact to Tourism	Potential Consequence of Impact
SLR impact on coastal recreational sites and cultural sites – direct and indirect impacts	**Directly** affects: - Cultural aspects of tourist destinations - many of the historical centres of coastal towns are just one or two metres above present sea levels. Zadar, Trogir, Split, Dubrovnik, Stari Grad and many others could be prone to flooding, while others may even become submerged – Krapanj, Tribunj, and a number of low islets; - Low-lying buildings, such as hotels, marinas, camps - Recreational areas may be threatened by erosion and/or beach flooding e.g. the famous and popular Zlatni Rat Beach and many coastal promenades). **Indirectly** affects: - Funding allocation - forcing the protection of cultural sites rather than the development of new recreational sites; and the re-building and repair of tourist facilities rather than urbanisation and infrastructure projects.
SLR impacts on salt water levels, salt water quality and temperatures – indirect impact	**Indirectly** affects: - Secondary tourism infrastructure (such as fresh-water pipelines, underwater communication cables, etc.) - Structure and development of coastal aquatic ecosystems and habitats that influence the supplies of environmental services enjoyed by visitors (such as Neretva, Krka and Lim river deltas or estuaries)
SLR impacts on coastal freshwater springs and wells (salt water intrusion into freshwater wells and springs) – indirect impact	**Indirectly** affects: - The drinking water supply due to the loss of coastal wells after salt water intrusion (the shortage of drinking water is already a problem, especially on the islands) - The functioning of coastal sewer systems due to flooding - The functioning of some water-pipe systems due to flooding

Figure 5-4: Coastal Image of Šibenik, the island Krapanj after a sea-level rise of 0.50 metres (light grey). (Mesh means urban settlement)



Source: OIKON d.o.o.

Figure 5-5: Image of the land covered by sea-level rise of 0.50 m (light grey) and 0.88 m (dark grey) on the northern part of Split. (Mesh means urban settlement)



Source: OIKON d.o.o.

5.3.2. Total land flooded at different levels and estimates of potential economic damage

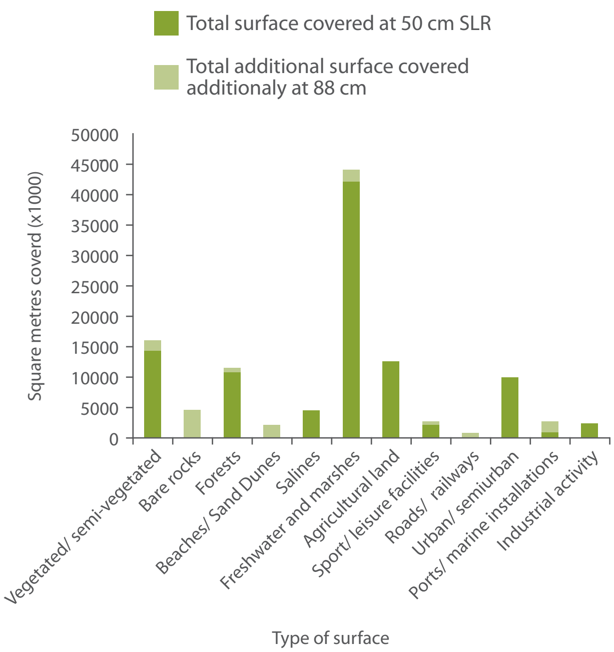
As part of the preparation of this NHDR, the authors analysed the amount and types of land which would be covered by sea water, or would be at risk, given two sea-level rise scenarios 50 cm and 88 cm. A 50 cm rise represents a high potential sea-level rise (described by the IPCC in 2007[11]), while 88 cm represents the maximum amount predicted if the Greenland and Antarctic ice sheets do not melt.[III] A simulation of 25 cm would have provided additional useful insight, but without a more detailed digital elevation model, this was not possible. As the IPCC provides no probability for various levels of sea-level rise, choosing 50 cm and 88 cm represents a "mid-range scenario" and a "worst case scenario" provided there is no significant melting of the Greenland or Antarctic ice sheets.

An analysis of all the coastal counties shows that, with sea-level rise at 50 cm, over 100 million square metres of land will be covered, including urban areas, roads, agricultural areas, forests, beaches, ports, among others. At 88 cm, the area covered increases by another 12.4 million square metres (See Figure 5-6 and Table 5-3). However, the methodology used to obtain these estimates has several limitations. The elevation model used in the analysis has a horizontal resolution of 25 metres. This means that if the sea-level rises and consequently the sea moves inland 12 metres, it would not register in the analysis. In some places, such as the Makarska Riviera, these hypothetical 12 metres could be disastrous to the local economy in terms of the beach area and shopping districts lost. Thus, the estimates of land at risk from sea-level rise can be considered somewhat conservative. Nevertheless, these estimates are still helpful for identifying the potential trouble spots on the coast and for showing a sense of scale for the potential economic damage.

As can be seen from Figure 5-6, perhaps the most vulnerable coastal resource may be fresh-water systems and marshes. This is particularly the case with the Krka

[III] The analysis was carried out using GIS data by OIKON d.o.o. as an in-kind contribution to the Report. The data for the analysis was provided by the Republic of Croatia State Geodetic Administration – A digital elevation model of the coastal counties.

Figure 5-6: Types of land which would be covered by 50 cm of sea-level rise and the additional amount covered by 88 cm.



River, Vrana Lake Nature Park and in the Neretva River Delta (See Figure 5-3). Additionally, urban and agricultural land will be at risk.

The estimates of potential land submersion shown in Table 5-3 would probably have a significant impact on human development on the Croatian coast. The various dimensions of the human development impacts are hard to measure, and indeed the economic losses can still only be approximated. Looking at Europe as a whole, the European Environment Agency (EEA) estimates that the economic damage due to sea-level rise in Europe will be between EUR 12-18 billion in 2080 – though it is unclear if this includes Croatia. The same study estimates that the number of Croatians who are vulnerable to coastal flooding will increase from fewer than 2000 people per year from 1960-1990, to 6000-8000 people per year in the 2080s.[12]

The economic damage due to increased flooding in Croatia is potentially quite large. To approximate this economic damage, the authors of the Report determined the areas potentially affected by sea-level rise

Table 5-3: Total surface area covered by Sea-Level Rise at 0.5 and 0.88 metres and values used for economic calculation.

Type of Land	Total surface covered at 50 cm SLR (m2)	Total land covered at 88 cm SLR (m2)	Lower value per square metre (EUR)	Lower value per square metre (EUR)
Vegetated/ semi-vegetated	14,175,625	15,897,500	0	0
Bare rocks	420,625	4,383,750	0	0
Forests	10,861,875	11,615,000	0	0
Beaches/ Sand Dunes	176,250	1,871,875	0	0
Salines	4,384,375	4,406,250	0	0
Freshwater and marshes	42,124,375	43,815,000	0	0
Agricultural land	12,393,750	12,410,000	5	30
Sport/ leisure facilities	2,386,875	2,499,375	50	100
Roads/ railways	60,625	559,375	50	100
Urban/ semiurban	9,803,125	10,010,625	200	500
Ports/ marine installations	965,000	2,682,500	200	300
Industrial activity	2,303,125	2,308,125	200	300
Total	**100,055,625**	**112,459,375**	50 cm: EUR **2,798,594,000**	50 cm: EUR **6,498,563,000**
			88 cm: EUR **3,215,238,000**	88 cm: EUR **7,180,675,000**

(for both 0.50m and 0.88m) and the corresponding value of the land affected (based on minimum and maximum 2008 land prices) (See Table 5-3).[IV] This valuation methodology represents the highest probable loss of value, as land values will either be lost or protected depending on whether or not the population moves inland and re-establishes the community and thus economic activity. However, the valuation does not reflect the forest, beach and marshland areas that may be lost. Despite this significant shortcoming, which was impossible to evaluate within the scope of the Report, these estimates do capture the value of the property at risk if nothing is done and sea-level rises to this extent due to climate change.[13]

Using this approach, the following results were obtained:

- Sea-level rise of 0.50 metres: estimated loss of EUR 2.80-6.50 billion (which would be distributed over the next century) (see Figure 5-7).
- Sea-level rise of 0.88 metres: estimated loss of EUR 3.22-7.18 billion (which would also be distributed over the next century) (see Figure 5-8).

Several other factors affected the legitimacy of the valuation methodology used and should be taken into consideration when discussing the results:

1. The measurement of submerged land may not be completely accurate due to the relatively poor resolution of the Digital Elevation Model.
2. The types of land were estimated using Corine Land Cover Data, which only has a resolution of 25 metres. Within these 25 metres there can be drastic changes in the type of land use. However, the physical plan was unavailable in Geographical Information System (GIS) format.
3. The value estimates of the types of land lost cover the entire coastline. This approach does not capture important variations from place to place. In addition, the value of agricultural land is hard to determine, because it reflects not only the value of the products grown (largely deciduous fruit), but also the potential future value of the land, such as for urban development.
4. Estimating the value and possible loss of value of the forest, beach and fresh water sources (such as the Neretva River, the Krka River, or Vrana Lake near Biograd) will require significantly more economic research. While most of the forests located directly on the coast are not used for timber supply purposes, they have economic value that can be measured in terms of the recreation and ecosystem services they provide. Further, the potential losses to biodiversity, due to the damage to particularly vulnerable areas, is not measured in economic terms, though these impacts would be significant, for instance, the Vrana Lake Nature Park.

It is important to note that the land in the Neretva River Delta is important for agricultural production and would probably be worth far more than the 5-30 EUR per square metre estimate in this calculation. Similarly, roads and ports are potentially worth significantly more than the estimated value of 50-100 EUR per square metre used. This is the estimated value of constructing a road and does not reflect the price of land or how much it would cost to move the road to higher ground. There are many such values that are questionable, but the numbers give a sense of the potential scale of the impact.

[IV] Prices per square metre of land are based upon expert judgement by UNDP – Croatia's "COAST" project (Conservation and Sustainable Use of Biodiversity in the Dalmatian Coast).

Figure 5-7: Estimated maximum and minimum value of area lost, by type, if sea level rises 0.50 metres

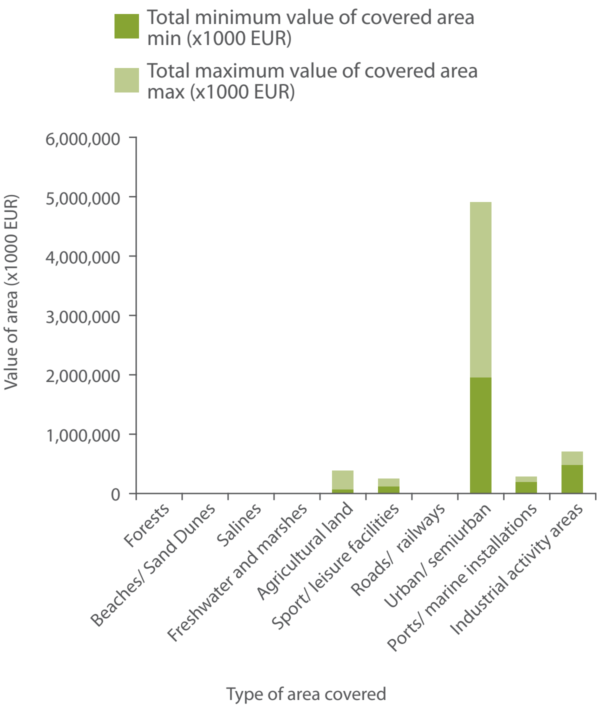
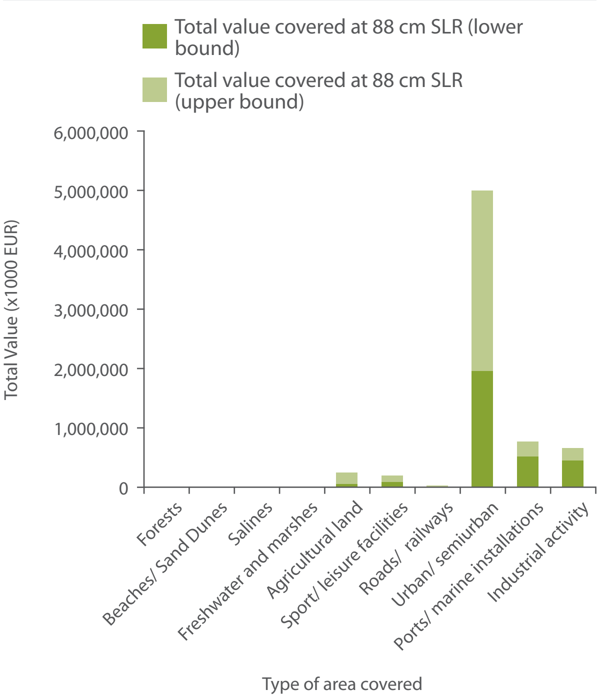


Figure 5-8: Estimated maximum and minimum value of area lost, by type, if sea level rises 0.88 metres.



5.4. Addressing sea-level rise

Sea-level rise is projected to occur quite slowly and the possibility of a sudden and large sea-level rise is quite small. The timing of sea-level rise is a very important factor in evaluating adaptation options to adjust to it. If the sea-level rises gradually, the populations and economic activities at risk have adequate time to respond and to carefully evaluate the alternative actions they will take. These options would include protecting property and structures from flooding and retreating from the coastline and re-establishing populations and economic activity further inland, or a mixture of the two.[V] Gradual sea-level rise also allows adaptation measures to take place slowly using short-term measures, instead of immediately making large investments in adaptation, that turn out to be based on faulty sea-level rise projections. This approach also allows coastal planners and resource managers the possibility of "learning-by-doing" over time. The time-span during which these actions can be expected to take place also makes it difficult to calculate the future benefits associated with avoiding damages from sea-level rise and the costs of avoiding these damages. This does not mean that the best strategy is to wait until there is better evidence of sea-level rise before looking at the alternatives. Indeed, many countries are already looking at alternatives. While the benefits and costs of protecting European coastlines have been estimated for a number of countries around the world, no estimates exist for Croatia.[VI]

Adaptation planning in Croatia could start by developing a more detailed map of the physical characteristics of coastal areas, the infrastructure and economic ac-

[V] Studies that compare the protection and retreat options include: Yohe and Neumann 1997, Yohe and Schlesinger 1998, Fankhauser 1994. Assessments of the costs and benefits of protecting populations from sea level rise include Nicholls, Leatherman, Dennis, and Volonte 1995, Nicholls and Lowe 2004, Tol, Klein, and Nicholls 2008.

[VI] A limited coastal data base is included in the DIVA Dynamic Interactive Vulnerability Assessment) model. This model was used in the EU's PESETA project to estimate the benefits and costs of coastal protection in the EU. However, the report covering the coastal impacts for Croatia has not been published.

"Local-level decision-makers in coastal communities must be on the frontlines of adaptation"

tivities and the value of the buildings and structures in these areas. This type of activity is perhaps best implemented through co-operation with other European/EU agencies and institutions engaged in collecting detailed physical and economic land-use data – such as the DINAS COAST project.[14] The next priority would be to develop the capability to use these databases to estimate the physical and economic damages from various sea-level rise and protection scenarios. This would include the costs associated with alternative protection and retreat strategies. Again, this capability is perhaps easiest to develop in partnership with other European institutions. It would be worthwhile for Croatia to expand this capability, to assess the damages of sea-level rise and the benefits and costs of avoiding these damages, for particularly vulnerable areas on the coast.

Local-level decision-makers in coastal communities must be on the frontlines of adaptation. To do this will involve not only increasing their awareness about the impacts, but also their capability of integrating planning for sea-level rise into their "business as usual" planning decisions. The public sector is involved in many activities that can avoid the damages from sea-level rise. These activities include land-use planning, port and coastal infrastructure development and location, and a wide variety of other activities related to regulation and taxation. Public sector involvement could be just as important for decisions about building dikes and sea-walls to prevent urban flooding, as it would be for developing the right zoning measures and fiscal incentives for reducing the costs of gradually moving entire communities away from the coastline.

5.4.1. Information availability for decision-makers to assess vulnerability and adapt to sea-level rise

In order for adaptation policies and adaptation projects to move forward, a great deal more information is needed. More information and steady tracking of actual versus projected sea-level rise will be necessary. There are a few institutions in Croatia that are monitoring sea-level. One is the Hydrographic Institute from Split, which has a joint project with the Ministry of Science and Technology entitled "Adriatic tides and sea-level on-line."[VII] One of its main activities is to supply any potential user with information about sea-level from the gauge station in Split. In 1997, the inter-institutional project "Systematic exploration of the Adriatic Sea as a base for the sustainable development of the Republic of Croatia – Project Adriatic" began.[VIII] The project continuously monitors the marine environment and sea-level, and covers practically the entire Croatian Adriatic. Cooperation among the institutions involved with this project and other institutions (e.g. the DHMZ, Andrija Mohorovičić Geophysical Institute, etc.) should be feasible. These organisations can work on continuous sea-level and related marine monitoring and then combine data resources.

Such central data collection should be placed within an institutional body responsible for Integrated Coastal Zone Management (ICZM) and Integrated Maritime Spatial Planning (IMSP) (see Box 5-2). Unfortunately, no such body currently exists and there is no clear legislation on this subject – particularly about ICZM. There have been suggestions that this data collection could become the responsibility of the Section for the Protection of Sea and Soil in the MEPPPC, located in Rijeka, but no action has yet been taken.[15] Another possibility is the Administration for the Islands, within the Ministry of the Sea, Transport and Infrastructure. The most suitable candidate would however be the already-designated body within the Ministry of Environmental Protection, Physical Planning and Construction - the Department for ICZM. While this Department was reportedly, formally introduced a few years ago, it never became operational. In February 2008, Croatia and 13 other Mediterranean countries signed the

VII See http://www.hhi.hr/mijene/mijene_hr/projekt.htm for more information.

VIII The project includes the Centre for Marine Research Institute Ruđer Bošković Rovinj, Institute of Oceanography and Fisheries from Split, Hydrographic institute from Split and Faculty of Science from Zagreb

Protocol on Integrated Coastal Zone Management (ICZM) in the Mediterranean, as part of the UNEP's "Mediterranean Action Plan" and the "Convention for the Protection of the Marine Environment and Coastal Zone of the Mediterranean" (Barcelona Convention). The Protocol assists countries to better manage their coastal zones, and addresses the emerging coastal environmental challenges, such as climate change. After ratification, all countries will have to integrate the elements of the Protocol into national legislation. This would be an ideal time to consider the influence of sea-level rise on the coast, on coastal structures and on infrastructure.

Figure 5-9: Storm surge in Rijeka.

Source: HINA.

Box 5-2:Integrated Coastal Zone Management and Integrated Maritime Spatial Planning

When we discuss coastal zone management, we often refer to, so-called, Integrated Coastal Zone Management (ICZM). There has long been a consensus that ICZM is important, but there are few examples worldwide where good practices have actually taken place. One of the definitions for ICZM is the following:

> "Integrated coastal zone management means a dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses and their impact on both the marine and land parts."[16]

As the definition implies, ICZM is a very complex concept and thus requires a broad-based approach involving different sectors. All of these sectors are relevant to human development, both within and outside the coastal area. Sustainably using coastal resources and strictly complying with ICZM legislation and policies would significantly reduce the adaptation options needed in the future.

The newly-emerging instrument for managing off-shore areas is Integrated Maritime Spatial Planning (IMSP). To address those cases where the ICZM is seen as an on-shore and coastal waters tool, IMSP takes a spatial planning approach that covers both on-and off-shore areas (thus covering maritime transport or off-shore drilling, for example). The use of IMSP is being strongly promoted by the EU, in its Future Maritime Policy.[17] IMSP also provides the methodology for implementing an ecosystem approach for the sustainable use of marine resources.[IX] The influence of sea-level rise on maritime off-shore activities will probably be less prominent, so adaptation options for this sector are of less priority. These adaptation costs would primarily consist of the cost of new measurements for new maps and charts and of moving mariculture production to new sites.

[IX] See UNESCO's Ecosystem-based Marine Spatial Management Initiative. Online: http://www.unesco-ioc-marinesp.be/

"The cost of inaction is still greater than the cost of action"

Part of any activity for adaptation should include detailed physical plans and elevation models of the coastline covering those valuable places at higher risk. Currently, most of the coastline is represented in elevation models with insufficient resolution – mostly a 25m grid resolution - with the exception of a few higher resolution plans produced by the State Geodetic Administration. Digital elevation models of very high resolution (such as 0.5 m resolution) would be needed to evaluate the valuable sites and areas at greater risk of flooding. Otherwise, no relevant risk and adaptation assessment will be possible.

Further analysis of particularly vulnerable and valuable areas – the Neretva Delta, Krka River, Vrana Lake Nature Park, Krapanj, and others – appears necessary. This analysis should include an examination of adaptation measures – including costs and benefits.

The above information should be made available to physical planners on the coast. This is a key aspect of low-cost adaptation preparedness for future sea-level changes. With relevant information, physical planners may solve possible future problems before they appear. Such information is also valid for the current ICZM plans. For example, by rigorously implementing construction laws for buildings which are being built too close to the present sea-level, future flooding related problems can be avoided and thus make adaptation cheaper. This is, of course, not applicable to historical sites built long ago. Adaptation for such structures should be assessed by a cost benefit analysis.

A case study from the Fondi Plain in Italy suggests that the cost of inaction is still greater than the cost of action. The study involved a socio-economic evaluation of local adaptation possibilities assessed through a cost-benefit analysis. The economic value of the areas at risk of flooding was calculated to represent the cost of the 'no intervention' option. Two alternative measures of land protection (improvement of the existing drainage system and restoring of coastal dunes) were then compared to the 'no intervention' option. In the conclusion, the cost of inaction was between EUR 130 and 270 million while the cost of action was between EUR 50 and 100 million. The point of this study is that economic analysis has to be complemented with social and political analysis within the local context.

5.4.2. Resource availability for adaptation and adaptation studies and the role of institutions and decision-making authorities

Coastal planning is mostly regulated by the "Ordinance on Regulation and Protection of Protected Coastal Area on the Sea"[18] which has incorporated some basic coastal protection measures against unregulated building within the Protected Coastal Belt (300 m from the coast line in the direction of the sea and 1000 m from the coastline inland). Unfortunately, in practice, this is often not observed and illegal building is one of the key problems and pressures within protected coastal areas. However, no legislation takes sea-level rise into consideration and there is no obligation for planners to consider it for planning purposes. This is one of the fundamental issues when attempting to decrease the costs of adaptation to sea-level rise. It may not be easy to change what has already been done, but with careful planning we can avoid future problems and associated costs.

5.4.3. Analysis of available technological options for adaptation

In general, the relatively long time it will take for sea-level to rise should help reduce the cost of adjusting to it for two reasons. First, it allows individuals and the Government to cope with the problem through long-term planning and investment decisions. Second, the long time scale will allow those involved to "learn by doing", which substantially reduces the probability of making large investment decisions that are later regretted because of bad forecasts. The long time scale of sea-level rise also means that adaptation can be incremental. Individuals can take interim "no-regrets" measures to reduce the adverse impacts of sea-level rise without eliminating the possibility of long-run options. For example, such a no-regret measure could be to replenish a sandy beach or gravel in the short-run to cope with a few centimetres of sea-level rise and then, if necessary, completely abandon the beach 50 years later. This type of no-regrets measure would be more beneficial than choosing an option calculated for 100 years into the future.

The same is true for adapting to the impact of sea-level rise on the tourism sector. Private sector actors can be expected to adapt to sea-level rise in both the short- and long-run. They have sufficient incentives – but perhaps not always the means – to avoid property losses caused by sea-level rise. Nevertheless, this fact does not eliminate the possibility of public sector involvement and leadership. The public sector should provide a legal backdrop and develop policies, which will support the initiatives of the private sector. Coping with sea-level rise can involve two areas where the intervention of the public sector is quite common:

Financing large capital improvements that are, more or less, public goods or that address a collective need, but are difficult to finance with private funds; and

Zoning and land use restrictions, including introducing Integrated Coastal Zone Management (ICZM – see Box 5-2).

The general options for adjusting to sea-level rise for the public and private sectors are described in Table 5-4:

Table 5-4: Adaptation options to adjust to sea-level rise

Adjustments to adapt to climate change	Detailed explanation
Structural and non-structural measures to prevent coastal erosion and inundation damage	- Structural measures would include increasing the protection of coastal resources from erosion, inundation and storm surges through measures such as beach replenishment, rip-raping, groynes,[X] sea-walls, raising structures above flood elevations, and other floodproofing measures. - Non-structural measures would include removing development away from flooding risk through zoning, land-use restrictions, and access to flood insurance.
Protection of property against long-term land loss	- This option would involve building dikes, sea-walls and other structures to hold back sea-water from property that will be below sea-level due to sea-level rise. This is a costly option, but the benefits of protecting high-value property can also be quite high.
Increasing fresh water supplies, purification treatment capacity to offset saline intrusion of coastal aquifers and estuaries, flooding and storm surges	- Supporting measures would include developing alternative water supply sources through the construction of new storage reservoirs, developing new uncontaminated groundwater supplies and inter-basin transfers, flood-proofing water treatment and purification facilities, and increasing the capacity of both as needed.
Protection of coastal and estuarine ecosystems	- By installing pumps and building dikes, sea-walls and other structures to hold back (and/or drain) sea-water, storm surges from coastal environmental resources. An individual site approach is necessary. It should be noted that once an ecosystem is lost – especially diverse ecosystems – it may be difficult or impossible to re-create conditions that will allow it to flourish again
Abandonment of low-lying coastal property and islands and relocation of displaced economic activity to higher ground	- A form of long-run autonomous adaption that can be encouraged by the public sector through tax policies to allow more rapid loss of value of vulnerable assets (if needed), land use zoning, and planning for investment in, and construction of, public works infrastructure and highways for urban development.

[X] A hydraulic structure built out from the shore (in coastal engineering) or from the bank (in rivers) that interrupts the flow of water and sediment.

5.5. Conclusions and recommendations

The basic options available for coping with sea-level rise are to protect vulnerable areas or to retreat from them. Estimates of the expected rates of sea-level rise are very uncertain. That coupled with the fact that sea-level rise will probably occur very gradually means that there is still time to develop the best methods for coping with the problem, locality by locality. A mixture of near- and long-term strategies involving both protection and retreat measures could be the best approach.

The role of the national and local governments in adapting to sea-level rise is currently unclear and needs to be defined. There are many laws and regulations that address the protection and management of Croatia's coastal resources. However, the existing body of law is largely a patchwork of legislation that is sometimes inconsistent and lacks the specific norms to address the management of the coastal areas in a comprehensive and consistent manner.

Therefore, the first "no regrets" step for Croatia to take in this area is to improve the institutional capacity of Croatia to comprehensively plan and manage coastal resources in a consistent manner. The second step is for coastal planners, managers and developers in the public and private sectors to take into account future changes in sea levels in developing coastal land use regulations, disaster risk management, and when planning for major infrastructure projects – such as sewerage – with planning horizons of 50 or even 100 years into the future. The next thing to do is to take this a step further by actively developing the capacity to formulate alternative policies, measures and projects for adapting to potential sea-level rise and assessing the benefits and costs of these options on an ongoing basis, as better information becomes available. Croatia will need to undertake more comprehensive and detailed mapping of its coastlines, their physical characteristics, land use patterns, and economic activities to achieve this.

Croatia should co-operate with existing agencies, institutions and centres of research expertise that are developing global and regional databases, as well as models for forecasting sea-level rise, physical and economic damages and the benefits and costs of alternative adaptation options. Participating in the development of these databases and tools will make it possible for Croatia to better forecast the physical and economic damages caused by sea-level rise and the benefits and cost of avoiding these damages. This will be essential to the development of a comprehensive Croatian policy to adapt to sea-level rise, no matter whether it is purely by facilitating private action, actively taking State action, or a mixture of the two.

Many valuable Croatian natural, historical and cultural heritage sites lie close to the sea and, if sea-level rise occurs to a great extent, these sites, once exposed to flooding, could be lost forever unless protective measures are taken. At the same time, it is not physically possible or economically feasible to protect the entire coastline from the rising sea-level. Developing the institutional capacity to formulate and implement policies, measures, and projects to protect Croatia's most valuable coastal assets, supported by the capacity to assess and compare all the benefits and costs of the alternatives for adapting to sea-level rise, is the best way to ensure that more is gained than lost to the rising waters.

Chapter 6

Health Impacts

6

Chapter 6 Summary

Health Impacts

Respondents to the public opinion poll discussed in Chapter 2 identified health impacts as a major concern regarding climate change. Already, events such as heat waves, which are likely to increase in frequency due to future climate change, have had an impact on Croatians. The 2003 heat wave caused an estimated 185 additional deaths in Croatia, a 4.3% increase in mortality. Therefore, it is very likely that climate change will have an impact on human health in Croatia.

The future health risks of climate change in Croatia are not fully understood. However, they are likely to include cardiovascular risks from heat waves, increases in allergic reactions resulting from changing pollen counts and changes in the distribution periods of plants/ pollens and increased frequencies of heat stroke and other acute impacts from hot daytime temperatures. Health impacts such as an increase in the vector-borne illnesses carried by mosquitoes (e.g. malaria), birds (West Nile fever) and other organisms; water borne diseases; and increased bacteria growth in food may also emerge. The tiger mosquito has already migrated into parts of Croatia, raising some concern about the possible spread of disease. However, climate change may also have some positive impacts in Croatia, including decreased death rates during winter months.

Adapting to the health impacts of climate change already appears to be necessary. Each country must strengthen its health system's preparations for changes in climate as well as the capability to respond. Numerous stakeholders must be involved in the effort to address the health-related effects of climate change.

Some actions are already underway in Croatia – including bioweather forecasts that highlight pollen counts and other pollutants, heat warnings by the DHMZ and initial conversations among the major institutions about establishing systems to cope with heat-waves. However, more information is needed to effectively address existing and future risks. Data on the incidence of infectious and chronic diseases and of sickness and daily death rates are needed to assess the scope of current problems in Croatia and to adjust policies accordingly.

6.1. Introduction

Climate change is very likely to have an impact on human health in Croatia. In fact, climate-related events such as heat waves, which may increase in frequency due to future climate change, have already had an impact on the health of Croatians. Health was identified as a major concern among respondents to the public opinion poll discussed in Chapter 2. In that survey, 80% of Croatians, who believed that climate change would have an impact on their lives, identified health impacts as a concern. Health certainly deserves more attention than this chapter provides. However, not enough data exists in Croatia about the health impacts of current climate variability or future climate change to carry out a full assessment.

6.2. The impact of existing climate variability and extreme weather on health

Over the last decade, it has become apparent that changes in climate can contribute to disease and premature death throughout the world. The distribution and seasonal appearance of infectious diseases has changed, and the frequency of some has increased.[1] Changes in immune system responses have occurred with the altered seasonal distribution of some allergenic pollen species.[2] More hot and sunny days may also increase the impact of pollution in the future – especially by the increasing formation of ground-level ozone, which harms the lungs and has been linked to asthma.[I] Currently, ozone levels are not a large risk in Zagreb, the most likely place to experience problems, though they may be increasing.[II] Future climate changes, combined with increased pollution, may further alter ozone levels and their corresponding impacts.[III] Heat waves are considered responsible for an increasing number of deaths, especially among the elderly and those with chronic diseases. In Croatia, it is estimated that the August, 2003 heat wave caused 185 additional deaths, which is a 4.3% increase in mortality.[3] The unexpectedly high mortality rates at that time in the European Union have partly been attributed to the lack of preparedness of governments and health authorities.[4]

6.3. Addressing climate variability / climate change impacts on health

The health risks of climate change in Croatia are not fully understood, but are likely to include cardiovascular risks from heat waves, increases in allergic reactions resulting from changing pollen counts and distribution periods, and increased heat stroke and other acute impacts caused by hot weather. Indirect health risks may also emerge from food insecurity and changes in the water system (increased flood risk and microbiological and chemical contamination) and related risks.[5] There may also be impacts from increased vector-borne illnesses carried by mosquitoes (e.g. malaria), birds (West Nile fever) and other organisms; from water borne diseases; and increased bacteria growth in food (e.g. *Salmonella spp.*). The tiger mosquito (*Aedes albopictus*) has already migrated into parts of Croatia, leading to concern about the possible spread of disease.[6] However, it should also be noted that climate change may have some positive effects in Croatia, including decreased mortality during the winter months.[7] While both positive and negative impacts are likely to affect Croatians – especially the elderly and those in areas dominated by agriculture and aquaculture – they may also affect tourists in Croatia, and thus the tourism sector as a whole.

To study the existing impacts of climate on human health, the City of Zagreb and the Institute for Cardio-

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[I] Ground-level ozone is different from atmospheric ozone declines due to chemical usage and thus destroying the "ozone layer."

[II] See Pehnec et al. 2005 for data from around 1999-2001 which showed no violations of permissible ozone thresholds, and Institute for Medical Research and Occupational Health 2006, which reports two violations of the permissible daily thresholds for ground-level ozone levels.

[III] For the threshold levels for ground-level ozone, see GRC 2005.

"The country needs to take further steps, several of which are currently in the planning stages. However, to address existing and future risks effectively, more information is required"

vascular Prevention and Rehabilitation, in cooperation with the DHMZ, began a five-year epidemiological study in 1999 entitled "Follow-up Programme on the Influence of Meteorological Changes upon Cardiac Patients", which examined the existing risks to people suffering from cardiac problems.[8] The results will soon be available and can then be analysed together with estimates for future climate change – especially in terms of the impact of heat waves. European studies already show an increasing mortality rate of 1-4% for every degree above a certain threshold, which varies by region.[9] An investigation performed by the DHMZ and the Medical Institute for First Aid in Zagreb on the influence of weather on neurovegetative disorders, indicated an increased number of neurovegetative disorders when the maximum temperature exceeded 35 °C.[10]

Adaptation to the health impacts of climate change is necessary. Each country must strengthen its health system's preparations for and ability to respond to climate change. Much of the health risk from climate change in Croatia – especially from heat waves – should be addressed by building human capacity and knowledge about climate risks. An effective approach involves increasing access to information about climate-related risks, as well as actually reducing the risks to the population, especially those at greatest risk. This can be done by continuously improving the infrastructure in health facilities, ensuring the provision of medicine and immunisation, and ensuring proper practices are employed for food and water supply and in sanitation.[11] It also involves engaging healthcare professionals to educate the public pre-emptively and to address the risks of heat waves and other potentially dangerous situations. The following activities are being implemented by the Ministry of Health, along with the Public Health Institutes (national and local) and the World Health Organisation (WHO) in Croatia, to build the capacity of health professionals and the healthcare system:

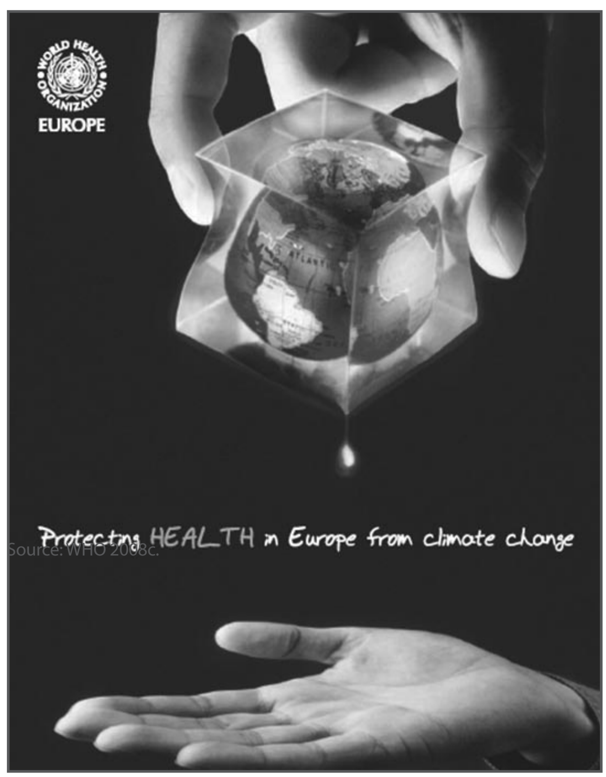
- Lectures, round-table discussions, and workshops, held for health professionals (general practitioners, epidemiologists and public health workers) and the public, on climate change and health, including at events for World Health Day 2008.[12]
- Leaflets, brochures, and other educational materials distributed to the public in drugstores, health institutions, and events such as World Health Day 2008.[13]
- Advice for the public during heat waves published on the Internet and distributed to patients in health institutions.
- Advice for the elderly during heat waves distributed in retirement homes and health institutions.
- The DHMZ announcing high temperature warnings in its biometeorological forecast.

To highlight issues related to pollen and other pollutants (not including ground-level ozone), a bioweather forecast for the City of Zagreb was launched a few

[IV] See, for example, the web-sites http://www.stampar.hr/, http://meteo.hr/ and http://www.plivazdravlje.hr/.

[V] For the day's forecast, see the web-site http://vrijeme.hr/biomet.php?id=bio_twh&param=.

Figure 6-1: Poster from the WHO's World Health Day 2008.



Source: WHO 2008c.

years ago and now contains information for much of the country. Forecasts are announced in the daily papers, on certain websites,[IV] and on television.[V] The aim of the programme is to educate citizens about the risks from allergens in the air as well as other potential health-related factors that can cause respiratory problems, such as extreme temperature, air pressure, humidity and ground-level ozone. The programme also offers advice on how to avoid health risks.

While these actions represent a good start for dealing with climate-related health risks in Croatia, the country needs to take further steps, several of which are currently in the planning stages. However, to address existing and future risks effectively, more information is required. Data on the incidence of infectious and chronic diseases and of morbidity and mortality on a daily basis is needed to enable a basic assessment of the scope of current problems in Croatia to be undertaken.

Numerous stakeholders must be involved in the effort to address the health-related effects of climate change. For example, a conference of health professionals in June 2008, sponsored by the World Health Organization, discussed addressing heat waves in Croatia. It was agreed that the Croatian Public Health Institute, along with its regional public health institutes, should serve as the leading body in dealing with heat waves. Other institutions that should be involved include the Ministry of Health, the Ministry of Education, other health services, the Croatian DHMZ and retirement homes. Between them they have the resources to carry out a fair amount of adaptation work and to deal with immediate risks. The conference also concluded that professional knowledge, especially among general practitioners, needs to be expanded and refreshed, and that the public should be educated on the impacts of climate change on human health. The following measures are planned:

- More workshops and round-table discussions with health professionals in cities around Croatia
- Special care for vulnerable groups in the population
- Telephone help-lines available free of charge before and during heat waves
- Establishment of an official 'heat wave warning' threshold.
- An early warning system for heat waves
- Tests of new technologies (especially air-conditioning) for their effects on human health
- Development of a strategic document detailing 'heat-health protection', in the framework of the Biennial Collaboration Agreement with the World Health Organization

An action plan for heat waves will be developed with the assistance of foreign experts from countries currently implementing their own plans. Contacts have already been made with representatives in France, Spain and Italy, and their advice will be incorporated into Croatian plans. The WHO also recommends emissions reductions campaigns in the transport sector highlighting the health benefits of certain modes of transport in terms of increased cardiovascular activity (e.g., cycling to work).

6.4. Conclusions and recommendations

While potential health benefits due to climate change do exist, such as milder winters, Croatia will have to adapt to the health risks. The spread of infectious diseases, such as malaria, could potentially become a risk in the distant future, though it is unlikely in the near-term, and will be related to temperature, sewage systems, and water management. Existing risks – primarily from heat waves – must be dealt with now, and the priority among public health institutions and actors should be to minimise illness and death due to the changing climate, especially among vulnerable populations such as the elderly and those with heart conditions.

"While potential health benefits due to climate change do exist, such as milder winters, Croatia will have to adapt to the health risks

Existing risks – primarily from heat waves – must be dealt with now"

Chapter 7

Water Resources

Chapter 7 Summary

Water Resources

Water is a critical natural resource. It is used for drinking water, agriculture, wetlands services, and the production of hydroelectric energy, amongst others. Croatian fresh-water resources are abundant - indeed they are among the richest in Europe. Therefore, water resources are not considered a limiting factor for development in Croatia. However, while there is no shortage of water per se for use in Croatia, problems do exist.

- First, a large amount of pumped water is wasted, which leads to lost revenue of up to EUR 286 million (0.9% of GDP) per year and increased GHG emissions resulting from the additional use of electricity for pumping.
- Second, farmers often face water shortages at certain critical times of the year's growing season and, in general, the soil lacks moisture.

Croatia uses a small fraction of the water resources available (about 1%). However, climate change may stress some of the systems that depend upon freshwater. This may be especially important in terms of wetlands services and hydroelectric generation. Wetlands services include nutrient and pollutant removal from water, providing habitat for biodiversity, providing timber and providing hunting areas.

During 2000-2007, 50% of all Croatian electricity production was from hydropower. The Croatian energy sector is potentially vulnerable if climate change results in reduced river flows – which is likely given the predictions of climate models simulating a drier Croatia. Reductions in hydroelectric generating capacity would thus reduce the nation's level of energy security. For example, in 2003 and 2007, droughts caused significant losses in production compared to the average. This resulted in increased costs for electricity production of perhaps EUR 39-46 million in 2003 and EUR 102-120 million in 2007. Future decreases in hydroelectric production due to reduced runoff and river flows may require lost production to be offset by domestic or imported electricity. Both of these options are more costly than hydropower. It is important to note that increases in costs for electricity production would have multiplier effects throughout the economy.

Climate change is likely to have impacts on the water cycle in Croatia. This could include more droughts, which will affect agriculture and natural environments – especially wetlands. It could also result in decreased river flows, and perhaps even lower levels of ground water, which is used for drinking. Flood severity and drinking water quality/quantity may also be affected by climate change, though more research is necessary to investigate these possibilities. While sufficient information is not available to plan adaptation projects, there are a number of steps that should be taken:

- Water management planners should begin incorporating climate change into planning. This will require further information – such as incorporating regional climate models into planning for flood protection, ground water recharge, and river flows.
- HEP and the MELE should also include climate change impacts into projections of energy supplies in Croatia beyond 2020. The initial analysis shows that the projected impacts may result in a loss of EUR 16-82 million per year in direct losses, with multiplier effects throughout the economy.
- More research should be carried out to look at likely climate change physical impacts on wetlands. Similar research should be carried out regarding flood risks and any adaptation that may be necessary.
- Finally, Croatia should undertake measures to improve the efficiency of the public water supply. The current loss is immense and may lead to problems if water resources become scarcer.

7.1. Introduction

Water is among the most critical resources for the environment and for human development. Water is used by households for basic nourishment and for cooking, sanitation, watering the garden and for a variety of other functions. Fresh water is used for many purposes, in many processes. It is used in agriculture and other industries to irrigate crops, water livestock, process foods, make wood products and chemicals and to wash and clean raw materials and finished products. Fresh water is also used non-consumptively to treat human waste, cool conventional and nuclear power plants and to generate electricity. It is essential for water-borne transportation, for swimming, bathing, and a variety of other recreational activities. In addition, fresh water is used to sustain wildlife and habitats in both aquatic and terrestrial ecosystems. These ecosystems also have value in terms of their impact on runoff and on flooding. The 2006 UNDP Global Human Development Report identified water and water-scarcity issues as one of the most pressing human development concerns in the world today.[1]

This chapter analyses the value of water in Croatia. It also examines the potential impacts from changes in the water cycle due to climate change – in particular the effects on electricity production levels. It then identifies the information necessary to assess the vulnerability of Croatia to changes in water due to climate change. Finally, it makes recommendations for future research and "no regrets" options for addressing current problems related to water, that will also be helpful in coping with climate change.

7.2. Water quantity in Croatia

Before examining the impacts of climate change on water resources, the current water quantity and quality in Croatia must first be examined and how these influence both society and the economy. Croatian fresh water resources are among the richest in Europe, yet only a small amount of this water – less than 1% – is used.[2] The supply of water in Croatia is not always in the right place at the right time, and problems with water supply are often encountered locally (e.g. on islands and in solitary mountain settlements).[3] Nevertheless, water resources are not considered a limiting factor for socio-economic development in Croatia, due to the abundance of water, low population density and the level of economic development.[4] Box 7-1 provides a detailed description of waterways in Croatia.

7.3. Water quality in Croatia

Water quality testing is currently underway in various areas to provide an overview of the ecological and chemical status of waters in Croatia, according to the standards set by the EU Water Framework Directive (hereafter called the WFD).[6] Preliminary results show the following:

The status of Croatian waters is good in comparison to most European countries.

- The ecological status of about half of the surface water of the Black Sea basin (to which most Croatian rivers and lakes belong) is "good" or "very good," which means that it meets the set requirements for all quality indicators.
- The most frequent reason the water did not meet the requirements was related to organic and nutrient pollution. Untreated urban wastewater is the main source of organic pollution.
- Agriculture and households are both accountable for nutrient pollution, though the proportion varies in different areas. Data from the Croatian Water Resources Management Plan indicates that in many areas, agriculture accounts for more than 90% of the total nitrogen pressure on Croatian water resources each year.[7]
- The nutrient pollution appears to be causing water sources to have higher nutrient levels than they should in numerous water sources – especially in the cleanest "Class 1 waters."[8]
- A few water bodies register pollution by hazardous substances (9.5%), whilst hydromorphological changes (changes in disturbing the ecological function of water) have been observed in 11% of water bodies.[9]

Box 7-1: Basic Information about water resources in Croatia[5]

Croatia has two large river basins – areas where the water flows downhill towards a salt-water sea. The Black Sea basin area in the north makes up 62% of the territory and the Adriatic Sea in the south makes up 38% of the area. The watershed runs along the Dinarides barrier close to the Adriatic coast. All of the major Croatian rivers belong to the Black Sea basin. These include the Danube (the largest and richest in water, which flows through the eastern borderland of Croatia for 138 km), the Sava (562 km), the Drava (505 km) and the Kupa (the longest Croatian river – 296 km – which flows through all of Croatia). The Adriatic basin area has short, rapid rivers with canyons. The largest rivers are the Mirna, the Dragonja and the Raša in Istria, and the Zrmanja, the Krka, the Cetina and the Neretva in Dalmatia. There are also shorter non-stagnant waters in the karst area of the Adriatic basin that tend to sink and flow together along underground watercourses. The largest of these is the Lika River.

The Black Sea basin is richer in surface water. However, the specific discharge of the Adriatic basin area is twice as high as that of the Black Sea basin. This is due to the considerably larger quantity of precipitation (by over 40%) and the karst nature of the geological base. The total length of all natural and artificial watercourses in Croatia is about 21,000 km.

However, Croatia is not very rich in natural lakes. The best known and most beautiful are the Plitvice Lakes – 16 cascading lakes interconnected by travertine downstream beds, filled by the Korana River. The site is Croatia's most famous National Park and has been inscribed in the UNESCO World Natural Heritage List. Other large natural lakes include Vransko Lake near Pakoštane (31 km2), Prokljansko Lake (11 km2), Visovac Lake (8 km2), and Vransko Lake on the island of Cres (6 km2). Large artificial lakes (water accumulations) represent a total volume of 1 billion cubic metres and serve primarily as reservoirs for hydropower plants.

Croatia is also a wetlands-rich country, and wetlands occupy 7% of the territory. There are 3,883 sites singled out as integrated wetland areas, of which four are listed on the Ramsar list of wetlands of international importance: Kopački Rit, Lonjsko and Mokro Polje, Crna Mlaka, and the lower Neretva.

The EU WFD requires that all water bodies achieve "good" status by 2015.[I] Croatia plans to meet most of the requirements set for water protection through the development of public drainage (which fulfils the requirements set by the Urban Wastewater Treatment Directive) and via other measures which control the source of pollution, such as the EU's Nitrates Directive and the Integrated Pollution Prevention and Control Directive. Considering the technological and technical state of public water supply systems, the overall test results for the quality of drinking water from public water systems nation-wide is considered satisfactory. However, there are significant differences among counties,[10] (See Table 7-1).

Table 7-1: Percentages of unsafe drinking water samples 1990 and 2005[11]

	1990	2005
Share of chemically unsafe samples of drinking water	30%	5.9%
Share of microbiologically unsafe samples of drinking water	45%	5.5%

A large portion of the population not connected to the public water system is supplied through local water supply systems. There are hundreds of such systems, mostly in the Black Sea basin area. The local water supply systems do not have an established system for water quality control. Water is tested if and when the user decides this is necessary. This also applies to water from private wells, which may be a major concern, as an analysis of Croatian Public Health Institute data revealed that, from 2000-2006, one out of every three samples analysed from private wells exceeded the Maximum Acceptable Concentration (MAC) for nitrates.[12]

[I] Or in exceptional cases, within two consecutive six-year planning periods

7.4. Importance of water to Croatia

7.4.1. Water use 1: Personal, industrial, and agricultural consumption

In terms of the quantity of water per capita, Croatia is ranked fifth in Europe and forty-second in the world.[13] Approximately 75% of the population is connected to the public water supply system.[14] The share of population covered by the public water supply network is somewhat higher - about 80% in total.

Most (90%) of the water for the public water supply is obtained from groundwater reserves, either from wells (mostly in the Black Sea basin) or springs (mostly in the Adriatic Sea basin).[15] Based on information provided by Croatian Waters[16] and the Institute for Public Finance,[17] it appears that in 2006, the Croatian population, industry and agriculture sector consumed less than 1% of Croatia's average annual water supply.[18]

Most of the drawn water was used for the public drinking water system. Water loss during distribution is estimated at an astonishing 40-46% on average.[19] Up to 267 million m^3 of water were lost in the public water supply system en route to the end users (Table 7-2). Losses in the water network differ from region to region and can be the result of poor maintenance, illegal tapping and a leaky distribution system (pipes).[20]

Overall, the public water supply in Croatia is reliable. Occasional shortages occur in tourist resorts during the high tourist season, notably on the islands. However, as several water supply projects are currently in progress, this problem is expected to be solved soon.

Agricultural and industrial water usage is also significant:

- The quantity of water used by farming accounts for 2%-3% of total water use in Croatia – up to 20 million cubic metres.[21]
- Irrigation is practised only on a very small percentage (0.7%) of agricultural land, and the most commonly used water for irrigation is surface water from rivers, lakes and reservoirs of different sizes. In some cases groundwater is used.[22]
- In 1994, irrigation used approximately 30 times more water per hectare than in 2006, as a result of the more efficient irrigation systems now in use (e.g. drip irrigation).[23]
- Since the introduction of the national irrigation project in 2005, the irrigated area has increased by approximately 50% and by the end of 2007 approximately 15,000 hectares were included in the irrigation scheme, out of a total agricultural area of 1.2 million hectares (see Chapter 8).[24]
- An additional 2% is consumed by industry (not counting hydroelectricity production).[25]

Table 7-2: Water use in 2006.

			Litres per capita	
	Million m^3	%	Per Year	Per Day
Public water supply system		**87**		
Total drawn water	578	100	130,313	357
Distribution losses	267	46	60,252	165
Supplied to end users	311	54	70,061	192
of which to households	175	56	39,423	108
of which to industry & agric.	136	44	30,638	84
Industry & agric. own water sources	**90**	**13**	**20,275**	**56**
Total consumption	**668**	**100**	**150,588**	**413**

Source: Bajo and Filipović 2008; CW 2008a.

"The tremendous amount of waste in municipal and non-agriculture industrial water use leads to lost revenues of up to EUR 286 million and increased emissions, as more electricity is used for pumping"

Overall, while there is no shortage of water in Croatia, there are two aspects that are problematic. First, the tremendous amount of waste in municipal and non-agriculture industrial water use leads to lost revenues of up to EUR 286 million and increased emissions, as more electricity is used for pumping (see Box 7-2). Second, water is often unavailable to farmers at certain critical times of the year and the soil, in general, lacks moisture.

Box 7-2: Water prices and the economics of water use

How water is priced will affect the extent to which it is conserved. However, the goal of conservation is sometimes constrained by cultural ideas about the value of water and the ability of various groups to pay. Water prices in Croatia vary significantly among different water suppliers and the price often takes into account the socio-economic situation of the country, as well as the fact that water resources are not equally distributed among all regions. There is a considerable difference in the price of water for households and businesses. In 2005, the average price of water for households was EUR 1.15 per cubic metre, while industries paid EUR 1.76 per cubic metre. In 2005, the total payment for all water was EUR 71.56 per person, of which EUR 38.39 was for households and EUR 32.58 was for industrial consumption.[26]

Although Croatia aims to follow the guidelines of the new European water policy, promoting the introduction of an economic price for water, prices charged by many Croatian suppliers still do not reflect this. Since water companies are owned by local government, they determine the price. Water prices are usually set below the economic price and local governments do not usually compensate the full difference (economic losses) directly to water utility companies. Due to this lack of revenue, the water infrastructure often cannot be maintained properly and falls into disrepair.

Water prices are based on variable, non-uniform criteria and currently vary from EUR 0.34-2.18 per cubic metre.[27] The large differences in price mostly result from the difference in the scope of the water services provided (water supply, wastewater collection, wastewater treatment). However, all water prices must include a charge of EUR 0.23 per cubic metre. This includes a water use charge of EUR 0.11 per cubic metre and water protection charge of EUR 0.12 per cubic metre. These charges are fixed for all. However, these fees have not changed over the last fifteen years. They are severely underestimated.[28] Croatia has recently begun following the guidelines of the new EU water policy promoting the "user/polluter pays principle." Consequently, it has gradually been introducing more economically efficient prices, including charges for water protection, anti-flood protection and measures against other eventualities.

In the last three years, the price of tap water has increased substantially. In the city of Zagreb, for example, the price of water for households in 2005 was EUR 0.9 per cubic metre. In 2008 it had increased to EUR 1.53 per cubic metre.[29] This is mainly due to the new wastewater service, which came on-line after the opening of the central wastewater treatment plant. The price rise can also be partly explained by water losses. On average, for every cubic metre of water delivered to end users, an additional 0.86 cubic metre is lost during distribution.[30] The cost of pumping and treating the lost water must be paid for by the utility, but there is no corresponding revenue. Therefore the utility must raise its water charges to cover the lost costs. In 2005, water losses amounted to EUR 286 million – an equivalent of about 0.9% of the entire national GDP.[31]

Climate change has the potential to push water prices up by creating local water shortages, by making water and waste treatment more expensive due to reduced water quality and by increasing the cost of pumping groundwater from greater depths. At the same time, any climate-induced increases in energy prices will also increase the price of pumping water and put even more upward pressure on water prices.

7.4.2. Water use 2: Electricity from hydropower

One of the most important ways in which water contributes to human development in Croatia is in the production of hydropower. The energy generated by hydropower in Croatia is substantial.[ll] In the period 2000-2007 half of all electricity produced was from this source (Figure 7-1). However, since Croatia is an energy importer (including oil, natural gas, and nuclear power), the share of the hydropower energy consumed is a smaller percentage of the total energy consumption (See Table 7-3).

In the period 2000-07, the average annual share of hydropower in the total electricity consumption was 39%. This means that the Croatian energy sector is potentially vulnerable to climate change should it result in reduced runoff into the major hydroelectric reservoirs. Any climate-caused reductions in hydroelectric generation capacity would, in turn, reduce the nation's level of energy security by intensifying the demand for imported energy to replace the loss in hydroelectric generation.

The last hydropower plant to be built in Croatia was in 1989 (See Figure 7-2 for a map of plant locations). The breakaway from the former Yugoslavia and post-war recovery prevented the construction of new hydropower plants. Additionally, the best sites suitable

[ll] Hydroelectric power plants owned by the Croatian Electric Company (HEP), both large and small, account for almost 98% of the renewable energy generated in Croatia. The rest is made up of hydroelectric power plants owned by the small business and individuals (1.75%), plants generating electricity from biomass (0.10%), are wind parks (0.30 %), and solar plants (0.0008%) (CEA 2008b).

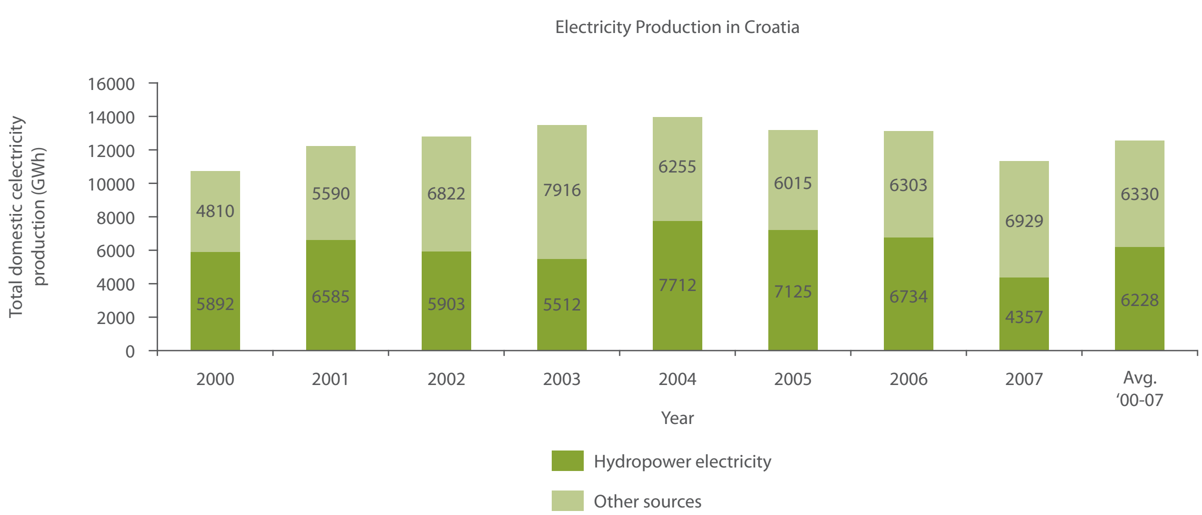
"The Croatian energy sector is potentially vulnerable to climate change should it result in reduced runoff into the major hydroelectric reservoirs"

Table 7-3: Primary energy production and gross inland consumption in the period 2001-05 (after MELE 2007)

	Unit	2001	2002	2003	2004	2005	Avg. '01-05
Primary energy production*	PJ	196	186	184	204	197	193
of which hydropower	PJ	66	52	46	69	62	59
of which hydropower	%	33	28	25	34	32	31
Gross inland consumption	PJ	372	376	396	412	412	393
of which hydropower energy	%	18	14	12	17	15	15

* Includes coal, solid biomass, crude oil, natural gas, hydropower and renewables

Figure 7-1: Annual (2000-07) share of hydropower in the electricity production.



Source: after CBS 2007 and HEP 2008b

"Wetlands provide a variety of ecosystem services: fishing, forest management, grassland farming, recreation, flood protection, carbon storage and regional climatic stabilization, water regime regulation and habitat for a number of plant and animal species, etc"

for hydroelectric generation have already been taken. New plants would need to be built in valleys with potential detrimental effects on the environment and on groundwater recharge. These poorer quality sites have less storage capacity and less force behind the water-propelled turbine blades. Therefore their final cost of production, including capital and operating costs, will be higher and their capacity will be lower than the old plants currently in operation. Only one hydropower plant is currently under construction – Lešće on the River Dobra – which should have a capacity of 43 MW. Several hydropower plants in Croatia – notably those in the Adriatic basin – depend on trans-boundary inflow from Bosnia and Herzegovina.

7.3.4. Water use 3: Wetland services

Wetlands provide a variety of ecosystem services: fishing, forest management, grassland farming, recreation, flood protection, carbon storage and regional climatic stabilization, water regime regulation and habitat for a number of plant and animal species, etc.[III] The MEPPPC (2006) suggests that aquatic and wetland habitats providing important ecological services, are

[III] The term "ecosystem services" refers to resource flows between the ecosystem and economic activity which makes it possible to place economic values on these flows and ultimately on the ecosystem assets that produce these flows.

Figure 7-2: Distribution of hydroelectric plants

Source: HEP 2008a

particularly vulnerable to changes in the quantity and distribution of precipitation, and that climate change is most likely to negatively affect these services.

Ecosystem services, while ubiquitous, are very hard to value without undertaking original research. In particular, it is difficult to measure the economic value of biodiversity – which is an important aspect of Croatia's environment. One ecosystem service – nutrient removal – can give us some idea about the magnitude of the economic importance of wetlands. This service involves wetlands and floodplain areas assimilating pollutants (for example Nitrates and Phosphates) and rendering them relatively harmless to the environment. The value of this service can be determined either by analysing the type of pollutant damage avoided, or the costs saved by not having to remove these pollutants by waste treatment. Using the results from a WWF study (1999)[III] the average value of the nutrient removal service (i.e. waste assimilation) of the floodplain and wetlands area of the Danube basin is EUR 250 per hectare per year. Using this estimate, the annual value of the nutrient removal service of 391,000 hectares of wetland habitats in Croatia would be EUR 98 million (1999 EUR value).

The value of other ecosystem services – and possibly the damages caused to them by climate change– could also be substantial. These other services include timber production, hunting land and grassland production. These three services total approximately EUR 1,000 per hectare per year (though this amount still does not include all ecosystem services, such as landscape values, GHG mitigation, fishing, etc.). Depending on the scenario of sustainable land use, the payment that society should provide for the ecosystem services of the Lonjsko Polje Nature Park wetlands was estimated at EUR 20-600 per hectare per year.[32]

Assuming that the value of these three services is about EUR 1,000 per hectare, per year for all Croatian wetlands, the value of these services at the national level would be EUR 391 million. Adding the previous value of EUR 98 million for nutrients removal, the total value of the combined ecosystem service would be about 2.36% of the average annual GDP in the period 2001-2005 (EUR 488 million). While this is a speculative

[IV] The study was carried out within the framework of a UNDP/GEF funded Danube Pollution Reduction Programme, involving more than 120 scientists from nearly all Danube Basin countries, co-ordinated by the Institute for Floodplains Ecology from Germany under the guidance of the UNDP/GEF team of experts from the Danube Programme Coordination Unit in Vienna. The study estimated that this value is based on the average nutrient removal potential of 100-150 kg N per hectare per year and 10-20 kg P per hectare per year.

Table 7-4: Ecosystem services and potential valuations

Ecosystem Service	Value	Notes
Nutrient Removal Service	EUR 250 per ha per year. For 391,000 hectares of wetland habitats in Croatia the value would be EUR 98 million (1999 EUR value).	- WWF (1999) study estimate of the floodplain and wetlands area of the Danube basin - Some wetland sites involved in this study had a much greater nutrient removal capacity. The Mokro Polje/ Lonjsko Polje wetlands exhibited a greater average nutrient removal potential (6 times more) than the average Danube wetlands. The Kopački Rit wetlands had a potential an amazing 53 times higher.
Timber production	EUR 500 per ha per year[33]	- Estimates for the Lonjsko Polje wetlands
Hunting	EUR 65 per ha per year[34]	- Estimates for the Lonjsko Polje wetlands
Grassland production	EUR 450 per ha per year[35]	- Estimates for the Lonjsko Polje wetlands

number, it shows the potential value of wetlands in Croatia. Additionally, wetlands are valuable due to the amount of biodiversity present within them. However, because there is insufficient information to evaluate the potential loss of biodiversity in economic terms in Croatia, this Report does not analyse this impact in depth. It is, however, important to note that a loss in wetlands would probably threaten biodiversity.

7.4.4. Other uses for water

Compared with agriculture, human consumption, electricity generation, and ecosystem services, all other water-related economic activities in Croatia appear to be of relatively minor importance. The network of navigable inland waterways consists of 804 km of the rivers Danube, Sava, Drava, Kupa and Una.[36] The Sava River between Slavonski Brod and Sisak is important for transporting oil to and from the refinery facilities. In 2006, inland water ports handled 2.9 billion tonnes of goods, less than 1% of the amount handled in the sea-ports.[37]

Lakes, rivers, ponds and other freshwater bodies are important for sport, swimming, angling and other forms of water-based recreation. Unfortunately, the economic value of these activities is not quantified in any official document. It might be particularly interesting to know the figures on the quantity and value of the fish caught by angling. It is apparent that for many low-income inhabitants, notably those living along the big rivers, angling represents an important part of a survival strategy.

The water-rich regions of the national parks (e.g. Plitvice Lakes, Krka, Kopački Rit) and nature parks (e.g. Lonjsko Polje) are important, both in terms of the richness of their biodiversity – especially for rare and protected birds – and the scenic beauty that attracts many tourists. The existence of several species of protected bird depends on the existence and management of carp ponds.[38]

There are also 70 commercial fishing ponds over 5 hectares in size.[39] In 2006 these ponds produced 5.1 kilo-tonnes of fish.[40] In the period 2004-2006, production increased by 50%.[41] However, the Water Management Strategy indicates that due to various socio-economic circumstances, this business is in decline.[42] Some ponds require a constant inflow of water, and maintaining a minimum inflow of water of a sufficient quality is difficult during drought periods.[43]

Figure 7-3: The Gacka River in the region of Lika

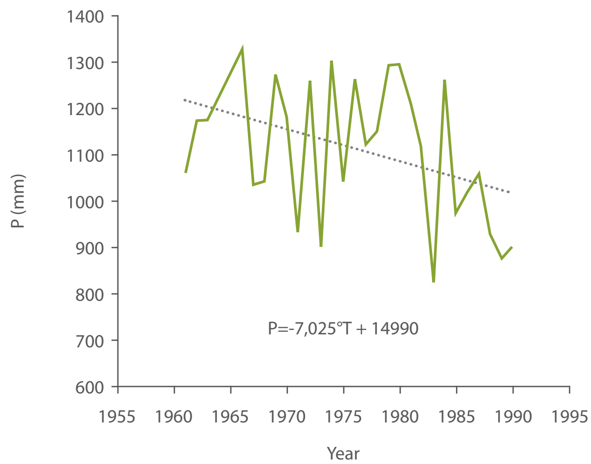
Source: Ivo Pervan

7.5. The impact of existing climate variability on Croatian water resources and water based economic activities

7.5.1. Existing impact in Croatian fresh water resources

It seems that water resources in Croatia are already facing impacts from changes in climate variability (See Table 7-5). Research suggests that changes in long-term climate variability are already having an impact on runoff, evapotranspiration, groundwater recharge, lake water levels and water temperature. Climate change is likely to cause more reductions in water availability and increases in fluctuations.

Figure 7-4: Sequence of annual precipitation amount P(mm) in Croatia with a linear trend 1961-1990.



Source: : MEPPPC 2006.

Table 7-5: Impacts of recent changes in the climate (adapted from MEPPP 2001 unless otherwise noted)

Characteristic Changes	Extent of the Impact/ Notes
Droughts have occurred with increasing frequency [44]	This has been a trend in recent decades. The intensity and duration of the 2003 drought was one of the most pronounced in the last 59 years. More severe droughts were registered only in 1946, 1947, and 1950.[45]
Potential evapotranspiration rates are rising[V]	Increase of 15% in Osijek (a part of the flat, fertile, continental region) and an increase of 7% in Crkvenica (in the coastal region). This is due to temperature increases in the last 100 years.
Actual evapotranspiration rates are rising	Increase of 8% in Osijek, though no increase in Crkvenica.
Precipitation trends are decreasing	In the period 1961-1990, a downward trend in average annual precipitation of about 7 mm per year - thus annual precipitation has dropped by some 210 mm over thirty years (Figure 7-4).
Declining runoffs and soil moisture	This is due to increased evapotranspiration rates, combined with decreases in precipitation - significant in Slavonia and Primorje.
Declining water levels in lakes and rivers[46]	Declining on the Sava and Drava rivers as well as Vrana Lake in recent decades. In 2003, the water level of the Sava River dropped to its lowest level in 160 years. The fall in lake water levels and river discharges is correlated with both increases in precipitation and temperature.
Declining annual mean flow rates of rivers	The River Danube at Bezdan in the period 1921-2001 shows a negative trend. A shift from glacial discharge to discharge from rivers and streams has been observed on the Drava River.
Increasing annual minimum and mean water temperatures of rivers[47]	The Danube River and its main tributaries in Croatia (the Kupa, the Sava and the Drava) have increased since 1988. This increase in water temperatures in Croatia has been attributed primarily to changing climatic patterns, including seasonal warming and reduced runoff from snowfall compared to precipitation. Alterations through regulation and drainage works, hydroelectric, hydraulic, and other large construction projects seem to be less important.
Drying of forest soils – endangering common oak forests among others	Due to the changed water regime and the decline in ground water levels - mostly in the lowland area of Central Croatia, the Spačva basin, in the wider surroundings of Našice and Osijek, and in the Podravina region.[48]

[V] Evapotranspiration is the discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces and by transpiration from plants.

Figure 7-5: Low water table of the Sava River in Zagreb on August 28, 2003.

Source: DHMZ 2005b.

7.5.2. Existing economic impact from climate variability related to water

Climate variability has already had adverse impacts on water supplies and water quality in Croatia. In agriculture, extreme droughts have caused hundreds of millions of Euros worth of damage – up to 0.6% of total GDP from 2000-2007 (See Chapter 8). On the other hand, the current declines in runoff, groundwater recharge, and lake water levels, do not appear to have had a severe economic impact on drinking water supplies or water quality, except for occasional water shortages in coastal communities during the peak tourist season, probably caused by lack of infrastructure and increased demand. This finding is logical since Croatia uses only a very small percentage of its available water resources in consumption. However, recent economic losses have occurred due to flooding and a decrease in hydroelectric power generation. These losses have not been estimated with a sufficient degree of accuracy, and it is too soon to tell whether there is a trend in these losses.

Water and climate variability already pose some risk due to floods.[49] Croatia is subject to periodic flooding which causes considerable economic damage. According to the Water Management Strategy[50] there are a number of different types of floods:

- River floods, due to extensive rains and/or sudden snow-melt;
- Flash floods in smaller watercourses, due to short rains of high intensity;
- Floods on karst (limestone) fields, due to extensive rains and/or sudden snow-melt;
- Floods of inland waters on lowland areas; and
- Ice floods.

Small-scale flooding is also caused by dams and barriers breaching, landslides and inappropriate construction.[51] In some urban areas, floods are induced by short, intense precipitation events (rain) combined with a high population and insufficient wastewater sewerage and drainage system capacities.

Since 1980, there were several big floods, among which the most important were:

- Sava River: in 1990 and 1998;
- Kupa River: in 1996 and 1998;
- Neretva River: in 1995 and 1999.

The damage caused by floods in the period 1980-2002 is estimated at EUR 409 million, representing 7.4% of all damages caused by natural disasters in this period.[52] In the period 2001-2007, floods caused damage amounting to EUR 74 million, accounting for 4.6% of all damage caused by natural disasters.[53] Some 58% of this was damage caused to agriculture.

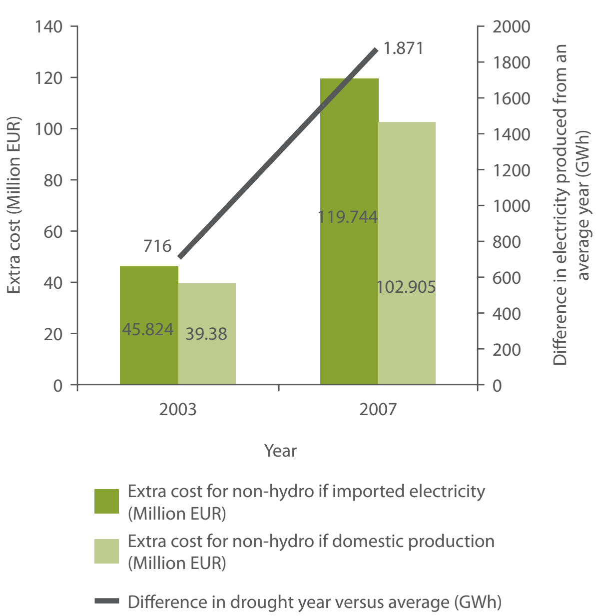
Investment in the maintenance of flood protection systems and their effectiveness was reduced after 1991.[54] The available financial resources for these measures were insufficient until the introduction of water protection charges for the water system in December 2005. Since then, revenues have grown significantly, but are still insufficient for all necessary investments to develop the protection system from water. The safety of the population and assets in many potentially flood-exposed areas is still insufficient. However, there are regional differences in this respect and the protection is generally much better in larger settlements and along larger rivers. In the Black Sea basin, the flood protection system has not been completed and there are still some unresolved issues even on the major rivers, such as the Sava and the Drava Rivers. In the Adriatic basin, protection against storm water requires substantial improvement.[55] The Government has plans to improve the effectiveness of the flood protection system[56], however, the ecological quality of waters should also be taken into consideration while designing these plans.

In addition to existing damage from floods, it should be noted that in 2003 and 2007, when there was a particularly strong drought, the amount of hydroelectric power produced dropped dramatically – by 716 and 1871 GWh respectively, compared to the average from 2000 – 2007. Decreases in electricity production due to reduced runoff may require the lost production to be offset by domestic or imported electricity, which is more costly than electricity produced by domestic hydropower.

The average extra cost of all other major sources of electricity (natural gas, coal, nuclear, importation) is approximately EUR 55 per MWh. Imports cost approximately EUR 84 per MWh (EUR 64 per MWh more than hydroproduction).[57]

Thus, the increased costs for 2003 and 2007 appear to be dramatic (EUR 39-46 million in 2003 and EUR 102-120 million in 2007).

Figure 7-6: Differences in amount and cost of electricity production in drought years versus the average from 2000-2007



7.6. Estimates of potential future climate change impacts on the water sector

7.6.1. Overview of potential impacts in general for Europe

The frequent alternation of flood and low flow events throughout Europe in the last decade has led to fears that the dynamics of the hydrological cycle have already intensified as a consequence of global warming.[58] The economic sectors, which are projected to be most affected by the impact of climate variability and extreme weather, are agriculture (increased demand for irrigation), energy (reduced hydropower potential and cooling water availability), health (worsened water quality), recreation (water-linked tourism), fisheries and navigation.[59] The major expected impacts are:

- Flooding in central Europe, concerns over hydropower, health and ecosystems in the northern countries, and water scarcity in the southern countries.[60]
- The number of drought-affected areas is likely to increase. Precipitation and seasonal runoff are projected to become increasingly variable, resulting in disrupted water supplies and quality and an increased flood risk.[61]
- In Europe, south of 47°N (which includes Croatia), annual runoff is expected to decrease by 0–23% by the 2020s and by 6–36% by the 2070s.
- Groundwater recharge is likely to be reduced in central and eastern Europe[62] and by up to 20–30% in south-eastern Europe by 2050.[63] This runoff reduction is particularly expected in the valleys[64] and lowlands, e.g. in the Hungarian steppes.[65]
- A decrease in runoff might become a serious problem particularly in the Mediterranean region, which is already sensitive to droughts. The Mediterranean climate is expected to become drier and water resources are expected to decrease, while water demand is expected to increase.[66]

- This change, together with population growth, is expected to increase the pressure on available water resources and may cause social instability in the area. Water conflicts might spread – notably between urban and agriculture users, as well as between upstream and downstream regions.

7.6.2. Overview of potential future climate impacts for Croatia

Climate change in Croatia is expected to result in changes to evapotranspiration, soil humidity and ground water recharge. Changes in the precipitation pattern are expected not only to affect runoff, but also to influence the intensity, timing, and frequency of floods and droughts.[67] Runoff in major Croatian basins is expected to be reduced by 10 to 20%, although in the eastern part of the country this change might be below 10%. During the summer months, it is possible that water shortages will occur, especially in the coastal areas where temporary water shortages are already experienced during the high tourist season. As Croatia is prone to the risk of forest fires, the projected decreased rainfall in the coastal area, notably during the summer period, is also expected to precipitate forest fires.[68] The water shortage in the soil during summer is expected to increase by 30-60% in the lowlands and 25-56% in the coastal areas.[69]

7.6.3. Potential climate change impacts on water supply for personal, agricultural, and industrial consumption

Croatia's latest report to the UNFCCC suggests that climate change might cause problems in water supply and in meeting the ever-growing drinking water requirements.[70] However, since Croatia is abundant in renewable groundwater reserves and since approximately 90% of the public supply of drinking water comes from the groundwater, Croatia will probably not experience drinking water shortages – except perhaps at the coast during the peak summer months. Climate change may, on the other hand, decrease the groundwater table, leading to an increase in the cost of water abstraction, resulting in an increase in water prices. With a lower groundwater table, it is very possible that a number of private wells, supplying water to nearly 22% of the population, may dry-out. This would impose an extra cost on their owners/users (mostly low-income groups living in remote areas) if they have to make the wells deeper. In some cases, due to geological conditions and/or the lack of adequate equipment, this might be technically difficult, if not impossible. The magnitude of the impacts of climate change on ground water supplies is difficult to determine. This is because of the uncertainty that surrounds climate change projections and because groundwater resources in Croatia have not been systematically and comprehensively mapped, nor have simulation models of the largest aquifers been developed. However, the number of people affected is not likely to be very high, as water supply plans have been developed to increase the population's access to the public supply system to 85 - 90% by 2020.[71] Climate change is also likely to affect agricultural production, which is covered in depth in Chapter 8.

Climate change also has the potential to cause a number of impacts on freshwater-based recreation. Decreasing lake levels and changes in the visual characteristics of both terrestrial and aquatic ecosystems in and around lakes may make lakes less attractive for recreation. Lowered lake and stream levels also decrease the capacity for assimilating waste and increase water pollution, making them less suitable for recreation. Finally, and perhaps most importantly, climate change may reduce runoff to the extent that river discharges will significantly decrease in karst formations, such as those of the Plitvice Lakes. These types of impacts have the potential not only to lead to reductions in tourism, but also represent a loss in ecosystem values of potentially staggering proportions.[VI]

[VI] See Chapter 4 for more on tourism and climate change.

7.6.4. Potential climate change impacts on the production of hydroelectric power

Changes in climate are likely to affect the production of electricity from hydropower. During 2001-05, the average annual GVA (gross-value added) of the production and distribution of electrical energy in Croatia amounted to EUR 444 million – 1.67% of GDP.[72]In the same period electricity produced by hydropower accounted for 37% of total electricity consumption. This means that the total value was approximately EUR 164.4 million (0.62% of GDP).

The Croatian electricity utility (HEP) makes annual electricity production forecasts based on data on aggregate water inflow into the reservoirs behind the hydro dams. Following this approach and assuming an average rainfall, the production forecast for 2008 was 5,890 GWh.[73] HEP assumes a linear relationship between the reduced water inflow and the electricity production from hydropower plants. In other words, a 10% inflow reduction will result in a 10% reduction in generated electricity. While no specific predictions exist for Croatia, macro-scale hydrological models predict that production in Southern European hydropower stations will decrease by between 20-50% by the 2070s.[74] Table 7-6 shows the potential impact of these reductions. In addition to reducing overall GDP, this scenario would require HEP to take one or more of the following measures:

1. Raise electricity prices significantly,
2. Reduce national consumption of electricity,
3. Replace the lost hydro-generation with production from existing, higher-cost (per kWh) domestic resources, or
4. Import more expensive electricity from neighbouring countries.

In addition to increasing the price of electricity (or reducing revenue from electricity sales if prices are not increased), this reduction would increase the country's vulnerability to the international electricity market conditions, which could be particularly problematic for HEP. Hydropower is by far the cheapest source of electricity in Croatia at present, costing approximately EUR 20 per MWh. Importing electricity costs approximately EUR 84 per MWh while the next cheapest domestic option – coal-fired plants – cost EUR 50 per MWh.[75]

An example of the potential economic impact of a 35% reduction in hydropower is presented in Table 7-7. While this scenario assumes that current costs for energy production stay constant – which is unlikely – it provides a sense of the scale of vulnerability of the energy sector to a loss of hydropower. The cost to HEP alone would represent 0.17- 0.31% of current Croatian GDP.

In the longer term, a sustained loss in the generating capacity of hydroelectric facilities – especially during the peak demand times, such as the summer – could require significant investment in new, higher-cost electricity generation from fossil fuels, nuclear power,

Table 7-6: GVA loss in the electricity sector due to 10-50% less inflow

		Anticipated reduction of hydropower-generated electricityinflow								
	Unit	10%	15%	20%	25%	30%	35%	40%	45%	50%
Lost GVA in the electricity sector	Million EUR	17	26	34	43	52	60	69	77	86
	%	4	6	8	10	12	14	15	17	19
Lost GDP	%	0.06	0.10	0.13	0.16	0.19	0.23	0.26	0.29	0.32

"A decrease in generating capacity would also have compound effects on the economy and on ordinary Croatians. Higher electricity production costs translate directly into either higher energy prices or lost revenue from the sale of electricity, both of which will be passed on to consumers"

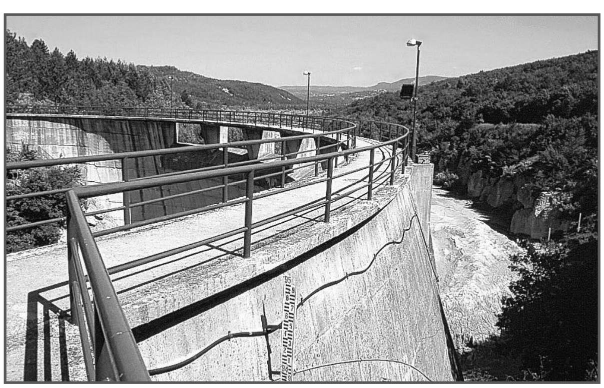
Table 7-7: Hypothetical cost for replacing a 35% loss of hydropower

Strategy for replacing a 35% loss of hydro-power	Cost per year for production
Replace hydropower with the cheapest alternative source (coal)	EUR 65 million
Import electricity at 2008 prices	EUR 117 million

other renewable resources, or the continuation of large imports of electricity from other countries, which presents some risk to Croatia's energy security.

No matter how the lost generating capacity is replaced, a decrease in generating capacity would also have compound effects on the economy and on ordinary Croatians. Higher electricity production costs translate directly into either higher energy prices or lost revenue from the sale of electricity, both of which will be passed on to consumers, who are already facing increased utility rates in Croatia. A further increase in utility rates and/or taxes may lead to increased economic hardship, especially among the poorer segment of society. As of 2006, one fifth of Croatian households surveyed were already reporting difficulties in paying their utility bills on time.[76] As energy prices go up, human development becomes more difficult and the options become more limited for those least able to pay. Additionally, a multiplier effect on the economy would be probable if electricity prices increased, driving up prices for many goods, such as food.

Figure 7-7: The Letaj Dam in Istria.



Source: Croatian Waters.

7.6.5. Potential climate change impacts on wetlands and ecosystem services

As was noted earlier, wetlands provide a variety of ecosystem services that can be valued in economic terms and whose value in Croatia is substantial - in the order of millions of Euros per year. Reductions in runoff, combined with higher evapotranspiration, have the potential to lower groundwater levels, increase eutrophication and, in the long term, eliminate wetlands and the ecosystem services they provide. Without detailed wetlands data and dynamic wetlands simulation models, it is difficult to even determine how changes in temperature and precipitation will affect the freshwater resource base in a given wetlands area, let alone the ecological response to reductions in runoff and water storage and the resulting loss in ecosystem services. However, the fragility of wetlands ecosystems and their heavy dependence on water availability is undeniable and there is no doubt that reductions in the water storage capacity of wetlands will jeopardise the services they supply to humankind.

Expected increases in air and water temperature and evapotranspiration rates, accompanied by decreases in runoff due to climate change, also have the potential to affect the functioning and health of other terrestrial and aquatic ecosystems. Unfortunately, the databases and the models needed to simulate the response of unmanaged ecosystems to climate change in Croatia have not been developed. While there is a great deal of visual and anecdotal evidence to suggest that recent climate trends have put several forest ecosystems at risk (oak, the common beech, and silver fir), the necessary data on growth, yields and inventories of forest types to quantify the damages is still being collected and needs to be processed.

7.7. Addressing climate change/ climate variability in the water sector

While freshwater resources are currently abundant in Croatia, climate change still has the potential to adversely affect hydroelectric generation, increase the intensity of floods and droughts and reduce the ecosystem services provided by wetlands. In the longer term, higher temperatures and reduced precipitation may also reduce the water stored in aquifers and threaten drinking water supplies. However, the current capacity to project the damages due to climate change, to estimate the economic value of these damages and to assess the effectiveness and the benefits and costs of possible alternatives for adapting to these impacts, is quite limited. For the private and public sectors to adequately meet the challenges of climate, both groups will need to further develop not only their analytical capacity, but also the institutional capacity needed to translate their findings into policies and actions that can be implemented on the ground to cope with climate change.

7.7.1. Information availability for decision-makers to assess vulnerability and adapt to climate conditions and climate change

Several organisations provide information relevant for the water sector:

- The Central Bureau of Statistics (CBS) collects and maintains annual data on water availability, supply and consumption.
- The Croatian Environment Agency (CEA) is in charge of monitoring, collecting and integrating data on the state and trends of water quantity, quality and impacts, as well as the response of society to impacts on the state and the quality of Croatian inland waters. It maintains environmental information databases and provides the statistics for reports on the national state of the environment. All this information is integrated into an environmental information system, which is accessible to the general public. The organisation exchanges information with the European Environment Agency (EEA) and its European Environment Information and Observation Network (EIONET).[77]
- Croatian Waters (CW) is the state agency responsible for water management. It is responsible for the collection and analysis of data and the evaluation of water quality in Croatia. They also publish yearly reports on water quality. Their work consists of investigating the quality of surface and ground water, as well as seawaters polluted by land-based activities. They investigate water quality indicators (oxygen patterns, nutrients, microbiological and biological indicators) as well as additional indicators (metal content, organic compound content, and radioactivity). Currently, the evaluation of water quality is being implemented in accordance with the "Regulation of the classification of water" which prescribes very high standards of quality. CW is also working on the implementation of the EU Water Framework Directive (WFD), which will standardize the evaluation and management of water in the Republic of Croatia and align it with EU standards. CW has an important role in implementing hydrological monitoring because it finances more than 50% of all monitoring stations. To protect against floods, CW has built its own automatic data collection system and remote control of hydro-technical devices. The data collected are used for monitoring and the prognosis of floods and provides a foundation for decisions on operational measures. All data are available to the public.
- The DHMZ is the central institution for meteorological and hydrological observations and data processing, and it has several hundred weather as well as water stations distributed over the entire country. It is currently undertaking research on the following topics:
  - Dynamical downscaling of climate change scenarios from the EH5OM global model: simulations for two 30-year periods, present climate (1961-1990) and future climate (2041-2070)
  - Estimation of present and future water cycles e.g. rainfall, evapotranspiration, surface runoff, particularly for the Mediterranean area

> "While freshwater resources are currently abundant in Croatia, climate change still has the potential to adversely affect hydroelectric generation, increase the intensity of floods and droughts and reduce the ecosystem services provided by wetlands"

"The ability to better simulate the range of water resource-related impacts associated with climate variability and climate change is critical to the development of effective policies to cope with climate"

- Occurrence and changes of extreme weather events, notably droughts and rainfall
- Occurrence and changes in the amount and variability of seasonal and annual precipitation
- Changes in the frequency and intensity of heavy precipitation events.

- The civil engineering and geophysics departments of the Universities of Zagreb, Osijek and Split also undertake hydrological and other water-related research. Some of this research deals with climate-change-related issues, including:
  - The analysis of the change of the water temperature regime of Croatian rivers and changes in water flows
  - Spatial comparison, variability and trends of water balance components
  - Calculation of future climate water balance – computed from the data produced from climate scenario models.

Information is urgently needed to assess the economic vulnerability to climate change due to water changes. First, it is necessary to develop the capacity to simulate the physical impacts of climate on the supply, distribution and quality of freshwater resources. Many of the same databases and models that are needed to simulate the physical impacts of climate change are also needed to cope with existing climate variability. The capacity to simulate the water-related impacts of climate variability and change should be strengthened in the following ways:

- Improve the ability to downscale GCM results to the level of catchments - making the results suitable for correlation with data from existing runoff gauges and weather stations used for monitoring.
- Develop a national database and system of rainfall-runoff models to project the effects of rainfall changes (for climate variability and climate change) on runoff and discharges (including peak and low flows). This should be done in important river basins and catchments and linked to an expanded national runoff and flooding reporting system.
- Improve the capacity of HEP to simulate systems operations based on improved rainfall runoff and hydropower simulation models at all existing hydro sites.
- Undertake selected, multi-agency hydrologic and ecological studies to simulate the impacts of climate variability and climate change on ecosystems that may be endangered by reductions in runoff or declining groundwater levels.
- It may also be worthwhile to undertake a programme to map existing groundwater resources in a comprehensive fashion, and then develop the databases and models needed to simulate the effects of climate variability and climate change on groundwater recharge, storage and water quality.

The ability to better simulate the range of water resource-related impacts associated with climate variability and climate change is critical to the development of effective policies to cope with climate. However, these tools are not sufficient. They should also be combined with tools to estimate the economic and social consequences associated with the physical impacts of climate change and to assess the economic and societal benefits and costs of adaptation policies, options and projects to lessen the economic losses and adverse societal consequences of climate change.

Simulating the economic impacts of climate change and the economic costs and benefits of adaptation policies, options and projects is quite a daunting task. A class of models has been developed to simulate a wide range of the economic impacts of climate change and climate variability for both large and small river basins.[78] However, this type of model depends on a great deal of information that does not yet exist in Croatia. Therefore, it would make more sense for Croatia to focus initially on the specific types of impacts that have already been identified. These are described in Table 7-8.

Table 7-8: Areas for future economic analysis related to water

Area to address	Descriptive notes
Loss of hydroelectric generation capacity	These losses and the benefits and costs of replacing the lost capacity with alternative types of generating resources can be valued using an electricity sector model[79] or, more simply, determining the amount of production that is lost and then calculating the cost difference between the lost hydro capacity and the next best (lowest cost) alternative.
Flood damage	Valuing these losses and the benefits and costs of protection measures requires detailed hydrological and historical damage data from past floods, to translate peak discharges at flooded locations into flood stage levels. Then flood stages must be translated into physical damage and finally physical damage must be translated into economic damage across the entire spectrum of flood frequencies.
Loss of ecosystem services	Ecosystem services can be valued by estimating the likely damage that would be caused if the pollutants were not removed by the ecosystem. The likely climate change economic impact is the increase in damage that is caused if future ecosystem destruction leads to more pollution. This can also be measured by estimating the cost of removing those pollutants by waste treatment. Other services, such as wood production and hunting values can also be valued by estimating the likely impact of climate change on the resources of the ecosystem and translating that into monetary terms – including endangered species.
Long-term impacts on availability and cost of ground water	In an extreme case, long-term reductions in supply may lead to groundwater recharge being less than the amount taken out (groundwater mining). This problem can only be solved by reducing the amount of water taken out. To analyse this, it would be necessary to develop a multi-sectoral economic model of water use in concert with a three-dimensional groundwater model, to find the optimal level of groundwater extraction and the long-term economic losses to households and industries associated with reduced water consumption and higher water prices.[80]
Drinking water quality	The economic losses due to reduced drinking water quality can be approximated by assuming that current water quality standards will be maintained and calculating the additional cost of water purification and waste treatment to maintain that standard.[81] The benefits of improving water quality can be estimated by asking people how much they are willing to pay for improvements (or to avoid a situation where the quality becomes worse).[82]

7.7.2. Resource availability for adaptation and adaptation studies and the role of institutions and decision-making authorities

Croatian authorities have not yet taken climate change into account when planning the management of their water resources. Croatia's current efforts in the water sector are mostly focused on aligning the national legislation with that of the EU. This task absorbs nearly all available institutional capacity and human resources. Croatian water legislation is partially harmonised with the EU WFD and further harmonisation is envisaged.[83] Croatia's policy mechanisms for addressing climate change and water are still unrealized. The only official documents dealing with this issue are the National Communications under the UNFCCC.[84] These documents emphasize that possible changes in surface and groundwater regimes (inflow) should be taken into account when planning water management work, such as the construction of multi-purpose channels, irrigation systems, or hydroelectric power plants.

Although official documents stress that water will become the most important strategic resource in the future,[85] the authorities, scientists, water managers and water users do not seem to be considering the consequences of climate change on water resources in their future planning. The Water Management Strategy is the fundamental and long-term strategic water management document for Croatia. It calls for the establishment of a holistic water management policy and an integrated/ coordinated approach to improving the water system, in line with international commitments.[86] It also defines strategic goals, establishes current/future needs and services, and identifies how these might be met through management plans for the four river basins in the country.[87] However, it does not deal with any aspect of climate change, its impact on water resources, water vulnerability to climate change, adaptation measures, etc.

In building capacities in the water sector, Croatia relies heavily on projects funded by the EU and World Bank. These projects are primarily oriented towards improving water quality standards, improving monitoring systems, for consistency with EU norms, harmonising legislation and information systems with the EU, and investing in infrastructure projects such as waste water treatment plants, water supply, and sewage systems.[88] However, none of the EU-funded projects in the water sector seems to have addressed the issue of climate change.

The EU WFD is the regulatory document governing the water sector in the EU. It is complemented by the new Flood Directive (FD), adopted in 2007. By establishing a framework for water management and policy, based on integrated river basin management, the WFD aims to achieve the "good" status for all European waters by 2015. However, climate change impacts on freshwater resources have received little attention in the WFD. This has been the subject of criticism.[89] The WFD is potentially a powerful implementation tool for climate change adaptation policy. Its integrated river basin approach encourages strategic planning and water resources management that incorporates sustainable supply-side and demand-side management, drought measures, flood protection, water quality issues and the environmental health of the basin. While the WFD does not explicitly mention that climate change impacts need to be recognised, the approach of the WFD will serve as an important adaptation tool.[90] See Box 7-4 for further information.

In managing the impact on energy production, HEP representatives are already well aware that drought

Box 7-3: Public institutions involved in water management in Croatia

There are a number of institutions involved in the monitoring and regulation of water issues . Croatian Waters (CW) is responsible for the preparation of the Water Management Strategy, drafting river basin district plans, as well as the preparation and implementation of water management plans. CW also initiates and supervises projects, studies and investment programmes related to various aspects of water management. It regulates watercourses and other water bodies, manages irrigation and drainage systems, provides sufficient water quantities for different uses, monitors and safeguards overall water quality and protects people and assets from the damages caused by water. Finally, CW supervises the implementation of the water rights acts, concession agreements and the construction of water works. The organisation covers the whole country through its five regional water management offices, managing 32 catchment areas and collects water-related charges, which make up its primary revenue. CW submits yearly plans for approval to the Ministry of Regional Development, Forestry and Water Management (MRDFWM).

The Croatian Parliament adopts all relevant water-related legislation and water-related national strategies. It has a committee dealing with water, which issues opinions on specific acts and documents. The Government adopts the river basin district management plans and proposes relevant legislation and strategies to the Parliament.

The MRDFWM is the central Croatian authority dealing with administrative and regulatory tasks related to water management. This means monitoring and adapting water management to the needs of economic development: the regulation of watercourses; protection from flooding and erosion; land drainage and irrigation; protection of water resources; the use of hydropower; and the development and construction of the national public water supply and sewerage systems.

The MEPPPC is the central Government body responsible for the overall policy and the administrative tasks regarding environmental protection. It also co-ordinates all of Croatia's climate change efforts, including Croatia's international activities related to climate change. However, the MEPPPC's involvement in water protection policy is limited and is primarily focused on the protection of water resources in nature-protected areas and participation in some inter-ministerial committees. The MEPPPC takes part in various national steering committees, task forces and expert panels on water. It cooperates closely with MRDFWM, CW and other water-related organisations. However, it appears that this co-operation has yet to include climate change and water.

Box 7-4: The Water Framework Directive (WFD)

The approach of the WFD encompasses the following steps and actions:

1. Comprehensive stocktaking and monitoring;
2. Defining a target level of environmental status,
3. Identifying the necessary measures to improve the environmental status of waters in a comprehensive, multi-year plan, taking into account and integrating all environmental stresses, taking an ecosystem approach,
4. Planning long term, and repeating this planning cycle in 5-6 years in order to reflect developments.

Because the time scale for WFD implementation extends into the 2020s, it is apparent that Member States should take climate change into account in their water policies. It is unlikely that the first River Basin Management Plans (2009-2015) will address adaptation to climate change. However, the ongoing discussions in the EU give a clear signal that specific adaptation measures will be included in the second River Basin Management Plan cycle (2015-2021). Some countries have already taken the first steps in this direction. Some activities related to climate change are envisaged under the EU-wide Common Implementation Strategy (CIS).

Croatia is fully committed to following the common European approach and methodology when implementing the WFD and the FD. In this respect, the main risks from climate change in Croatia should be taken into account in the context of meeting the WFD's objectives in the second planning cycle. This would mean examining the potential risks of climate change to key phases of the river basin management process that supports the WFD. Consideration of climate change impacts at an early stage might help the selection of the most effective measures to be included in the second River Basin Management Plans (due for 2015). This work may be well suited to form part of the on-going, EU-funded project *"Implementation of the EU Water Framework Directive in Croatia."*

and runoff impact the system and the economic situation. However, since no decisive study has yet been undertaken on the likely impacts of climate change, potential impacts have not been included into future energy planning scenarios. Carrying out a study looking at the likely impacts of climate on energy production seems to be another logical step in analysing the impacts of climate change related to water.

7.7.3. Analysis of available options for adaptation

Unless the global community drastically reduces its emissions of greenhouse gases in the next few years, climate change will probably have numerous impacts in Croatia, especially near the end of the 21st century and beyond. However, looking forward twenty to thirty years, the possible impacts may be as follows:

- Loss of hydroelectric generation capacity;
- Increased flood damage;
- Loss of some ecosystem services;
- Reduction in the availability of groundwater (unlikely); and
- Reduced drinking water quality (unlikely).

In each of these cases, climate change would lead to economic and social losses. Adaptation will always involve some changes in how water resources are managed and used by the public and private sector. In some cases, changes will be made through investments in infrastructure and existing or new technologies related to the storage, conveyance or use of water. In most cases, options for adapting to climate change already exist and are commonly implemented to respond to climate variability and other climate shocks. The rest of this section briefly outlines the most important alternatives for avoiding climate change damages.

Adaptation to loss of hydroelectric production

There are two broad alternatives for adapting to losses in hydroelectric generation capacity:

- Increase retail electricity prices to the point where the reduction in consumption, as a result of the price increases, matches the average electricity loss. The result of this policy would be to induce electricity users to conserve electricity by whatever means they find most cost-effective. There are, however, two problems with this approach. First, if the consumption of electricity is not very price-responsive (and it often is not), then prices may have to increase by a great deal to reduce consumption by a small amount. The second problem is related to vulnerable groups within the population. In 2006, 20% of Croatian households surveyed reported difficulties in paying their utility bills on time.[92] The poorest people are the least likely/able to change behaviour based on electricity price and are hurt most by this approach. This impact can be softened by subsidy programmes for the urban poor and by electricity conservation programmes to encourage more rapid adoption of using electricity-saving appliances and energy efficient building practices. New pricing schemes have already been introduced encouraging households that consume more energy to reduce consumption – especially at peak times.
- The second adaptation option for addressing losses in hydroelectric generation capacity is to replace some amount of the lost capacity with imported electricity or with new generating capacity from other energy sources, such as renewable energy (including building new hydroelectric dams), fossil fuels and nuclear energy.

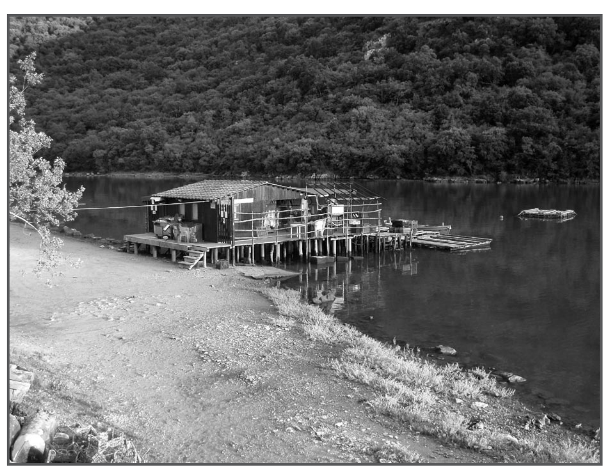
Adaptation to flooding

There are two broad approaches to flood damage reduction:

- Protective structures (protecting human activity from floods). The traditional approach to flood protection has been to protect highly valued property (such as population centres and buildings) from floods and allow damage to occur on low value land (such as agricultural land). This approach has not changed in thousands of years, but has become expensive. It can also be counter-productive, because once a flood plain is protected, it tends to attract more highly valued land uses. The land then becomes vulnerable to very large floods that are too costly to protect against anyway. These two factors have led to an increasing reliance in developed countries on the second broad approach.
- Non-structural measures (protecting flood prone areas from human activities – e.g. flood plain zoning measures). These measures either restrict settlement on flood plains or impose economic disincentives on activities that move onto flood plains - such as denial of insurance or requirements to flood-proof structures. These measures are effective against seasonal flooding but not always against flash flooding, caused by sudden intense storms that can threaten households in suburban or rural areas or campers, hikers, etc. In these situations, flood-warning systems that include sirens and wide dissemination by public broadcast media have helped to reduce the loss of human life in many countries.

While Croatia currently has numerous flood protection systems and is working to improve them, climate change may push these systems to the limit – especially in coastal areas that will have to deal with sea-level rise (see Chapter 5).

Figure 7-8: A small oyster farm on the coast in Lim channel



Source: Damir Vejzović

Adaptation to loss of ecosystem services

It is difficult to recover from the loss of many ecosystem services when the environmental "infrastructure" and the natural systems in it are very fragile. Thus, many ecosystems impacts are regarded as irreversible or nearly so. This is especially the case if there is a loss of biodiversity. On the other hand, some ecosystem losses are reversible in some situations. This applies in particular to wetlands that are susceptible to drainage due to agricultural encroachment or if the runoff areas have been adversely affected by human disturbances, such as logging. In these cases, human activity can be curtailed to prevent drainage for human use or to prevent logging and other disturbances, which influence runoff into the wetlands. However, in many cases the lost wetland services can only be replaced by human actions. In the case of lost waste assimilation capacity, the damages can be alleviated by treating the water (for example waste-water treatment). In general, projects to replace ecosystem values have to be evaluated on a case-by-case basis and some ecosystem services cannot be replaced by any adaptation measures.

Adapting to reduced groundwater availability

As already mentioned, the water loss in the Croatian public drinking water supply of 40-46% is exceptionally high. The EU's maximum acceptable water loss in a public water supply is 18%.[93] While seemingly unlikely, decreases in the water table may pose a risk to future water supplies. Adapting to the reduced availability of groundwater can take several forms.

- As the supply of water in some types of aquifers falls, the cost of access increases. Water can be pumped from greater depths or it can be pumped and transported longer distances as underground reservoirs dry up – or both. This means that the cost of supplying water will rise and, if consumers are charged for these costs, water prices will rise. As a result, consumers may cut back their consumption – a form of autonomous adaptation.
- In cases where Croatian water utilities experience large water losses due to water leakages, the increased pumping and distribution costs can provide an incentive to act to reduce these losses, another form of autonomous adaptation.
- If Croatian decision-makers choose not to price water because of economic efficiency principles – for example for reasons of equity or protecting vulnerable populations – governments can provide incentives to consumers and water utilities to engage in water conservation programmes.
- In addition, the authorities can improve the management of groundwater recharge areas to reduce water loss due to plant evapotranspiration.
- They can also regulate groundwater mining by imposing pumping restrictions.
- Finally, it is possible to find substitute sources of freshwater supplies and store this in aboveground or groundwater reservoirs. However, this is a very expensive adaptation measure.

Adaptation to reduced drinking water quality

Because most drinking water comes from groundwater in Croatia, it does not appear likely that its quality will be compromised in the near future due to climate change. If this does occur, there are only two ways to improve drinking water quality.

- Add more chemicals to the water being delivered to consumers.
- Clean the water that is discharged into the surface or groundwater reservoirs from which drinking water is pumped. This water treatment further reduces the volume and kinds of chemicals that have to be used to purify water.

In Croatia, as in most developed countries, point source pollution from existing industrial sources is declining and can be expected to reach a level close to zero within ten or twenty years. Meanwhile, non-point source pollution from agriculture is on the rise. The most toxic contaminants from non-point source pollution are pesticides and older herbicides. There is also substantial groundwater contamination from historical industrial pollutants, including highly toxic heavy metals and solvents. Except for some urban concentrations of these pollutants, the distribution of these pollutants is largely unmapped. Croatia is currently taking important steps to reduce water pollution and is expected to continue to do so in the future.

The EU accession process will also necessitate the introduction of further water quality improvements. Additional improvements to adapt to climate change would be limited and very costly, involving wastewater treatment such as filtration and nutrient removal. This may not be cost-effective. Should drinking water quality become a problem, it is likely that increased water purification by utilities will be the primary option available for adapting to climate change. As the Croatian economy develops further, water purification capacity will increase. Additional capacity to purify drinking water will probably be most pressing where water is drawn from alluvial sources (e.g. from rivers and streams) and not karst formations, due to the much higher flow rates and oxygenation in karst formations.

7.8. Conclusions and recommendations

Climate change will have potentially significant impacts on the water cycle in Croatia. These could include increased droughts affecting agriculture and natural environments – especially wetlands. It will probably result in decreased river flows, and perhaps even lower levels of the groundwater that is used for drinking. While sufficient information is not available to plan adaptation projects, there are a number of steps that can and should be taken.

First, authorities that are developing water management plans should incorporate the possible impacts of climate change into their planning. This may require the further development of specific information – such as developing and incorporating regional climate models into planning for flood protection, groundwater recharge, and river flows.

HEP and the MELE should also include climate change impacts into projections of energy needs and supplies in Croatia beyond 2020. As such, it would be helpful to initiate research on the probable impact of reduced inflow on hydropower-generated electricity. The initial analysis of this Report shows that the projected impacts may result in a loss of EUR 16-82 million per year in direct losses, with multiplier effects throughout the economy. HEP should also consider research into alternative strategies for electricity production that could cushion the impacts of a potential reduction in the electricity generated by hydropower.

In addition, more research should be carried out to look at likely climate change impacts on wetlands and their economic services. The value of these services is estimated at more than EUR 238 million per year, and they may be at risk. Similar research should be carried out regarding flood risks and any adaptation that may be necessary.

The above-mentioned research could also be implemented in co-operation with research institutes in other countries such as the EU-funded Seven Framework Programme. Alternatively, the MEPPPC might work with the Ministry of Science, Education and Sports (MSES) to fund more research projects on water and climate change.

Finally, it is strongly recommended that Croatian authorities urgently undertake appropriate measures to improve the existing infrastructure, management, and supervision of the public water supply. The current loss of EUR 286 million per year and 267 million cubic metres is immense and may lead to problems if water resources become scarcer.

Chapter 8

Agriculture

Chapter 8 Summary

Agriculture

The impact from climate change on agriculture is expected to be significant because of the vulnerability of agriculture to climate conditions in general. Precipitation, temperature, weather extremes and evaporation rates all impact production. Agriculture is important to the economy of Croatia due to its overall value and its impact on food security, vulnerable populations, and the employment it generates. In 2001, 92% of Croatia was classified as rural and 48% of the Croatian population lived in rural areas. Generally, rural households are more vulnerable due to poorer access to basic infrastructure and poorer housing conditions than households in urban areas.

Existing climate variability already has a significant impact on agriculture. Extreme weather events have resulted in average losses of EUR 176 million per year during 2000-2007. This represents 0.6% of national GDP, or 9.3% of the GVA generated by the agricultural, forestry and fisheries sector. Looking at the future effect on maize alone, the lost revenue due to climate change would be EUR 6-16 million in 2050 and EUR 31-43 million in 2100. This corresponds to 0.8-5.7% of all revenue from arable crop sales in Croatia in 2005. Most of this damage is due to water shortage during critical times, as well as flooding and hail-storms which also cause damage. Particular years, such as 2003 and 2007, suffered huge economic damage that is difficult to recover. While some Government-supported insurance programmes and a new irrigation programme exist, current vulnerability to climate variability remains – particularly related to drought.

However, little information is available to assess the consequences of farm practices and climate variables. There are few crop models or agricultural sector economic models that would help the sector understand current levels of vulnerability or future levels due to climate change. Furthermore, basic economic information about the sector and about the gross margins of crops is not available. Thus, while climate change may be a risk in the future, there are a number of actions that could be taken now to address current vulnerability to the climate.

Models to simulate the effects of climate (including climate change) on crops need to be calibrated for Croatian conditions to understand how the country should adapt. Furthermore, the Government should conduct a comprehensive overhaul of its existing systems for collecting data on agricultural production, prices and accounting for farm revenues/ costs in order to produce information. This should reflect the reality of the situation on the ground.

A multi-crop, multi-region agricultural sector model should be developed to assist the public sector in developing strategies and measures for coping with existing economic development, pressures to preserve the quality of the environment, climate variability and finally climate change. This would also assist farmers in implementing best management practices, as well as support national agricultural development and marketing strategies. More work also needs to be done to assess economic impacts from the agricultural sector on the larger economy.

Adaptation options can only be evaluated once a basic understanding of the interaction between climate, agricultural production and the economy is developed. This should include a comprehensive cost-benefit analysis of the Government's current large irrigation programme, as well as the other programmes discussed in this chapter as possibilities for dealing with water shortages. Adaptive actions may require a change of practice and may include management changes, technical adaptation/ equipment changes and infrastructure measures (e.g. the choice of crop variety and pesticides, sowing dates, the adoption of new husbandry practices, on-farm water harvesting and storage facilities, irrigations systems, etc.).

8.1. Introduction

Agriculture is expected to suffer severely from the impacts of climate change.[1] Precipitation, temperature, weather extremes, and evaporation rates all have significant impacts on production and agricultural production impacts economic development, food security, and Croatia's development. Impacts in this sector particularly affect vulnerable groups who use agriculture as a means of subsistence and for income generation. Agricultural production also affects food prices, which impacts the entire economy. This chapter discusses the importance of agriculture for human development and the current and potential future impacts from climate variability and climate change. It then evaluates the potential for adaptation, including "no regrets" and "low regrets" measures and makes recommendations for the further analysis of potential adaptation measures within the agricultural sector.

8.2. The role of agriculture in Croatia

Agriculture has been Croatia's backbone for millennia.[2] In the 20th century Croatian agriculture endured three wars, which destroyed farms and rural communities.[3] During the war from 1991 to 1995, a third of the livestock was destroyed and a quarter of the agricultural machinery.[4] More than 200,000 farmers were displaced and became consumers rather than agricultural producers.[5] Nearly a third of agricultural land remained inaccessible for cultivation due to minefields.[6] About 1.7% of the utilised agricultural area (UAA) still contains mines.[7] The farming sector has not fully recovered and the volume of agricultural production over the period 2000-2004 was about 15% lower than 1986-1990.[8]

The structure of the Croatian population has changed drastically in recent decades. Rapidly developing industry has required a large labour force. Most people were recruited from rural areas. Independent farmers became industrial workers. Over time, many rural areas became depopulated. Land remained abandoned and returned to shrubs and forest.[9] As policy measures in recent decades have not favoured the development of private farming,[10] mostly less educated, poorer, and older farmers have remained. Over time, society has developed a negative attitude towards farmers and farming that is still prevalent today.[11]

Figure 8-1: Dried out corn field in the middle of a drought in Požega.

Source: Borislav Trninić.

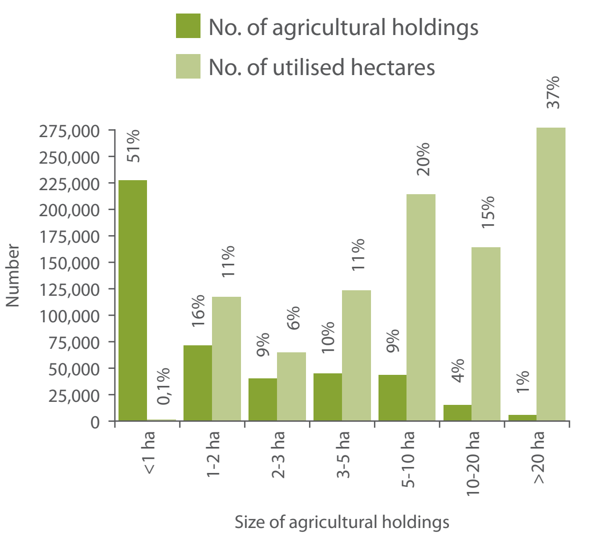
> "While family farms form the core of Croatian agriculture, private companies, which have mostly evolved from former state-owned enterprises, are much larger in terms of land-use"

8.2.1. Family farms and agricultural companies

Croatia has two parallel production systems: family farms and private agricultural companies. While family farms form the core of Croatian agriculture, private companies, which have mostly evolved from former state-owned enterprises, are much larger in terms of land-use (Figure 8-2). This farm-size structure is the result of past communist agrarian reforms and continuing inheritance laws that allow for the division of farms between heirs, even if the farms become unviable.[12] While family farms are very important to Croatian agriculture, there is a vast discrepancy in the distribution of land, which favours larger agricultural companies. This is not a particularly new or unique phenomenon, as large farms are generally more efficient. However, small farms are, relatively speaking, much greater generators of employment and economic value.

Many people still live on agricultural land. In 2003 every third Croatian lived in an agricultural household.[13] Thus, the majority of agricultural households are not viable commercial enterprises. They are outside of the administrative, bookkeeping, fiscal, and inspection systems. They are subsistence, non-market-oriented farms, producing for self-consumption. Their owners usually earn their living working in other sectors but use the homesteads as places to live. In a number of cases, people without sufficient pensions or other income use small-scale farms to survive.[14] Contrary to most family farms, the industrial agricultural actors have access to capital and are geared towards industrial, high external-input farming aimed at maximising yields.[15] Agricultural subsidies are very unequally distributed among farmers and benefits go primarily to the big producers.

Figure 8-2: Distribution of utilised agricultural land and the number of agricultural households and companies according to size.



Source: Znaor 2008.

8.2.2. Economic importance of agriculture

Agriculture is very important to the economy of Croatia due to its basic value, as well as its impact on food security, vulnerable populations, and the number of people it employs (which is far more than its economic output would suggest). Some recent calculations question the validity of the official figures of annual GVA from agriculture, suggesting that it is significantly lower – see Table 8-2 for more.

Table 8-1: Characteristics regarding family farms and industrial farms in Croatia

There is a large difference in farm sizes	- The average size of family farms is 1.9 hectares, while the average size of the land used by the agricultural companies is 152 hectares.[16] 51% of agricultural holdings are less than one hectare in size. - 52% of the UAA is made up of 5% of holdings larger than 10 hectares
Small family farms are very important	- Small-scale, family farms account for 82% of annual working units (AWU)[I] and create 54% of all gross value added (GVA)[II] generated by farming and related upstream sectors (energy supply and distribution, trade, transport, agri-chemical industry, veterinary, advisory, research, education and administrative services). - Agricultural households account for 99.7% of the total number of agricultural holdings, occupy 80% of UAA, own 85% of all livestock and 98% of all tractors.[17]
Subsidies, like land are distributed unequally	- For example, the top 5% of milk producers receive 41% of all subsidies paid for milk production.[18]

[I] The AWU is defined as full-time equivalent employment (corresponding to the number of full-time equivalent jobs), i.e. as total hours worked divided by the average annual number of hours worked in full-time jobs. In the European context a working week is considered to be the equivalent of 40 hours (EC 2007).

[II] GVA is slightly different than Gross Domestic Product (GDP). National GDP takes into account some taxes and subsidies, which are impossible to obtain at the sectoral level in Croatia. GVA is therefore a close approximation of GDP.

The GVA produced by people not included in the mainstream economic and administrative systems still adds value to the economy but is not counted in national statistics. Their products are mainly for their own and (extended) family consumption, are bartered or sold directly on farms or at farmers' markets for cash, without receipts or VAT charges. These farmers are not obliged to practise bookkeeping or pay income tax. More than 90% of agricultural holdings inscribed in the Farm Register do not practise any bookkeeping and their economic size is unknown.[19] This means that a fairly large amount of agricultural production is not being accounted for. Additionally, the agriculture sector is important for the balance of trade and food self-sufficiency. Since independence in 1991, Croatia has been facing an increasing agricultural negative trade balance.

8.2.3. Role of agriculture related to employment and vulnerable people

A significant amount of the Croatian population lives in rural areas. Generally, rural households are more vulnerable in a variety of ways, which tend to be characterised by poorer access to basic infrastructure, such as roads, connections to the public water supply, public sewage systems, telephones and central heating systems. They also have poorer housing conditions (electricity, water supply, sewage systems, central heating, kitchens, toilets and bathing facilities in the house) than households in urban areas.[29]

The agricultural labour force is decreasing and many people engaged in the sector are not employed full-time. However it is unclear what percentage of the part-time workers' income comes from agricultural

"The agricultural labour force is decreasing and many people engaged in the sector are not employed full-time"

Table 8-2: Economic importance of agriculture in Croatia

While GVA and GDP from agriculture are important, it is not clear how much they contribute to the Croatian economy	- The GVA of the agricultural sector in the period 2000-2005 increased from EUR 1.50 to 1.76 billion per year, yet its share in total GDP decreased from 7.4% to 5.8%. [20] - Some recent calculations question the validity of the official figures of annual GVA from agriculture, suggesting instead an annual GVA of EUR 395 million during 2000-2003,[21] EUR 623 million in 2005[22] and EUR 626 million during 2001-2005.[23] - If these estimates are correct, farming makes up just 2.5% of GDP instead of the 5-7% reported by the Central Bureau of Statistics (CBS). [III]
Much of the value of farms is not captured by official statistics	- In 2007, 176,027 agricultural households were registered. [24] However, the number of commercially viable farms was about 50% lower and in the same year only about 86,000 farms received production subsidies. [25] - There are estimates that nearly 60% of holdings that are commercially oriented have gross margins below EUR 7200 per year.[IV]
Direct payments/ subsidies are quite large and comparable to EU levels	- The share of direct payments (subsidies) from the Government in the total gross output is very similar in Croatia (37%) and in the EU-27 (38%). - In 2005 Croatian farmers received just 6% less in direct payments per hectare than their colleagues in the EU-15 (EUR 238 vs. EUR 253).[26]
Croatia's food self-sufficiency has been decreasing over time.	- In the period 2000-2005, Croatia was self-sufficient in only five products: wheat, maize, eggs, poultry, meat and wine. [27] - In the period 2001-2005, imports of agricultural goods increased from EUR 287 million to EUR 377 million (an equivalent of EUR 85 per capita). For the same period, agricultural exports decreased from EUR 70 million to EUR 57 million.[28] - In the period 2001-2005 the deficit increased dramatically from EUR -217 million to EUR -320 million.

[III] Although this may appear very unlikely, these figures are probably more reliable than those of the CBS, which calculates farming GVA using 3.13 million hectares (instead of the 1.2 million hectares actually in use). The CBS suggests that on the per hectare basis Croatia generates some 20% higher GVA than the EU-15 or 40% higher than the EU-25. Taking into account the overall structure and development of the Croatian agriculture sector this is very unlikely. The CBS also applies a flat rate for the costs of production – extrapolated from a survey of 25 years ago. This means that each year they assume a fixed percentage of the cost of the crops to be the production cost, of regardless the actual cost of production for farmers.

[IV] One ESU is equal to EUR 1,200 of standard gross margin.

> “While agriculture in Croatia constitutes a significant part of GDP, its importance to the economy and to food security is more than just that of a component of GDP, especially in rural areas and among vulnerable populations”

activities. This is due to the structure of employment within the agricultural sector – with many workers actually being unpaid family labour. A vast majority of small-scale farmers, engaged in farming, are not registered with the Labour Office or the Revenue Office. Agricultural jobs do not pay well and, therefore, these farmers are exempt from paying pension insurance or income taxes.

The Croatian farming community is generally older than the general population. Since younger rural inhabitants regard farming as a labour-intensive and unprofitable business and tend to work elsewhere, the ageing process of the agricultural population is accelerating.[30]

As noted earlier, two-thirds of agricultural households have less than 2 hectares. It is very likely that most of these households practise subsistence farming and that agriculture forms the backbone of their survival strategy.[31] However, the exact number of smallholdings personally consuming more than half of their final production is unknown.

Agriculture is also a survival strategy for many urban people who go to the countryside over the weekends to help or farm on their own and return to the city with free or cheap food.[32]

This analysis shows that, while agriculture in Croatia constitutes a significant part of GDP, its importance to the economy and to food security is more than just that of a component of GDP, especially in rural areas and among vulnerable populations. Industrial farming is also important to Croatia, though perhaps more because of the impact on national food security and the balance of trade than for employment. However, population migration away from rural areas and shifts in the employment structure will probably mean that fewer people are dependent on agriculture in the future.

Table 8-3: Characteristics of the agricultural labour force

Significant amounts of Croatia are rural – including a large portion of the population	- In 2001, 92% of Croatian territory was classified as rural, and was populated by 48% of Croatians.
The agricultural labour force is decreasing, and many people engaged in the sector are not employed full-time.	- In the period 1991-2001, the agricultural labour force decreased by 37%.[33] - The CBS estimates that about 84,000 people (44% of which are women) are employed full-time in agriculture, accounting for about 6% of all the employed labour force.[34] - The labour survey also suggests that in 2005, 272,000 people were employed on a full-time or part-time basis in the agriculture, forestry, hunting and fishing sectors.[35] This total is approximately 6.2% of the entire population.
The percentage of people that earn their livelihoods in agriculture is more than the proportion of GDP	- The proportion of people working in agriculture is more than double the proportion of GVA from agriculture and much more important for livelihoods than the 84,000 figure suggests - There are estimates that the average AWU of those engaged in the Croatian farming sector in the period 2001-2005 was 180,824.[36] This means that many people worked part-time in the sector.
A vast majority of small-scale farmers who are engaged in farming are not registered and the jobs are not well paid	- The World Bank[37] suggests that three-quarters of those employed in Croatian agriculture are self-employed farmers. Most of this is unpaid family labour. - The average number of private farmers contributing to the pension insurance scheme in the period 2004-2006 was only 49,450 and their number has been declining every year, by 11% on average.[38] - The average monthly income (net), in all sectors in 2005 was EUR 591, while in the agricultural sector this was only EUR 502 per employee (15% lower).[39]
The Croatian farming community is generally older than the general population.	- In 2001 the ageing index (ratio between the population older than 60 and younger than 19 years) was twice as high in the rural population as in general (1.8 vs. 0.8). - 47% of the population living in agricultural households are older than 45 years of age.[40]

8.3. The impact of existing climate variability and extreme weather on the Croatian agricultural sector

Climate variability impacts and weather-related disasters appear to be occurring more frequently throughout the world and in Croatia. This variability has already had significant impacts on agriculture and the well-being of the rural population. A 2006 European study[41] analysing changes in natural annual events, such as the flowering of plants, suggests that changes in climate are affecting the seasons. In the future, agricultural yields could drop sharply as temperatures rise and water becomes scarcer, resulting in yield losses of 10-30%, notably in Southern Europe.[42]

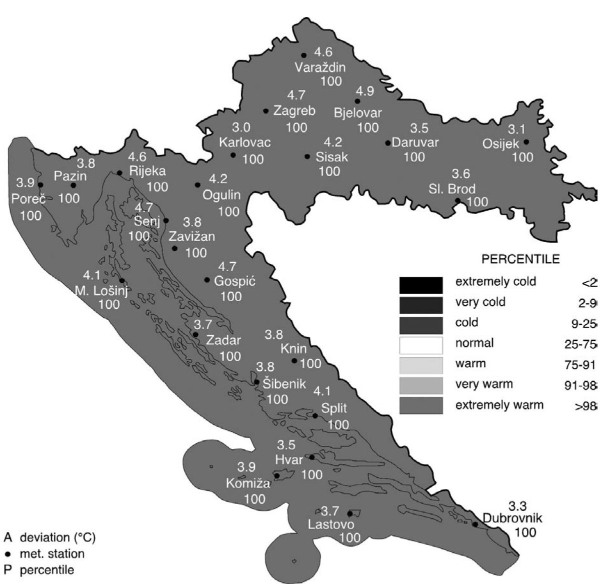
8.3.1. Droughts and heat waves

The period 1991-2000 was the warmest decade of the 20th century in Croatia.[43] The annual minimum daily temperature is rising. This process is more advanced along the coast than inland.[44] Summers have become steadily warmer in the last ten years.[45] The number of cold days and nights is diminishing, while there are more warm days and nights. In the 20th century,

Table 8-4: Problems related to water availability and heat in agriculture

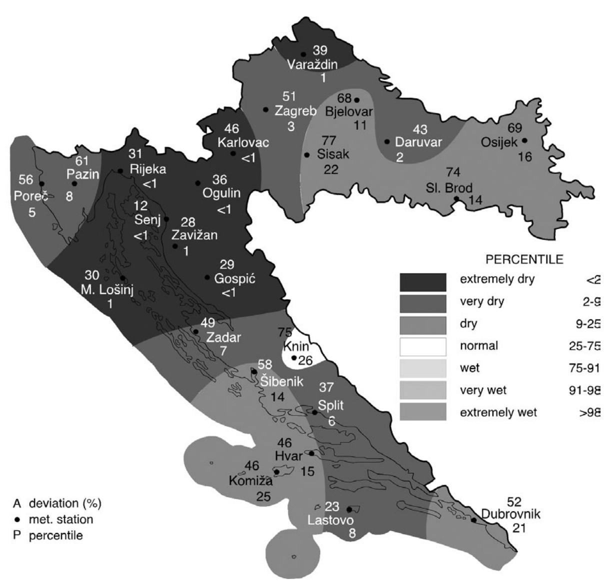
The shortage of water in agriculture is growing	- In the period 1994-2003, Croatian agricultural soils exhibited a much higher shortage of water than in the larger period 1961-2003. - In 1994-2003 the average annual water deficit was 57 litres per square metre, 19% higher than in 1961-2003. This has been attributed to changes in climate.[46]
The frequency of drought appears to be increasing	- During the period 1970-1992, droughts occurred 40% more frequently after 1981.[47] - The frequency of drought occurrence has increased over the last 20 years throughout Croatia. From 1982 to 1992, there were 55 drought periods, 29 of which affected all five geographic regions.[48]
Heat stress on crops is a problem	- Frequent air temperatures above the 25°C threshold (above which crops suffer from heat stress) have become a problem in some parts of Croatia over the last 20-30 years.

Figure 8-3: Summer 2003 - the mean seasonal air temperature deviation (°C) from the corresponding average values for the period 1961-1990.



Source: DHMZ 2004.

Figure 8-4: Seasonal precipitation quantities for summer 2003, expressed as a percentage of the average values for the period 1961-1990.



Source: DHMZ 2004.

annual precipitation dropped throughout the country, with the reduction being more pronounced in the northern Adriatic, on the Dalmatian islands and in eastern Slavonia.[49] A decreasing trend of average annual cloudiness has also been identified throughout Croatia. Average annual precipitation is decreasing, especially along the coast. The northern Adriatic, Northwest Croatia, and the bread-basket region of Eastern Croatia are becoming increasingly dry.[50] As a result, the need for water is growing in Croatian agriculture. Similarly, due to high temperatures and the risk of summer drought, agriculture in the mid-Adriatic coast and islands indicates the highest vulnerability to climate variability.[51]

Severe droughts inflicted severe damage on Croatian agriculture in 2000, 2003 and 2007 (See Table 8-5).

8.3.2. Additional damage from weather events

In addition to droughts, during 2000-2008, agriculture suffered from hail-storms, exceptionally strong winds, frosts, heavy rains and flooding.[60] The hail-storms that hit some parts of Croatia (particularly on the Adriatic coastline) in 2001 destroyed large areas of grapevines and other crops.[61] In the same year, summer frosts damaged/destroyed crops in several parts of Northern Croatia and Istria.[62] However, 2002 did not suffer many extreme weather conditions, although some parts of Croatia were affected by frost, causing damage to some crops, notably fruit.[63]

In 2004, a severe bora wind (north wind) blew along the entire Adriatic coast on November 14 and 15, killing 2 people, injuring over 50 and causing substantial

Table 8-5: Effects of the droughts of 2000, 2003 and 2007 on agriculture

2000	- Extremely hot and dry, with some regions going without rain for around 40 days. The last time the same intensity of drought occurred was in 1893. - The mean annual temperature in 2000 in Zagreb was the highest since the beginning of systematic recording in Croatia in 1861.[52] - Fifteen out of 20 counties declared a state of natural disaster due to the combined effects of drought and wildfires. - Some of the most important agricultural areas, such as Vukovar, received only 3-10 litres of precipitation per square metre in the period April-August, which was far below the requirements for the normal growth of crops.[53] - Agricultural production was reduced by up to 30%. In some cases, crops were almost completely destroyed.
2003	- Croatia and several other areas in Europe were gripped by a heat wave and the worst drought in 50 years.[54] - The heat wave began in March and lasted over three months, causing severe damage to agriculture. - Due to high temperatures and low precipitation, the entire country was classified as 'extremely warm' (Figure 8 3). - With the exception of the Knin region, dry weather prevailed throughout Croatia (Figure 8 4). - By the beginning of June, the main agro-meteorological station in Križevci found that the field moisture capacity of the soil was already 27 litres per square metre short at a depth of 10 cm, 77 litres at 30 cm and 170 litres at 60 cm.[55] - The soil was not only dry but it was also extremely warm – up to 45°C in Osijek, resulting in all plant crops experiencing a temperature shock. This situation affected the fertile region of eastern Croatia the hardest, where precipitation amounts reached barely 30% of the 30-year average. - Crop yields were diminished by 30% on average, with some crops, such as sugar beet, suffering a 50% reduction.[56] - In May 2003, a state of natural disaster was declared in 10 counties in eastern and northern Croatia and the Government formed a crisis group headed by the Prime Minister.[57] By the end of the growing season, 19 out of 21 counties had proclaimed a state of natural disaster.[58]
2007	- Croatian agriculture was again struck by a severe summer drought, causing shortages of both grain and corn.[59]

damage to infrastructure, buildings, and agriculture. Many olive trees were uprooted, while the sea salt left on vegetation caused damage to sheep farming on the northern Adriatic islands.[64] Again in 2007, hail damaged or destroyed crops in several regions.[65] The following year, in June, July and August, exceptionally strong hail hit northern Croatia, causing severe damage to maize and vineyards.[66] A state of natural disaster was declared in several municipalities.

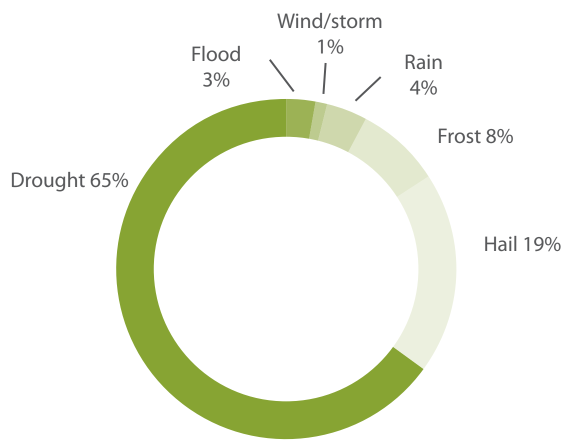
Figure 8-5: "The Harvest of 2008" - exceptionally large hailstones size of an egg on August 8, 2008 in Zagreb.

Source: Ana Pisak.

8.3.3. Existing economic damage from current climate variability

All of these natural disasters and climate variability events have resulted in economic damage. During 2000-2007, Croatian counties claimed EUR 1.4 billion in crop damage caused by extreme weather conditions.[67] This figure is equivalent to an average of EUR 176 million per year, representing approximately 0.6% of GDP or almost *one tenth* of the GVA generated by the agriculture, forestry and fisheries sector. This damage surpasses, by 25%, the value of the average annual direct payments (subsidies) for the same period, paid to farmers by the Ministry of Agriculture, Fishery and Rural Development by (see Figure 8-7). Therefore,

Figure 8-6: Share of extreme weather conditions in damage claims.



Source: Znaor, after MF 2008

the damage caused by existing climate conditions and climate variability already has a substantial impact on agriculture in Croatia. This may or may not be due to climate change, but it certainly points towards current vulnerability.

In the period from 1980-2002, natural disasters caused approximately EUR 5 billion in damage in Croatia (average EUR 217 million per year). Some 73% of this damage was due to weather. The damage from drought, frost and hail – extreme weather conditions causing damages predominantly in agriculture – is estimated at EUR 3.5 billion for the period 1980-2002, which is the equivalent of EUR 152 million per year.[68] Drought has caused the most damage, followed by hail, frost, rain, floods and wind/ storms (Figure 8-6).

[V] Assuming that the GVA figure of about 626 MEUR as estimated by the Economic Institute (2007) and Znaor (2008) is more accurate, this damage would be equal to some 28% of the GVA created by agriculture.

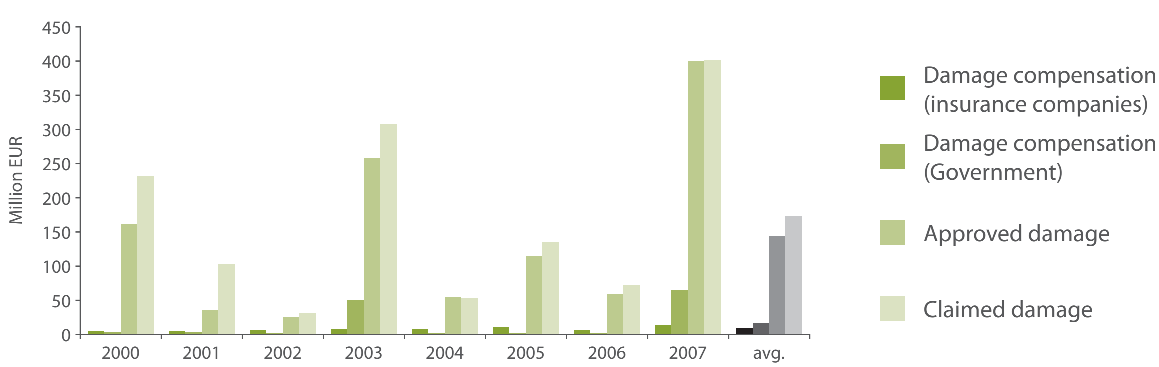
Table 8-6: Claimed, approved and compensated damage to the agricultural sector in the period 2000-2007.

Year	2000	2001	2002	2003	2004	2005	2006	2007	Avg.	
Claimed damage (Million EURO)										% of damage
Hail	16	35	15	13	33	41	64	52	34	19
Drought	238	17	0.4	313	0.2	-	2	346	115	65
Erosion	-	-	-	-	-	18				0
Flood	2	9	1	-	20	5	5	0.2	5	3
Wind/storm	-	-	0.4	-	4	5	-	8	2	1.2
Rain	-	-	-	-	-	52	2	-	7	3.8
Frost	-	51	29	5	-	22	-	-	13	7.6
Total	256	112	32	332	57	143	73	406	176	100
Approved damage	175	36	26	270	57	117	59	401	143	
Compensation										
Government	3	3	2	51	1	1	1	62	15	
Insurance companies	4	5	6	7	7	10	5	12	7	
Total	7	8	8	58	8	11	5	75	23	

Source: after MF 2008 and Hanfa 2008.

The Government has attempted to relieve some of the risks and damages associated with climate variability. Subsequent to the Act on the Protection from Natural Disasters, the Government approved damage payments of EUR 1.1 billion (78% of all claimed damages). However, due to a shortfall in funds, only EUR 124 million (11% of approved damage) was actually paid out. The most significant payment was in 2007, when EUR 62 million was paid to compensate grain farmers and cattle breeders adversely affected by the drought. In 2003, the Ministry of Agriculture and Fisheries (MAF - the name of the ministry at that time) also granted a one-year grace period on MAF loans to 1,030 farmers who suffered damage from the 2003 drought.[69] During 2000-2007 farmers with insurance policies received EUR 57 million (on average EUR 7 million per year) from insurance companies (See Figure 8-7 and Table 8-6). However, generally speaking, insurance companies will not insure farmers against drought.

Figure 8-7: Claimed, approved and compensated damage to the agricultural sector in the period 2000-2007.



Source: after MF 2008 and Hanfa 2008.

The 2007 drought also caused economic damages reaching beyond the agriculture sector. Shortages of both grain and corn resulted in increased food prices. Retail prices of milk, bread, eggs, and meat all rose following the Government's announcement that there was just enough wheat to meet domestic demand and there was a corn deficit of up to 300,000 metric tonnes.[70] To try to stabilise the local market, the Government imposed a tariff of EUR 108 per tonne on corn exports.[71]

8.3.4. Potential impacts of future climate change on agriculture in Croatia

While current damages due to climate variability are estimated at 0.6% of GDP, or 9.3% of the GVA generated by the agriculture, forestry and fisheries sector, the scale of damages could get worse in the future. Climate models predict a further decrease in precipitation, and the Government expects that climate change will cause crops in Croatia to suffer from water shortages, notably in the fertile region of Slavonia. [72] Most climate change models predict an increase of drier summers and extreme heat waves and droughts. For this reason, an increase in the frequency of extreme weather events may be the most serious potential impact on agriculture from climate change. However, in addition to the frequency of extreme weather events, there may also be an impact from the change in the average temperatures, the average precipitation rates, and overall changes in climate.

The potential impact of changes in the averages of climate variables (long-term climate change) on the Croatian agricultural sector is largely unknown. The forecast for climate change in Croatia is not optimistic, and negative climate trends are predicted to worsen.[73] As discussed in Chapter 3, the various climate change scenarios for Croatia envisage significant temperature increases, regardless of the season, as well as decreases in precipitation.

The First, and then the Second, Third and Fourth (combined) National Communications of the Republic of Croatia to the UNFCCC detailed significant expected climate change impacts on agriculture (See Box 8-1) – some beneficial, others not. However, much more information and analysis will be necessary in order to actually transform these generalized statements into predictions about specific crops, the economic impacts of climate change, and to identify actions that will lead to adaptation.

Except for a series of closely-related studies,[74] the impacts of climate change on crop yields have not been quantified in Croatia. This work focused on the effects of climate change on maize development and yield in the central part of Croatia. The results of these studies correspond quite closely with those obtained for western Hungary.[75] This sort of research is necessary to better understand the relationship between climate and agriculture (See Box 8-2 for more information). The results showed:

A shorter growing season (30-36 days in 2050 and 34-44 days in 2100);

A reduction in grain production (3-8% in 2050 and 8-15% in 2100); and

No significant difference in the yield of biomass (range between -2% and +2%).

“Climate models predict a further decrease in precipitation, and the Government expects that climate change will cause crops in Croatia to suffer from water shortages, notably in the fertile region of Slavonia”

Box 8-1: Expected impacts from climate change according to the National Communications to the UNFCCC

Regarding the potential impact of climate change on the Croatian agricultural sector, the First National Communication of the Republic of Croatia to the UNFCCC concludes the following:[76]

1. Soil moisture during summer months in lowland Croatia (the most fertile and most important agricultural region) is expected to decrease by 30-60%.
2. The annual number of days with temperatures exceeding 10ºC is expected to increase to 25-40 or 55-90 days.
3. The mountainous areas, which at present do not face water shortages, are expected to experience shortages during August.
3. The vegetation period is expected to extend by 25 to 45 days.
5. The coastal region of Croatia is expected to have a decrease in soil moisture by 25-56%.
6. It will probably be possible to plant/seed spring crops earlier, and, depending on the water quantities available for irrigation, the growing season will be prolonged.

In the more recent document, the Second, Third and Fourth National Communication of the Republic of Croatia to the UNFCCC[77], climate change is expected to:

1. Have a positive impact on yields and crop quality (notably winter crops) due to the extended vegetation period. The overall number of active vegetation days (temperature above 5°C) will increase by 35-84 days in the lowlands of Croatia and the period with temperatures above 20°C will be prolonged by 45-73 days.[VI]
2. Endanger spring crops because of high temperatures and water shortages during summer months.
3. Expand the area suitable for fruit and vine growing due to the disappearance of very cold winters and late spring frosts. This will particularly benefit southern Croatia, where it will probably be possible to grow more types of Mediterranean fruit.
4. Result in unfavourable conditions for pests, resulting in a significant reduction in pesticide use. A warmer and drier climate is expected to reduce the outbreaks of natural infections by mycoses that depend on frequent precipitation and high air humidity.
5. Result in more cost-effective production due to temperature rise, assuming that irrigation will be practised.
6. Lower yields and quality of pasture, forage crops and cereals.
7. Cause salinisation in coastal areas and impoverish pastures due to high-intensity rainfall and stronger winds in the coastal area. This is expected to have an adverse effect on milk production and the growth of small ruminants. Also strong winds (bora), lasting for several days, in the Dinarides may kill weaker and undernourished sheep, goats and their young (already frequently happening during gale-force winds blowing at 80 km/h).
8. Accelerate the multiplication of various pathogenic micro-organisms and parasites hazardous to livestock.

[VI] This may be an important threshold for some crops, though it is unclear.

Box 8-2: Modelling the potential impact of climate change on crop production – how to start.

"I began my research into crop models 15 years ago on my own initiative for my PhD dissertation. Analysing agricultural systems and modelling the potential impact of climate change on crop production is a very important topic, particularly now as food supplies are becoming scarcer in many parts of the world. My crop-modelling research activity was very slow and I had to take great efforts in learning everything myself in my free time. To my knowledge I am the only one in Croatia who has applied climate change to any crop-model. Corresponding with eminent experts from the USA, Slovenia and Hungary I was sent papers, books and the Decision Support System for Agrotechnology Transfer (DSSAT) software which helps analyse the effects of weather on agricultural systems.

In 1999 I carried out field maize experiments at the Faculty of Agriculture of the Zagreb University and simulated the yields using the Zagreb historical data (1949-2004). Then I stopped because I did not have the weather generator and climate change scenarios and could not analyse projections for the end of 21st century. Having waited for five years, in August 2005, I participated in the AGRIDEMA workshop *Introducing tools for agricultural decision-making under climate change conditions by connecting users and tool-providers* which was held in Vienna. With the help of the project, I carried out the Pilot Assessment *Modelling of maize production and the impact of climate change on maize yields in Croatia.*

The AGRIDEMA project was very useful because it connected providers and users. After publishing the results of the Pilot Assessment, the State Hydro-Meteorological Service improved its resources available by procuring an updated version of the DSSAT software. Presently I am participating in the Croatian Ministry of Science project *Climate variations and change and response in affected systems* and I am a delegate in the Commission for Agricultural Meteorology of World Meteorological Service and in the Management Committee of the European Cooperation in the field of Scientific and Technical research (COST) Action 734 *Impact of Climate Change and Variability on European Agriculture.* I am also participating in the COST Action 725, which aims to establish a European phenological database – a database describing the relationship between climate and biological phenomena.

There are not many agrometeorologists in the world and only 1.5 in Croatia – my husband Marko Vučetić who deals with protection from forest fires and "half of me" because agrometeorology is my "hobby". I really would like for agrometeorology to become a main topic of my research in my Service. I am eager to learn the new version of DSSAT model in the upcoming year. While the research is difficult and complicated, it will be necessary for ensuring that we understand the risks that climate change poses to the food supply in Croatia."

MSc Višnja Vučetić is the head of the Numerical Modeling Unit in the Meteorological Research and development Division of the Meteorological and Hydrological Service of Croatia and has been with the Service since 1982. She is the author or co-author of approximately 80 scientific and professional papers regarding agrometeorology, wind and wind energy.

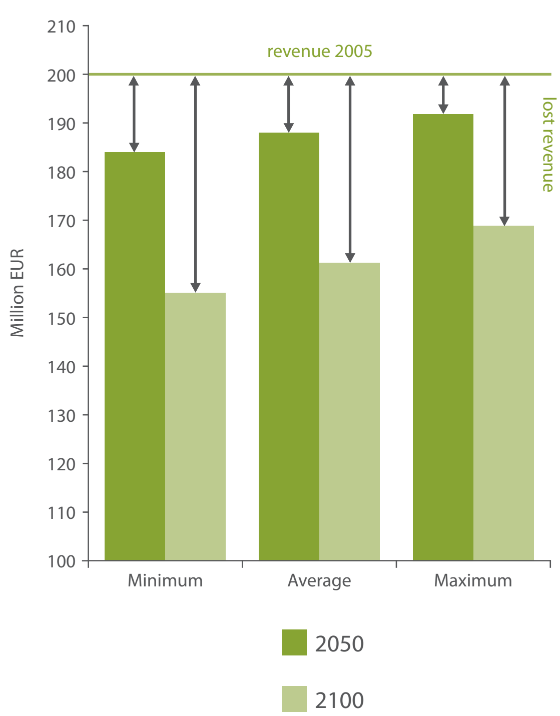
While these studies are important, they need to be supplemented by a much larger effort. The focus of these studies was on a single crop in a single region. This work needs to be extended to include more commercially-important crops and to cover more regions in Croatia.[VII]

[VII] There are technical limitations to these studies. For example, they did not take into account direct effects of atmospheric CO_2 on crop yields. Also, instead of using composite climate scenarios, taken directly from global climate models, the data need to be downscaled to a smaller geographic grid. Finally, instead of using composite climate scenarios, the effects of climate change and higher CO_2 concentrations on crop yields need to be investigated for various IPCC scenarios.

> “If the reductions in maize production are similar for other crops, the possibility of lost revenue and lost food sources is significant”

Predicting crop yields in the future is only one step. Crop yield results[78] were used for an economic analysis which estimated the potential loss of revenue from the production and sale of maize due to climate change, taking the year 2005 as the baseline for maize yields, area harvested and prices. In 2005 grain maize was by far the most economically important single crop with 59% of arable land (318,973 hectares) and 39% of the total harvested area growing maize. Croatia produced 2,207 kilo tonnes of maize grains in 2005.[79] When multiplied by the average annual producer price[80] the realised revenue from maize sales was EUR 199 million, representing 20% of the total crop production output.

Figure 8-8: Revenue from maize sales obtained in 2005 and projected for 2050 and 2100



If climate change reduces maize yields, as described in the crop models above,[VIII] the lost revenue would be EUR 6-16 million in 2050 and EUR 31 – 43 million in 2100 (2005 EUR value) (Figure 8-8). This corresponds to 0.8-5.7% of the entire revenue from the sale of arable crops in Croatia in 2005.[81] This estimate does not take into account any change in production costs due to climate change, nor does it take into account adjustments that farmers might make to their crop mixes, or changes in the market price of maize due to the effects of climate change on the production, exports and imports of maize and other crops in the rest of the world and Croatia.

If the reductions in maize production are similar for other crops, the possibility of lost revenue and lost food sources is significant – perhaps 4-20% of all agricultural economic production. While this is a large conjecture, it indicates that there is risk associated with a change in mean temperatures and precipitation levels associated with climate change that should be examined further.

8.3.5. Combined impact of climate on agriculture

As shown above, existing climate variability has already had a significant impact on agriculture. Extreme weather events have resulted in average losses of EUR 176 million per year from 2000-2007, representing 0.6% of national GDP, or 9.3% of GVA generated by the agricultural forestry and fisheries sectors. More research would be necessary to determine whether this amount is greater than damage from extreme weather prior to 2000.

[VIII] As stipulated by Vučetić 2006a, Vučetić 2006b, Vučetić 2008

Table 8-7: Revenue from maize sale obtained in 2005 and projected for 2050 and 2100.

Crop	Year	Area (ha)	Yield (tonnes per hectare)			Yield (kt)			Price per kg (2005 EUR)	Revenue from sale (MEUR)			Difference from 2005 (MEUR)		
			min	max	avg.	min	max	avg.		min	max	avg.	min	max	avg.
Grain maize	2005	318,973	6.9	6.9	6.9	2,207	2,207	2,207	0.09	199	199	199	0	0	0
Grain maize	2050	318,973	6.4	6.7	6.5	2,031	2,141	2,086	0.09	183	193	188	16	6	11
Grain maize	2100	318,973	5.4	5.9	5.6	1,726	1,868	1,797	0.09	155	168	162	43	31	37

Furthermore, looking at the future effects on maize alone, lost revenue would be EUR 6-16 million in 2050 and EUR 31-43 million in 2100 (using a 2005 EUR value – see Figure 8-8). This corresponds to 0.8-5.7% of revenue from arable crop sales in Croatia in 2005. In human development terms, this translates to increasing vulnerability among rural populations, which are already among the most vulnerable. In order to address the risks posed by climate in rural areas, action must be taken to reduce vulnerability to current climate shocks and future climate change.

8.4. Addressing climate variability / climate change in the agricultural sector

The previous section highlighted the current impacts of climate variability/ climate change and some of the potential physical and economic impacts of future climate change on agriculture in Croatia. In general, Croatia lacks the information to quantify the full extent of these physical impacts and to value them. However, it is apparent from looking at current climate impacts and likely future impacts to maize that agriculture is vulnerable to climate change.

However, there are a variety of measures that can help agriculture adapt. These measures can be applied to both climate variability and climate change and can be divided into three basic groups (see Table 8-8):

1. Actions that build adaptive capacities;
2. Field adaptive (technical) actions; and
3. Autonomous or unassisted adaptation.

The rest of this chapter analyses some of the adaptive capacity of the Croatian agricultural sector, such as: the information currently available to stakeholders which can help them incorporate climate into decision-making; the current resources available for adaptation – including institutions involved; and some of the potential adaptation options that are available, including "no regrets" measures.

8.4.1. Information availability for decision-makers to assess vulnerability and adapt to climate conditions and climate change

In order to adapt to climate change and variability, both the private and public sectors need information that will help them to adjust better. This includes information about the impacts of climate on agriculture,

> "Extreme weather events have resulted in average losses of EUR 176 million per year from 2000-2007, representing 0.6% of national GDP, or 9.3% of GVA generated by the agricultural, forestry and fisheries sectors"

Table 8-8: Approaches to adaptation in the agricultural sector.

Type of Adaptation	Characteristics	Examples
Building adaptive capacity	Creating the information and conditions (regulatory, institutional, and managerial) that enable adaptation actions to be taken.	- Climate change impacts research funded by agriculture advisory services. - Awareness-raising among farmers. - Genetic resources for breeding programmes. - Policy support tools.
Taking adaptive action	Taking actions that will help reduce vulnerability to climate risks or exploit opportunities.	- Creating water collection and storage facilities on farms for use in irrigation. - Introducing new crop varieties. - Diversification. - Resource management tools and infrastructure.
Autonomous or unassisted adaptation	Adaptation that occurs naturally or arises not as a conscious response to changing climate.	- Natural responses of agricultural crops to seasonal changes (e.g. earlier springs). - Autonomous farming practices evolution (e.g. treatments and sowing dates).

Source: AEA 2007

adaptation options that can be used to avoid damages from these impacts and information about which adaptation options work "best" for avoiding damages, including the benefits and costs.[82] For example, one study[83] used physically-based and statistical crop yield models to estimate the impacts of climate change in the original 15 EU countries for five different IPCC climate change scenario-GCM model scenario combinations. The results generally showed that, in both the short- and long-term, crop yields would reduce in Southern Europe, but increase in most of the rest of the Europe.

The study also used an economic model[IX] to simulate the effects of these yield changes on GDP. This analysis showed decreases in GDP in all countries, for all five scenarios, ranging from -0.16% to -0.60% by 2080. It is important to note that this higher amount is equal to the average amount of damage that Croatia has already faced due to climate variability and extreme weather events since 2000.

Croatia was not included in the analysis of EU countries, nor could it have been, as Croatia currently lacks the information necessary to undertake these exercises (See Table 8-9).

Improving the capacity to simulate the impacts of climate change and higher CO_2 concentrations on crop yields would involve the following steps (See Box 8-3 for more details):

- Improving the capability to downscale global climate model results to the regional and local-scales, compatible with existing models to transform climate into daily weather data,
- Selecting and calibrating appropriate crop yield simulation models for different crops, environmental and climatic conditions and management in Croatia, and
- Applying models to simulate the impacts of climate change and elevated CO_2 on the yields of commercially-important crops and introducing management options for avoiding these impacts.

Currently, the only institution involved in monitoring, collecting data, and conducting research about the impacts of climate change in the Croatian agricultural sector is the DHMZ. This organisation runs its own climate change models, but these are general and not agriculture-specific. Only one person[87] conducts research dealing with climate change and crop (maize) models, but this does not appear to be a programmatic decision of the DHMZ. The DHMZ also participates in the EU-funded research project COST 734 – involving 27 European countries and the World Meteorological Organisation – which evaluates the possible impacts

[IX] The GTAP general equilibrium model

Table 8-9: Information needed to carry out adaptation assessments in agriculture

Information Needed	Notes
Crop models required to assess the impacts of current climate variability, climate change and increased atmospheric concentrations of CO_2 on various crops, pastureland and livestock, and methods to simulate the physical damages avoidable by adaptation options.	- A certain amount of information exists from the previously cited work on maize yields.[84] - Theoretical predictions are available on the potential impact of the climatic change on Croatian crops, livestock and soils.[85] However, these provide few Croatia-specific calculations and information that goes beyond theoretical predictions and general warnings that climate change might soon affect Croatian agriculture. - Several authors also report on the water retention capacity of Croatian soils and on the water requirements of different crops.[86] However, these calculations (often based on long-term monitoring or experiments) are mostly used to justify the need for the expansion of the irrigation practice. - Crop yield simulation models were originally developed to help farmers cope with climate variability. - Developing the capability to calibrate and apply these models to Croatian climatic and environmental conditions represents a "no regrets" capacity-building approach that is useful for coping with the existing climate.

on agriculture, arising from climate change and variability.[88] The DHMZ Agro-meteorological Division also monitors and forecasts agriculture-relevant meteorological data. It publishes a weekly bulletin, providing weather-related information for agricultural producers. These include the meteorological data for the last 7 days, minimum and maximum temperatures, soil temperatures and a map with precipitation, sun intensity, forecasts, etc.[89] The crop (maize) model described previously seems to be the only such model available for Croatia. No plans or concerted actions seem to exist to incorporate the findings of this model or to initiate similar research for the purpose of strategic planning and policy making.

Economic and management information

Simulating the effects of climate change on crops – even many crops at many locations – is far from the end of the story. Croatia also lacks the ability to simulate how physical impacts will influence the management decisions of farmers. It lacks the ability to model the impact of these decisions on production costs, on income from the sale of agricultural products, on the prices of these markets, and on the imports and exports of agricultural commodities. Once a farmer recognises that the climate is changing, he/she also understands that it will affect the profitability of the many different crops he/she can grow. He/she also realises that he/she will have to sell the crop to a national and/or international market where the effects of climate will influence the crop selection, management and production of many other farmers, not to mention the equilibrium market price for each crop and, ultimately, the farmer's net income. This knowledge will motivate the farmer to think about which crops to plant and when/ how to manage them. Agricultural sector models (see Box 8-3 for more information) take these farmer-market interactions into consideration in both the climate variability and climate change context.[90] However, Croatia lacks much of the information necessary to create such sector models, as well as the sector models themselves (See Table 8-10).

As with crop yield simulation models, developing agricultural sector models also represents a "no regrets" approach to improving the agricultural modelling expertise of a national government. These types of models are already used in developed countries to assist policy makers in exploring a variety of policies related to the impact of climate variability, as well as supporting national agricultural development and marketing strategies in the context of modern market economies. In other words, developing this analytical capacity is a good idea, regardless of climate change, so that policies can be geared towards helping farmers improve their economic situation.

> "Developing this analytical capacity is a good idea, regardless of climate change, so that policies can be geared towards helping farmers improve their economic situation"

Improving the capacity to simulate the impacts of climate change and higher CO_2 concentrations on crop yields would involve the following steps:

- Developing a Croatian agricultural sector model with sufficient spatial detail to capture the effects of different environmental conditions on production decisions,
- Linking the model to a system of crop yield simulation models, to allow a large number of simulations without an undue amount of external data handling,
- Using this tool to assess the economic impacts of climate change, estimating the value of damages and the benefits and costs of avoiding these damages by various, selected adaptation measures.

It is important to note that Croatian farmers are generally poorly educated. Ninety-eight percent of those living in agricultural households rely on practical experience and have no agricultural education. Only 0.3% attended an agricultural course, while 1.3% finished secondary agricultural school and 0.4% finished agricultural college or university.[91] This indicates that there is a fairly low level of academic knowledge among farmers that could present difficulties in terms of spreading knowledge on adaptation.

Table 8-10: Information needed on economics in the agriculture sector

Information Needed	Notes
Information on input use, management, and crop yields – basically "farm budgets"	- The standard gross margins (SGM) for different commodities and regions have not been established. [92] - The Faculty of Agriculture of the University of Zagreb does have some gross-margin (GM) calculations but these are for selected, commercial holdings over 10 hectares, ten years old and thus of limited relevance for today.[93] - The GM for different crop and livestock production has also been calculated by the Croatian Agricultural Extension Institute (CAEI).[94] However, these are based on theoretical assumptions of the potential results that could be achieved if farmers implemented good management practices, optimally applied agricultural inputs and if the yields obtained were as envisaged as the norm in agricultural textbooks. - Croatian farmers tend not to implement best practices – generally obtaining lower yields than the standard during 2001-2005.[95] - In early 2008, the World Bank-financed project "Establishment of the Farm Accountancy Data Network (FADN)", began to establish a better farm accounting system - first undertaking a survey of the farms throughout Croatia. - Within the framework of this project a trial survey will be carried out on a selected sample of farms and a typology of farms will be developed. - A full survey is expected in line with EU methodology in 2010.
Reliable macro-economic data on the gross and net income from agriculture production. (i.e. GVA)	- The GVA for the agricultural sector alone is not available – it is combined with forestry and hunting under official statistics. - Agricultural output seems to be derived from the non-existent agricultural land area of 3.15 million hectares and not calculated in accordance with the EC methodology.[96] - The GVA created by Croatian agriculture seems to be 50-65% lower than reported in official figures.[97] - If the CBS figures on the GVA were correct, this would mean that Croatian GVA per hectare basis is 20% higher than the EU-15 or 40% higher than the EU-25,[98] which is very unlikely. - The GVA is very difficult to determine since more than 90% of agricultural holdings in the MAFWM Farm Register do not practice any bookkeeping.
Agricultural sector models	- These simulate the impacts of climate change and elevated CO_2 using yield results from crop simulation models as inputs. - They can also be further modified to include simulating the effects of climate change on the livestock sector and on the supply and demand for irrigation water. - In addition, the sector models can be developed to include a wide range of farm policy options. - They can simulate adaptation to climate change in two ways: 1. Adaptation that involves changes in management at the farm level; and 2. Adaptation that occurs normally because of farmer reactions to changes in product prices in the market.

Box 8-3: Description of models needed for addressing climate variability and climate change

To address the risks to agriculture from climate variability and climate change, the effects of the physical systems must be understood, as well as the sector as a whole.

Models of the physical environment's effects on crops:

Crop models are representations of how crops respond to certain characteristics of the physical system. Phenological-based simulation models are considered state-of-the-art in crop yield modelling related to climate change. These models, which relate to the timing of plant maturation, include CERES, EPIC and DSSAT, and they all help to analyse a number of row crops and are expanding to include additional crops. These models are readily available "off the shelf," but they must be calibrated to local geo-physical and climatic conditions. In most cases, this applied work is supported by crop-specific, plot-level agronomic research and by larger field studies, which look more closely at issues such as disease and pest management.

These types of models are generally calibrated from plot data at a few locations. The calibrated model is used in a representative fashion to simulate yields over a number of other locations with the same characteristics as the plot locations. The models simulate the effects of daily weather on the growth and yield of individual row crops. As such, they require daily observation of a number of meteorological variables, as well as information about the physical environment in which the crop is grown, related to soils, drainage, water uptake, other physical factors, and "management." This feature of the models requires the output of Global Climate Models (GCMs) to be downscaled spatially to local and regional scales. Then the data have to be transformed to the hourly level, using a weather generator. These types of models can also be used to simulate a number of different types of management practices related to the type, timing and quantity of inputs applied (water, fertilizer, harrowing, ploughing, etc.). The relevant output of these models is the physical yield of the crop that can be harvested in weight units.

Agricultural sector models:

In addition to modelling the physical systems upon which agriculture is based, it is necessary to understand how these physical changes will affect the sector as a whole. To predict how climate change will affect crop mixes, production levels and crop prices at the national level a "price-endogenous" spatial equilibrium (SE) sector model for the agricultural sector is necessary. Price-endogenous simply means that crop and food product prices are a result of the model. They are not a variable put in to the model to yield results. Spatial equilibrium means that the model represents the different production possibilities in various locations and the various methods of transporting products to different market locations. Both features are very important for modelling the impacts of climate change from the bottom up, because changes in climate will vary in different places and, because many producers and consumers in many places will be affected differently by climate change at the same time, market prices will also be affected.

"While the Government has supported the agricultural sector following climate-related damage, the subject of adaptation to climate change within agriculture does not seem to be high on the agenda of policy-makers, researchers and other stakeholders"

8.4.2. Resource availability for adaptation and adaptation studies and the role of institutions and decision-making authorities

Following Croatian independence, the agricultural sector was almost completely "privatized" overnight. All the important monitoring, data collection and management activities conducted under the previous government were scrapped. The adoption of a new agricultural system of "governance", in terms of information management, was further postponed by war in the early 1990s. The Government in general considers the agricultural sector and rural development to be a priority for funding and for political action. Some of the programmes that support agriculture are outlined below. There are significant budgetary resources available to address human development risks within agriculture.

The estimated total budget of the Ministry of Agriculture, Fisheries and Rural Development for 2008 was EUR 630 million, of which EUR 530 million (EUR 440 per hectare) was allocated to various forms of agricultural support, such as subsidies. This is a significant amount of resources considering the entire sector's contribution to GDP is approximately EUR 1.76 billion. There are already some schemes in place to protect farmers from climate risk.

Aid scheme for insurance against possible damage to agricultural production[99]

A major current policy measure that relates to climate change adaptation is the Insurance Programme from Possible Damages in Agricultural Production.[100] The programme was introduced in 2003 to motivate farmers to insure production. Under the scheme, agricultural producers can receive aid from the Ministry of Agriculture, Forestry and Water Management towards the payment of insurance premiums. This aid is 25% of the cost of the total insurance premium (or a premium under collective insurance), regardless of the risk covered by the insurance policy.[101] However, no private insurance company in Croatia will provide insurance against drought.

The compensation for damage caused by natural disasters, as ensured by the Natural Disaster Protection Act[102], can also be regarded as a policy measure which reduces the risk to farmers. It makes it possible for farmers to receive compensation for damages caused by drought, floods, frost and hail.[103] Local and regional authorities assess the cost of the damage caused by adverse weather conditions and then report the damage to the national authorities. The requests for damage compensation payments are forwarded to the Ministry of Finance, which then makes the payments. However, this policy only addresses actual (past) damage and does not address climate change through adaptation or with forecasting damage. Furthermore, as evidenced by the lack of funds available in previous years during drought, the resources available for reimbursing farmers are often not nearly enough. Finally, such schemes need to be looked at with caution. If they act as subsidies for certain practices, they can impede autonomous adaptation and could be unsustainable.

While the Government has supported the agricultural sector following climate-related damage, the subject of adaptation to climate change within agriculture does not seem to be high on the agenda of policy-makers, researchers and other stakeholders. Consequently, there is hardly any on-going dialogue or cooperation

Table 8-11: Number of beneficiaries and total amount of aid to the agricultural sector due to damages.

Aid for insurance against damage					
2004		2005		2006	
Number of beneficiaries	Amount (EUR)	Number of beneficiaries	Amount (EUR)	Number of beneficiaries	Amount (EUR)
5739	Apprx. 2 million	4141	Apprx. 2.78 million	4583	Apprx. 2.95 million

between different ministries, Government agencies, research organisation and the business sector on the topic of climate change and agriculture. However, the national irrigation programme (which will be discussed in more detail below) has significant high-level Government support – though it does not explicitly address the threat of climate change. The programme is being supervised by a National Project Commission headed by the Prime Minister, with the Minister of Agriculture, Forestry and Water Management as its deputy. The Minister appointed an Expert Team that prepared a Project Strategy, which was adopted in November 2005.

Limited cooperation regarding climate change explicitly has been in the form of the expert committees preparing inputs on climate change and agriculture for the agriculture chapter of the National Communication of the Republic of Croatia under the UNFCCC. Ten experts from the Faculty of Agriculture of the University of Zagreb and an expert from the Ministry of Agriculture contributed to the last report.[104]

Some initiatives do exist to address climate-related issues in agriculture. Croatia is a signatory of the UN Convention to Combat Desertification in Countries Experiencing Serious Drought and in 2002 the Government established the National Committee to Combat Desertification. This Committee has 14 members, representatives from the ministries, scientific institutions, NGOs and the business sector. There is also an Expert Working Group dealing with agriculture.

There are an increasing number of climate change-oriented projects financed by the Ministry of Science,[105] but it is difficult to find evidence suggesting that these specifically cover the agriculture-related aspects of climate change. Neither the MEPPPC, MAFRD, nor Environmental Protection and Energy Efficiency Fund finance research or education by demonstration projects dealing specifically with agriculture and climate change. The Environmental Protection and Energy Efficiency Fund may be in a good position to provide resources for adaptation studies. It is an extra-budgetary institution owned by the Republic of Croatia whose objective is to finance environmental protection programmes and projects. In 2008 the Fund had EUR 182 million available for programmes. While climate change adaptation in agriculture is not specifically mentioned in its current activities, it would be an interesting avenue for new programmes.

8.4.3. Analysis of available technological options for adaptation

In this section we discuss how farmers in Croatia might adapt to present climate variability and future climate change. Farmers adapt by taking measures to avoid damages and thus reduce their losses in net income. We expect that farmers will adapt to climate change because they already adapt to climate variability. Regardless of the cause of climate variability, the principles of adjustment at the farm level are the same, although the actions taken to adjust to climate change and their outcomes may be different.

Commercial farmers, for example, will adjust their use of fertilizer, pesticides or water to reduce crop yield damages, as long as their increase in revenue is greater than the increase in cost. Household farmers will carry out a similar calculation, but it will be related more to the way in which they re-allocate household resources to provide for their families and may include nutrition for themselves as a factor. If climate change causes significant damage, it will probably be either impossible or too costly to completely eliminate the damages. However, in many cases, it will be possible for farmers to make adjustments that will actually make their households better-off financially and nutritionally. This type of adaptation is sometimes referred to as “autonomous adaptation,” because farmers and households will adapt in order to lessen the possible damages, irrespective of Government action.

"A great deal of the adaptation that will take place in Croatia will not involve new technologies"

Box 8-4: Differences in adapting to climate variability and climate change

There are two differences in adapting to climate variability and climate change. The first is that climate change implies that the mean values for meteorological variables, such as daily precipitation and temperature, are changing over time. The second is that climate change may involve fluctuations in meteorological variables that are outside their usual range in the existing climate record. In either (or both) case, the actions used to adapt to existing climate variability may not be enough for optimal adaptation to climate change.

In particular, entirely new adaptation actions may be required in the agricultural and other sectors. Some may have to be more forward-looking (long-term planning and investment to prevent damages). For example, having occasional droughts may be within the range of current climate variability, and, if so, farmers can do a better job of adapting to these droughts. But if droughts become more frequent or more intense, there may be no mechanisms in place that would facilitate adaptation to such changes. Thus, proper adjustment to climate change will require better information on long-term climate changes, and projections will need to be downscaled both spatially and temporally to meet the needs of farmers.

Autonomous adaptation constitutes just one part of adaptation to climate change. The public sector can also help farmers and households adapt, just as governments take action to help farmers and households adjust to the adverse impacts of climate variability. The involvement of the public sector as an agent of adaptation can take place in at least five different ways:

1. Disaster risk planning and disaster risk management.
2. Longer-term Government programmes focused on maintaining or improving the nutritional or economic well-being of farmers and households. This includes schemes to make crop insurance available more cheaply and a variety of crop and land subsidies. This is already underway in Croatia as outlined above.
3. Helping to finance large-scale investments in climate-sensitive infrastructure, such as irrigation water supplies, and non-climate sensitive infrastructure, such as transportation to improve market access.
4. Increase incentives which encourage farmers and households to adapt, by reducing the costs and/or increasing the benefits of adapting. This can include encouraging the utilisation of better farming techniques that can reduce vulnerability to climate-related risks.
5. Providing information about climate change that will help both the private and public sectors to adjust more smoothly, with less risk at lower costs.

A great deal of the adaptation that will take place in Croatia will not involve new technologies. It will involve changing the way in which crop and pastureland is managed, through changes in land use and crop mixes, substitution of inputs, changing the timing of management activities, etc. Some of these adaptations will simply be extensions of existing practices to cope with existing variability, but will also work well for adaptation to climate change. Many of these will be short-term measures. Some management changes may also involve changes in capital equipment or inputs; e.g. new types of machinery/ equipment or new pesticides and herbicides. As such, these measures will have to be supported by investment planning and, farmers will have to be sure that the expected benefits of making these investments will be greater than their costs.

Finally, some adaptation measures in agriculture may involve substantial investments in infrastructure, for example: irrigation equipment, dykes, tiles and drainage canals, which may have to be financed collectively or by the Government. In these cases, climate risk increases the costs of either over- or under-estimating these investments. This fact highlights the importance of having good information about climate in order to reduce the economic risks of making bad planning decisions about the state of the future climate.

It is not possible to predict which adaptation options will be best for the Croatian agricultural sector without better information. However, there are "no regrets" options, which can be adopted as Croatia's first line of defence against climate change.

There are several "no regrets" options that would help to reduce the vulnerability of the agricultural sector. These include a variety of options to increase water availability and address the problem of the lack of water content in soils.

Option 1: Increasing the carbon content in the soil

In his June 2008 address, the EU Commissioner for Environment, Mr. Stavros Dimas stated that increasing the carbon stock in the soil is essential in "mitigating the impacts of … more frequent and severe droughts."[106] Wider crop rotation could increase the carbon content in the soil. The current crop rotation is very narrow and largely determined on the basis of contracts between farmers and the companies to which farmers sell their products (often the food processing industry). Stable forms of organic carbon, such as humus, can absorb up to seven times their own weight in water, although some authors use a more conservative figure.[X]

In this respect, it may be helpful to stimulate the adoption of measures aimed at increasing the water absorption capacity of the soil. An increase in the amount of organic matter (carbon) in the soil would increase its water absorption capacity and thus help to fight drought. It would also contribute to climate change mitigation. A detailed explanation of the multifunctional benefits expected from the increase of carbon stock in Croatian soils and the calculation of the expected cost-benefit ratio is presented in Chapter 12, on mitigation.

Introducing fast-growing crops, such as various annual legumes, mustard, Sudan grass, other grasses and fodder crops, can help develop biomass in a short period of time. Once sufficiently developed, they can be incorporated into the soil to contribute to the soil's organic matter. Alternatively, a forgotten, once common practice of under-sowing can be applied. Assuming that the Government had to pay farmers an incentive (subsidy) of EUR 200 per hectare for soil moisture conservation measures over the next 10 years, to initiate this practice as a standard measure in agriculture, the cost of this policy would still be a fraction of the cost of the irrigation project outlined later.

[X] Morris 2004 for instance uses a factor of four for Australia, while the EU Commissioner for Environment claims a factor of twenty (Dimas 2008). Vukadinović (2008) claims a factor of three.

[XI] It is estimated that one part of the soil's organic matter in Croatia retains (on average) three parts of soil water (Vukadinović 2008). Since about 58% of the soil's organic matter is pure carbon and with the average dry bulk density of Croatian soils of 1.45 g per cubic cm (Vukadinović 2008), it appears that in the top 30 cm layer, Croatian soils contain 5.0 kg C per square metre on average. Assuming that 1 kg of organic matter holds three times that in water, it follows that 1 kg C can retain 5.2 litres of water. Šimunić, Senta, et al. (2006) estimated the average annual water deficit of agricultural soils at 55 litres per square metre. In order to provide at least 25% of this water shortage (14 litres per square metre), which would probably be sufficient to keep crops alive during dry periods, an increase in soil carbon content of 55% (2.8 kg C per square metre) would be required In terms of organic matter, this would mean that the present average organic matter level in Croatian soils of 2.2% (Znaor, 2008) would have to be increased to the level of 3.5%.

Table 8-12: Basic information about increasing carbon content in soils as an adaptation option

Description of the measure	Characteristics	Examples
Increase the carbon content in the soil: Wider crop rotation - more perennial legumes and grass-clover mixtures Under-sowing - sowing crops into the existing main crop during the growing season. The under-sown crop continues to grow after the main crop is harvested.	- By increasing the carbon content of the soil by 55%, it could be possible to provide about 25% of the water (14 litres per square metre) required, but currently missing for optimal crop development. [XI] - The amount of organic matter gained per year depends on crop rotation, manuring, geographic location, temperature, rainfall, and soil type. It would probably take 30-50 years to achieve this increase, so this is a long-term approach, but could help with long-term climate change.	- An incentive (subsidy) of EUR 200 per hectare would be required to stimulate Croatian farmers to introduce cover crops and under-sowing.[107] - The pilot agri-environment measures under the SAPARD/IPARD programme envisage a subsidy of EUR 106 per hectare for introducing green cover and EUR 156 per hectare for widening crop rotation.[108]

Option 2: Conservation tillage and liming

Conservation tillage is a technique for crop production in fields where the residue of a previous crop is purposely left on the soil. Some Croatian scientists[109] argue that current conventional tillage methods accelerate the deterioration of soil quality making it more prone to the adverse effects of climate change. The principal benefits of conservation tillage are improved water conservation and the reduction of soil erosion. Shallow ploughing of cereal residues after harvesting is another soil moisture conservation technique. It is recommended in nearly all agronomic literature in Croatia, but very rarely practiced and should be promoted. The application of lime prior to drought years was found to increase maize yields up to 50%[110] but why this method works is still unknown,[111] especially since there are no long-term trials underway on this topic. In this respect, it is highly recommended that a few long-term liming trials be undertaken. These are relatively cheap (a few hundred EUR per hectare per year) but could cast more light on the question of whether liming could potentially be a useful climate change adaptation measure.

Option 3: Promoting the adoption of organic farming.

Organic farming avoids, or largely excludes, the use of synthetically produced fertilisers, pesticides, growth regulators and livestock feed additives. Organic farming systems rely on crop rotations, crop residues, animal manure and mechanical cultivation to maintain soil productivity, supply plant nutrients and to control weeds, insects and other pests. Water use appears to be much more efficient on organic farms. The FAO states that "properly managed organic farming helps to conserve water and soil on the farm"[112] and that "due to the change in soil structure and organic matter content under organic management, water efficiency is likely to be high."[113]

Option 4: Irrigation Investments

Investments to substantially increase the area of irrigated land in Croatia may or may not be a "no regrets" measure. The reason we include a discussion on this option is to illustrate how difficult it is to decide which adaptation measures should be undertaken in Croatia, given the insufficient information about future trends in the local climate, the potential impacts of climate change, the value of the economic damages associated with these impacts, and the economic benefits and costs of avoiding these damages. The irrigation project described below is currently the most tangible adaptation measure that has already been initiated by the Croatian Government.

Irrigation programmes transport water from lakes, aquifers, and other sources directly to the crops. In 2004, the Government initiated a massive irrigation project entitled the National Project of Irrigation and Management of Agricultural Land and Waters.[114] The project objective is to ensure more efficient agricultural land management and provide more water to crops by constructing irrigation facilities on 65,000 hectares, by 2020, thus raising the percentage of irrigated land from 0.86%[XIII] to 6%.[115]

The estimated investment is about EUR 592 million, of which the Government is expected to contribute EUR 213 million by 2010. The remainder will be financed by counties, cities and end-users.[116] While most projects are still awaiting the completion of technical documentation and location and construction permits, irrigation systems have already been completed and put in operation on 5,000 hectares. The project is supported by all key stakeholders and has received good media coverage. However, a detailed cost-analysis of this project was not available to the authors of this Report.

The economic feasibility of the national irrigation programme is questionable. Theoretically, the production of some of these crops, which cover more than 65,000 hectares, might repay the irrigation investment costs (See Table 8-15). However, a more detailed analysis reveals that the economic benefits of the project are unlikely to outweigh the costs (See Box 8-5).

The strategy paper of the national irrigation project[117] relies heavily on farmers' genuine interest in irrigation and foresees that farmers will apply for the irrigation projects under various EU funds, notably the SAPARD programme. However, this has yet to happen. Out of the 37 projects awarded under the SAPARD, only one irrigation project was financed, with a total budget of just EUR 0.23 million.[118]

XIII The percentage of the irrigated agricultural land in Croatia believed to be among the lowest in Europe (GRC 2007)

Table 8-13: Cost-benefit analysis of the national irrigation project

		Period	Hectares	EUR per year (millions)	EUR per hectare per year
A	Gross-margin (GM)				
A	GM from crop production	2001-2005	1,052,178	503	478
A	Lost GM due to damage from drought	2000-2007	1,052,178	115	109
	Total A			**618**	**587**
B	Annualised capital cost of the irrigation project*	20 years	65,000	51	779
	Difference A-B				**-192**

* Assuming an adjusted discount rate of 4.48% (annual discount rate of 5% and depreciation rate of 0.25%) and amortisation period of 20 years.

Box 8-5: Economic analysis of the irrigation project

Although the average annual damage from drought in the Croatian agricultural sector during 2000-2007 was EUR 115 million, the required investment in the national irrigation project of EUR 9,100 per hectare (2005 EUR value)[119] seems to be difficult to justify economically. Assuming an adjusted discount rate of 4.48% (annual discount rate of 5% and depreciation rate of 0.25%) and an amortisation period of 20 years, the annualised capital cost of the irrigation project would be EUR 779 per hectare (Table 8-13).

On the other hand, the average annual gross-margin (GM) of Croatian crop production is EUR 478 per hectare (for 2001-2005).[120] The GM is the difference between gross output and variable costs (these are volume sensitive and always change according to the size of production, e.g. use of fuel, seeds, etc.). With this level of economic return on production, the investment repayment cannot be realised. However, some crops, such as vegetables, tobacco, fruit, olives, and grapes have a GM higher than EUR 779 per hectare (See Figure 8-9 and Table 8-14).[121] These crops cover an area of 86,936 hectares, of which 9,265 hectares are already under irrigation.[122] This leaves an area of 77,671 hectares producing crops whose GM is higher than the annualised cost of the capital investment for the irrigation project.

As the Government plans to establish irrigation for 65,000 hectares (12,671 hectares less than the area under these crops (Table 8-15), the project would seem to make sense. At least theoretically, it seems that producing these crops might repay the irrigation investment costs.

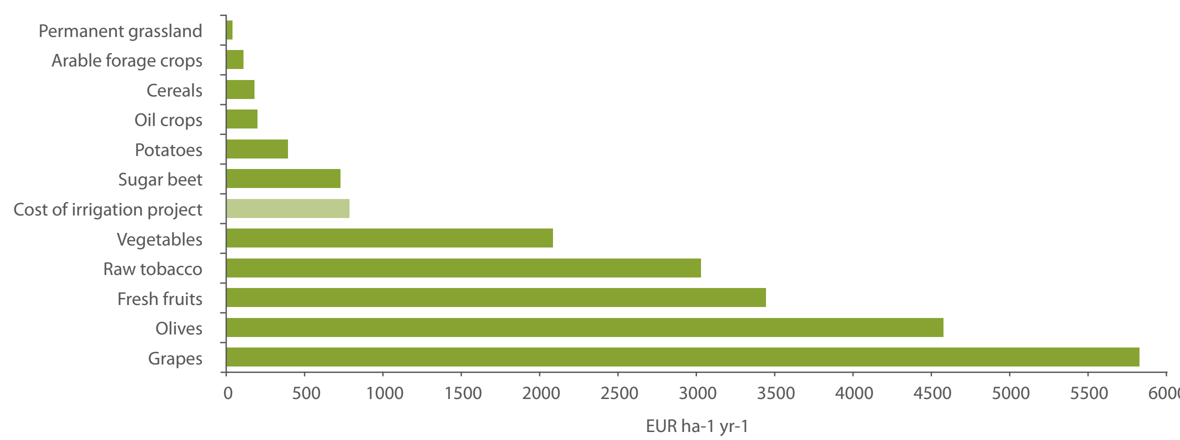
From the GM, farmers still have to pay their own labour costs (salary), depreciation and fixed costs. Fixed costs (overheads) are not commodity-specific and remain constant regardless of the volume of production. They include energy and transport, maintenance and repair of farm buildings and machinery, utilities and communication, insurance and loan repayments. In the case of fruit production for instance, the average annual GM is EUR 4,767 per hectare.[123] However, the Agriculture Extension Service sets apple orchard establishment costs at EUR 37,260 per hectare.[124] Assuming an adjusted discount rate of 4.48% (annual discount rate of 5% and depreciation rate of 0.25%) and an amortisation period of 20 years, the annualised capital cost of establishing an apple orchard would be EUR 3,192 per hectare. This leaves just EUR 1,584 per hectare for all other costs, as well as for the repayment of EUR 779 per hectare for the annualised capital cost of the irrigation project. It should also be noted that the costs of the energy and water required for the irrigation is not included in this calculation.

One might argue that the above-presented calculation is incorrect, since the producers are expected to pay only 33% of the total investment cost, while the Government provides the rest.[125] This is only partly true, since the above calculation takes into account the entire public investment. Public money has to be obtained from somewhere – either by taxing businesses or individuals.

Table 8-14: Gross margin (GM) of croatian crop production, annual average for the period 2001-2005 (Znaor 2008)

Crop	Area (hectares)	EUR per hectare
Permanent grassland	265,000	44
Cereals	542,883	167
Oil crops	119,661	196
Arable forage crops	89,358	103
Potatoes	18,903	389
Sugar beet	29,370	725
Vegetables	21,161	2.079
Raw tobacco	5,131	3.021
Fresh fruits	30,644	3.441
Olives	12,357	4.575
Grapes	30,000	5.819
Total	**1,164,467**	**478**

Figure 8-9: Cost of irrigation project investments and GM in crop production.



Source: Znaor 2008.

Table 8-15: Area with GM higher than the annualised capital cost for the irrigation project

Crop	Area (hectares)
Crops with GM > 779 EUR per hectare *	86,936
Present area under irrigation	9,265
Area requiring irrigation	77,671
Planned by the project	65,000
Difference (required - planned)	12,671

* without olives

Considering that the national irrigation project is currently one of the biggest Government investments and a key endeavour in the response to climate change, it is highly advisable that before pursuing further investments, the Government makes a thorough cost-benefit analysis of its strategy. These calculations currently do not seem to exist. The project is driven primarily by the fact that Croatian agriculture suffers from frequent droughts, even though Croatia has ample amounts of water. Before investing further into irrigation, the Government should compare the cost-benefit analysis of this project with potential alternative solutions, notably the introduction of the soil moisture conservation measures described in the options above.

Most of the above-mentioned adaptation measures (with the notable exception of irrigation) can be implemented as "no regrets" measures, as they address the lack of water risk, which is helpful regardless of future climate change. These measures should be demonstrated beforehand in a capacity-building programme, as they are capacity-building oriented, practical and will have an effect after just a few years of application. Their adoption does not require special skills, tools or machinery beyond those already available and they are unlikely to involve high costs and can easily be replicated by other farmers.

The adoption of measures promoting the conservation of soil moisture (Options 1-3) will undoubtedly be higher if the Government introduces subsidies for their adoption. These measures are likely to be able to solve the water shortage problem, at least partly, and are probably cheaper than irrigation. Additionally, measures to increase carbon content in soils could have a number of other beneficial effects (see Chapter 12 on mitigation) and are in line with the latest recommendations of the EC. While investing in the irrigation project could provide a solution for 5.4% of agricultural land, investing the same amount of money into other soil moisture conservation measures could benefit 42% of agricultural land (See Table 8-16).

The required annual subsidy to accomplish this much coverage would be equal to some 19% of the total Ministry of Agriculture's 2008 budget for agricultural subsidies. Therefore it is highly recommended that the Ministry of Agriculture re-analyse the costs and benefits of the irrigation scheme versus the potential of other methods that would encourage soil moisture conservation. Because of climate change, it is also important to evaluate various options regarding the long-term sustainability of planned irrigation schemes, taking into account changing climatic conditions. Costly investments that would provide services for decades need to be evaluated against their ability to continue to provide the same services in the future. If the irrigation project goes ahead, projected changes in the water sector in Croatia must also be taken into consideration, so that it does not rely on water resources that may become scarce in the coming decades. When designing these adaptation measures and related payments, the Government should also take into account the proposed agri-environment pilot measures due to be implemented under the EU IPARD programme[126] and those foreseen by the World Bank/ Global Environment Fund projects on agricultural pollution of waters.[127]

Table 8-16: Cost comparison: irrigation project vs. soil moisture conservation measures

				Irrigation project investment sufficent for	
		EUR per hectare per year	Total cost EUR per hectare	Hectares	% of agric. land
A	Annualised capital cost of the irrigation project	779	15.580	65.000	5,4
B	Subsidy for soil moisture conservation measures	200	2.000	506.360	42,0
C	Difference A-B	579	13.580		

Addressing water-logged fields and hail damage

Another climate related problem that may need adaptation is the problem of excessive water in Croatian fields due to heavy rains and inadequate drainage (See Box 8-6). Due to the changing precipitation patterns expected from climate change (including wetter winters), this could become more of a problem in the future. Increasing the carbon stock in Croatian soils can also help in addressing this issue, as the increase of organic matter in the soil would serve not only as an anti-drought measure, but also as a measure to prevent damage from floods. This is very important since Croatian soils are relatively poor in organic matter, leading to a constant or temporary water surplus or shortage.[128]

Box 8-6: Facts about water-logging in Croatia

- About 50% of the Croatian agricultural area requires drainage during certain times of the year.
- Full or partially built drainage systems exist on 2/3 of those areas with excessively moist soil, while the remaining 1/3 has no drainage at all.
- Subsoil pipe drainage has been installed on only 19% of the area required.[129]
- Since most of the drainage system was built before 1990 and has been inadequately maintained, it is in rather poor condition.[130]
- Some 57% of agricultural land (mostly arable) suffers from seasonal water-logging.[131]
- Water-logging enhances soil acidity which seriously hinders the fertility and the effective utilisation of applied nutrients, particularly phosphorus.[132] It is estimated that about 35% of all agricultural land is acidic.[133]

Another negative impact of the climate is hail damage. Unfortunately, very little can be done to prevent damage from hail. It damages all crops mechanically. Hail-storms are too infrequent and too hard to predict in the short-run, so it is hard to do anything in advance to avoid damages. However, even if the number of hail-storms increases, they will probably still remain so unpredictable that people won't abandon their land.

Adjusting to changing seasons

One longer-term adaptation issue may involve adjusting to changing seasons. Adjustment may entail a number of changes in farm practices. These could include changing the type, timing, date of, and duration between management activities, planting different crops/ different crop rotations/ different crop phenotypes, etc. If, for example, the crop seasons simply changed to different months, farmers wouldn't need to change anything but the dates of management. However, if other stress factors become prevalent – long-term drying out of the land, increased numbers of "hot" days that damage crops, etc. – other management decisions may be necessary. Almost all of these adaptations are measures that farmers already take to adjust, but it will take time for farmers to become more certain about how the climate is changing. An effective flow of information between farmers, the offices of the Agriculture Extension Service, and climate data services will be important in this process.

8.5. Conclusions and recommendations

Current climate-related impacts have already cost Croatia EUR 176 million per year since 2000, in terms of drought and other damages. Future climate change may mean an additional decrease in agricultural production. Taking into account the negative effects of extreme weather conditions and climate variability in Croatia, it is highly recommended that policy-makers and farmers begin dealing with climate in the following ways.

Recommendation 1: Build adaptive capacity – knowledge and information

- To build adaptive capacity, key Croatian stakeholders should be made aware of current and potential future climate-related impacts on the agricultural sector, the level of vulnerability, and adaptation measures that can be taken. This has not been happening. A programme should be designed and implemented which strengthens the adaptive capacities of the key stakeholders: farmers, farmers' unions, farm advisors, scientists, policy-makers and consumers. The MAFRD, in close co-operation with the MEPPPC, should take the lead in initiating such a programme.
- This programme would develop the knowledge and increase the information about the agricultural sector and the economic aspects of agriculture in its current state. Models to simulate the effects of climate change and elevated CO_2 concentrations on crop yields need to be calibrated for Croatian conditions, to understand how to adapt to these impacts. This can be done within Croatia or in conjunction with partner institutions outside the country.
- In addition, the Government should conduct a comprehensive overhaul of its existing systems for collecting data on agricultural production, prices and accounting for farm revenues and costs, in order to produce information that reflects the reality of the situation on the ground.
- A multi-crop, multi-region agricultural sector model should be developed to assist the public sector in developing comprehensive strategies and measures for coping with economic development, environmental quality pressures, climate variability and climate change. This should be designed to assist farmers in implementing these measures and to support national agricultural development and marketing strategies.
- Finally, a methodology needs to be developed to project the economic impacts of climate change in the agricultural sector on the larger economy, by coupling the agricultural sector model to a model of the Croatian economy.
- A committee responsible for the supervision of programme implementation should be established, consisting of representatives from different stakeholder groups. The Ministry of Agriculture, Fisheries and Rural Development could set-aside some (perhaps 1% - EUR 6.3 million) of its annual budget to support the design and implementation of this capacity-building programme, which could enable the actions outlined above in terms of information gathering. Money for this programme could also be provided by the following sources:
  1. Bilateral projects (e.g. such as government to government aid programmes already being developed between the Netherlands and Croatia);
  2. EU or GEF-funded projects (such as the on-going GEF project on agricultural pollution of waters); and
  3. The Environmental Protection and Energy Efficiency Fund, in the form of a new programme oriented towards adaptation to climate change.

Recommendation 2: Develop a cost-benefit analysis of potential adaptation options

After developing a basic understanding of the interaction between climate, agricultural production, and the economy, alternative options for adapting to current vulnerabilities from climate variability should be evaluated using crop yield and agricultural sector models. This should include a more comprehensive Cost-Benefit Analysis (CBA) of the irrigation programme, as well as the other programmes put forward as possibilities for dealing with water shortages. These options and whatever is identified as the most cost-effective for agriculture would represent "no regrets" options for adaptation if they help address current climate variability/ climate change. In particular, the irrigation programme should be re-assessed in terms of a cost-benefit analysis in comparison to some of the other programmes outlined above.

Along with examining "no regrets" options for adaptation to current climate variability, future climate change and its effects on agriculture should also be analysed. This will involve developing and incorporating downscaled regional climate models into crop yield studies and then into sector models. This will provide some level of understanding of the future risks of climate change to the Croatian economy and particularly the agricultural sector. It will also yield information about what areas may be helpful for adaptation and what the costs and benefits may be.

Recommendation 3: Take adaptive action – especially no regrets and low regrets options

Once future climate change is better understood, along with its likely impacts on Croatian agriculture, adaptive action addressing present climate variability and future climate change can be developed into projects that will reduce future risks. The implementation of adaptive actions requires a deliberate change of practice. Adaptation options in the agricultural sector can be divided into three groups: management, technical/equipment, and infrastructure measures. The management measures can include the choice of crop variety and pesticides, sowing dates, etc. The technical/equipment measures refer to the technical understanding required to implement management decisions - the distinction between the two being somewhat arbitrary. These include the adoption of new husbandry practices, introduction of new equipment, etc., and the adoption of these measures often largely depends on the advice provided by government agencies. Infrastructural measures require capital investment and include the establishment of on-farm water harvesting and storage facilities, irrigations systems, etc.

Existing climate variability is already having a dramatic effect on the agricultural sector due to the lack of water and severe droughts. This has amounted to approximately 0.6% of total GDP during 2000-2007 or EUR 176 million per year for the period. Future changes in precipitation rates and increased heat effects are likely to have increased impacts in the future. The effects of climate are having and will have a large impact on vulnerable populations in Croatia, both in rural communities and potentially because of the effect on food prices. There are "no regrets" options that should be further investigated and implemented to deal with some existing impacts. Further study is necessary into understanding the sector, its interactions with the economy, and the interaction between climate and agricultural production.

Chapter 9

The Fishing and Mariculture Industries

Chapter 9 Summary

The Fishing and Mariculture Industries

Croatia has a long history of fishing and mariculture and a coastline that is well suited for developing a modern industry in these areas. The fishery and mariculture sector in Croatia accounts for a small portion of the national Gross Value Added (GVA) – an average of 0.25% or around EUR 56 million in 2003 and 2004. Climate change and increasing temperatures may result in important impacts in the near future that will continue to challenge this industry.

The abundance of marine fish populations is already showing significant fluctuation. These populations are also changing behaviour and migration patterns in the Adriatic. This all has implications for fish catches. The relationship between these fluctuations and large-scale climate change is of great concern.

Research has shown a large movement northward of fish species that are more suited to warmer water. Many new species in the northern parts of the Adriatic Sea have been recorded over the last thirty years. Climate change is also likely to have positive impacts on species currently under mariculture in the Eastern Adriatic, as the growing season will lengthen and the rearing cycles will shorten. Tuna, the most important economic product within the sector, is a warm water species, as such, tuna farming in the Eastern Adriatic will undoubtedly benefit from global warming. The situation with two other species – sea bass and the European oyster – is different, as they generally prefer colder water. For these species, adaptation measures may become necessary.

Another result of climate change will probably be the introduction of new species. The impact of previously introduced new species in the Adriatic Sea has been economically both positive and negative. However, from an environmental standpoint it is troubling, as there have been significant threats to both commercial and non-commercial indigenous species. Groupers and bluefish provide two examples where the effects on fish populations and the industry were mixed. Two potentially poisonous fish species have also been found in the Adriatic Sea – the oceanic puffer fish and the blunthead puffer fish. Although still rare in the Adriatic, public awareness should be raised about the potential threat of these fish to the public – especially amongst subsistence fishermen.

Overall, changes in the distribution of species in the Adriatic will result in revenue changes for the fishery sector and benefits and losses may not be distributed equally. To develop adaptive fishery management and adequate measures to prevent losses and to promote the potential benefits of climate change, more research will be necessary. Available technological options for adaptation already exist in neighbouring countries with warmer climates – especially Turkey and Greece. Their experiences in mariculture management, fishing techniques – specifically regarding invasive species - can be transferred to local conditions.

9.1. Introduction

As a country with a large coastline, thousands of islands and a historical association with the sea, Croatia has highly-developed fishing and mariculture industries that are important to the country's identity as well as its economy. Fishing involves catching fish and other sea organisms that are not cultivated. Mariculture involves the cultivation of marine organisms for food and other products in an enclosed section of the sea, or in tanks and ponds filled with seawater.

Climate change and increasing temperatures may have severe impacts on this sector in the near future that will continue to challenge the industries. These impacts will be felt in a number of ways. Changes in the sea temperature may make some fish and mariculture products that are "farmed" more susceptible to disease and make the water too warm for them to survive. Other, non-farmed fish may be affected by new species that invade the Adriatic. Finally, the ecological make-up of the sea may change, leading to opportunities for new commercially viable fish and necessitating changes in the marketplace. This section will examine the importance of both the fishing and mariculture industries to Croatia's economy and people; identify potential threats and opportunities created by climate change; and make recommendations for addressing climate change.

9.2. The fishing/ mariculture sector in Croatia

Croatia has a long history of both fishing and mariculture and a coastline that is suitable for developing a modern industry. The fish-processing industry has been a part of the economy on the Croatian coast and its islands for more than 130 years. Both industries are under pressure today to adapt to EU legislation at all levels. The war (1991-1995) and the unsuccessful privatisation of the sector and export barriers, led to the collapse of most pelagic fish-canning factories (those that swim in the water and not on the bottom such as sardines[I] and anchovies[II]).[1] This collapse led to

Figure 9-1: A fishing boat off the coast.

Source: Ivan Bura

the demise of pelagic fishing. Mariculture enterprises faced similar problems. Shellfish producers particularly suffered as exports to the EU were banned, due to difficulties in establishing ecological and sanitary-hygienic standards in shellfish production.[2]

The fishery and mariculture sector in Croatia accounts for a relatively small portion of the national GVA.[III] The absolute value of the fisheries sector is continuing to grow over time, while its share in total GVA is decreasing.

While the fishing sector accounts for a rather small share of GDP, it plays an important role in the socio-economic status of a large number of people. [4] The number of commercial fishermen seems to be relatively constant. Currently, 70% of fishing, farming and processing activities take place on islands, where income sources are limited, making this activity important for development in economically vulnerable areas. At the regional level, mariculture is an important industry in Zadar and Dubrovnik counties. This is reflected in regional strategies and, more importantly, in spatial plans. In some regions, fisheries and particularly fish farming is being strongly linked with the development of rural tourism. Fish also represent a source of

"While the fishing sector accounts for a rather small share of GDP, it plays an important role in the socio-economic status of a large number of people"

[I] *Sardina pilchardus*

[II] *Engraulis encrasicolus*

[III] Gross Value Added (GVA) can serve as an estimate of Gross Domestic Product (GDP). GVA = GDP – the taxes on the product + the subsidies for the product.

Box 9-1: The fishing sector at a glance

- Represents a small amount of the national GVA – an average of 0.25% or around EUR 56 million in 2003 and 2004
- Tuna farming, in particular, is the only food-producing industrial activity in Croatia that has a positive trade balance (high export values amounted to more than EUR 43 million in 2003).[3]
- More than 20,000 people are employed directly in the commercial Croatian fishery sector
- Currently, 70% of fishing, farming and processing activities take place on islands, where income sources are limited
- There were 3720 licensed professional fishermen in 2007, with 3692 registered fishing vessels, most of them (80%) multi-functional
- More than 15,000 licences were issued for small-scale fishing for personal consumption. While fish caught with this licence are not supposed to be sold, this catch frequently enters the market.
- Fishing and mariculture produce 45,000 tons of marine organisms annually
- White fish and tuna farming produce around 4,000 tons each annually
- Mussel and oyster farming produces 3,500 tons annually
- Tuna farming is carried out at seven large companies, while the white fish sector is composed of 34 companies that are mostly smaller, family-owned companies with a capacity of 50 tons.
- The shellfish sector is fragmented and still has not adapted to modern management principles. More then 150 smaller companies and crafts operate in this sector, organized into shellfish growers associations, but with low political and economical influence.

high-protein food, which is an important element of human nutrition in vulnerable coastal communities.

The main Governmental body dealing with this sector is the Department of Fishery (under the Ministry of Agriculture, Fishery and Rural Development). At the national level, strategic fishery and mariculture policy guidelines have been defined by the "Development Strategy for Agriculture and Fisheries,"[5] However, most of the targets and projections for the fishing sector, including calls for a significant increase in mariculture production, have not been achieved.

In general, this sector is highly sensitive to fluctuations in the market, as well as to climate. The industry currently receives direct subsidies from the Government to help deal with its vulnerability. Both fishing and mariculture are supported through production subsidisation (see Table 9-1). However, most of these schemes will disappear during the EU pre-accession phase and funds will probably be reallocated to support capital investments.[6]

Table 9-1: Subsidies to the fishing/ mariculture industry

Product	Subsidy
Kilogramme of sea bass and sea bream	EUR 0.74-1.00
Kilogramme of mussels	EUR 0.11
Piece of European oyster	EUR 0.07
Fingerling of indigenous sea bass and sea bream	EUR 0.035
Kilogramme of catch fish (such as pelagics like sardines)	EUR 0.05
Kilogramme of canned production in factories (i.e. canned sardines)	EUR 0.32-0.42
Fuel used for boats – "blue diesel" also falls under a special price regime	

9.3. Indirect economic impacts of the fishing sector – tourism and the seafood industry

While no study has yet been conducted describing the impact of seafood on the tourism sector in Croatia, it does play a role. Some areas, such as Mali Ston Bay, have become tourist destinations, specifically because of their locally-produced oysters and mussels. The producers of farmed shellfish, sea bass and sea bream as well as most of the lucrative rocky-coast fish species, are directly tied to the tourist industry. Expensive seafood is mostly limited to restaurants, while hotels tend to offer cheaper imported products, such as fish fillets, frozen mussels, etc. Other fish – namely small pelagic fish such as anchovies and sardines – are only occasionally offered at Croatian tourist destinations, unlike countries such as Italy and Portugal. Most farm-raised tuna is exported to Japan.

Croatian seafood is internationally renowned and represents one of the main features of traditional tourism. However, this reputation is mostly based on expensive seafood. The sale and availability of less expensive seafood in restaurants, such as pelagic fish is insignificant. Therefore the sale of less expensive seafood represents significant potential for future development.

Figure 9-2: Fish market.

Source: Ivan Bura

9.4. Trends in production

Croatia is a multi-species fishery. In terms of biological resources supporting the fisheries sector, there are about 434 fish species in the Adriatic Sea, out of which 100 species are commercially exploited.[7] In 2007, the catch of marine fish and other marine organisms amounted to more than 38,000 tonnes.

The fishing industry as a whole has not yet been modernised due to several factors that include the war and the subsequent unstable political and macroeconomic situation. The unrealised potential for development is particularly noticeable in the white fish (sea bass and sea bream) and shellfish (oyster and mussel) sectors, where development strategies and potential have remained largely on paper.

On the other hand, tuna farming reached 4,000 tonnes in only 10 years due to strong demand from the Japanese market.[10] The capture of fish for culture is based on quotas proposed by ICCAT (The International Commission for the Conservation of Atlantic Tunas). During the last five years the Croatia quota has been around 900 tonnes of tuna and has been decreasing. As tuna is considered to be over-fished, restrictions on fishery activity are ongoing, which will probably result in lower quotas in future years.[VII] The technology for tuna juvenile production is still not commercial, and in the 'best case' scenario, production is likely to remain at the level of 4,000 tonnes for the longer-term. The Government's strategic goal is to reach 10,000 tonnes of white fish and 20,000 tonnes of shellfish per year. But due to many obstacles – the most prominent being competition for space with other end users (tourism, marinas, buildings, traffic) – the prospects are not very bright for reaching this goal.

The recent developments in tuna farming, currently the leading Croatian agricultural export, and the increased demand for fresh pelagic fish as food for the

[VII] See http://www.iccat.int/ for more information on international tuna conservation.

“Numerous fish species previously found in more southern areas are moving northwards”

tuna, has enabled the resurgence of the traditional pelagic fishing industry. The large demand for salted anchovies in the EU, mainly the Italian market, has also resulted in the production growth of this commodity in Croatia, which is influencing the redevelopment of fishing activities for this species. In the mariculture sector, both fish and shellfish production have been restructured in preparation for entering the EU market. However, despite all these recent achievements, the sector is still fragile and faces an unknown future.

Table 9-2: Description of the markets for fisheries products.

Type of fish	Description of the market
Marine species in general	- The total marine species production in Croatia in 2005 was around 10,000 tonnes, which included 3,000 tonnes of sea bass and sea bream, 3,425 tonnes of tuna, 2,500 tonnes of mussels, and 800,000 specimens of European oysters. The catch of marine fish, including both demersal and blue fish species, was around 36,500 tonnes.
Small pelagic fish – sardines, anchovies and sprat[IV]	- Dominate production in Croatia (about 87% of the total weight) - Mainly include fish destined for fish-processing plants and feeding of farmed tuna. - Also the most common fish consumed in the domestic market. - Between 2004 and 2007, the demand for pelagic fish increased at the same rate as overall production: 7%. - Around 17,000 tonnes of small pelagic fish are processed annually, including production of salted fish such as anchovies (6,110 tonnes), frozen fish (1,935 tonnes), canned fish (6,920 tonnes) and smoked fish, fish pâté, and marinated fish (1,980 tonnes).[8]
Demersal/ bottom feeding catches	- As much as 80% of demersal catches are composed of not more than ten species,[9] with the most important being hake,[V] Norway lobster[VI] and striped mullet.[VII] This can be attributed to over-fishing of other important demersal fish species. - Demand has been increasing over the last few years

[IV] *Sprattus sprattus*

[VI] *Merluccius merluccius*

[VII] *Nephrops norvegicus*

[VII] *Mullus barbatus*

9.5. Assessment of the vulnerability of the fishing sector to climate change

The impact of climate change on the Croatian fishery sector is complex, as the impacts are both positive and negative. They include changes in the marine environment, changes in the migration patterns of fish in the open sea (including pressure to migrate in cold-water species), potential changes in the growing season and rearing time for farmed fish, and the potential increase of invasive species, which has increased catches of certain new species but threatened the production of others.

9.5.1. Existing impacts from climate change

Marine fish populations already show evidence of significant long-term fluctuations in abundance, which has implications for the medium and long-term predictions of fish catches. The relationship between these fluctuations and large-scale climate change is an important concern.

Research[11] in the Adriatic Sea has shown that the inflow of Mediterranean water into the Adriatic increases productivity in the Adriatic waters, that otherwise have relatively low nutrient levels. Different biological phenomena[IX] have been observed and linked to the stronger inflow of water from the Mediterranean into the Adriatic. In addition, the temperature and salinity properties of the water (thermohaline properties) have had proven impacts on phytoplankton and fisheries.[12]

The level of fish biodiversity in the Adriatic Sea generally increases from north to south. While there is a range of factors which may affect this pattern, the main factor seems to be temperature. Research has already shown a large northward expansive movement of fish species that are more suited to warmer waters (thermophilic).[13] This indicates a change in marine biodiversity, as numerous fish species previously found in more southern areas are moving northwards . Numerous new species in the northern parts of the Adriatic Sea have been recorded over the last thirty years. During 1973-2003, there was a strong correlation between average annual air and sea surface temperatures and the number of species.[14] There was also a strong correlation between annual sea surface temperature and the yearly total number of fish.[15] The variations in Adriatic temperature conditions correlate to the North Atlantic Oscillation (NAO) index – indicating that local temperature changes at least partly result from hemispheric temperature changes. As the NAO will be affected by climate change, so too will the temperature changes in the Adriatic.

Year-to-year fluctuations of small pelagic fish landings – the number of fish that are actually taken ashore – on the eastern Adriatic coast were compared with climatic fluctuations over the Northern Hemisphere and to salinity fluctuations in the Adriatic.[16] Basic climatic oscillations were determined over a period of approximately 80 years, and researchers found a relationship between climatic fluctuations over the Northern Hemisphere and small pelagic fish landings.[17]

Such long-term variation was observed worldwide and was considered part of the normal life cycle of pelagic fish.[18] However, the latest observed changes on sardines in the Adriatic Sea include prolonged spawning seasons and spawning on spawning grounds that were historically unknown.[19] This change in behaviour should be attributed to global climate change. In other words, climate change is already changing the behaviour and migration patterns of pelagic fish in the Adriatic.

> "Climate change is already changing the behaviour and migration patterns of pelagic fish in the Adriatic"

[IX] Such as production fluctuations, changes in phytoplankton species composition, higher biomass and a changed zooplankton community composition

"Positive impacts may occur, such as the increased potential for aquaculture, in general"

Other categories of biological responses to climate have been observed:

- Changes in the migration patterns of sprat
- The drastic collapse of the European anchovy stock since 1995
- Mass mortalities of round sardinella were recorded along the Apulian and central Croatian coasts in January 2002, when an abrupt fall in seawater temperature occurred.[20] This fish is a warm water species that was recorded for the first time along the Croatian coast 40 years ago. As this fish is not yet utilised commercially in Croatia, there was no commercial impact on the fishing sector. Furthermore, this event has not affected native species.

9.5.2. Future impacts: temperature changes

Climate change-related warming may have the following implications for the Croatian fishing sector:

- Due to faster biological processes at all levels of marine ecosystems, the growth rate of fish should be higher and reproduction seasons should be longer for most species. As a result, the recruitment of species that thrive in warm water should be significantly better.
- The opposite is likely to occur with species that thrive in cold water, such as Norwegian lobster. These species will migrate to colder areas, either horizontally (moving north, south, east or west) or vertically (moving to deeper levels).
- Temperature increases will heighten the risk of oxygen level decrease and depletion in shallow areas of the Adriatic. This situation will create conditions that allow for the increase of species that tolerate warm water and lower oxygen levels.
- The introduction of new disease organisms or exotic or undesired species is likely to occur due to increased sea temperatures.

Tuna, which is the most important economic product within the fishery and mariculture sector, is a typical warm water species. Tuna farming, as currently practiced in the Eastern Adriatic, will probably benefit from global warming due to higher growth rates resulting from more intensive feeding and a higher feed conversion index.

Certain positive impacts may occur, such as the increased potential for aquaculture, in general. The warmer seawater temperature in the winter, as a consequence of expected climate change, might create favourable conditions for the growth of marine organisms during this season. Therefore, rearing time could be shorter and aquaculture production could become more efficient. This applies in particular to two species: gilthead sea bream[X] and the Mediterranean mussel.[XI] These two species are better adapted to higher temperatures, and will benefit from a rise in Adriatic water temperatures. The only potential problem relates to the reproduction period of the mussel, during which the species needs freshwater inflow – inflow that could be limited due to lower precipitation levels in the area. This will be especially important during the summer months, when precipitation levels on the coast are expected to drop – perhaps up to 39.3% in the summer months in Dalmatia (See Chapter 2).

The situation with two other species – sea bass[XII] and the European oyster[XIII] - is different, as they generally prefer colder water. Experiences from Greece and Turkey can be applied to future conditions on the Croatian coastline, as their sea bass farming has decreased due to warmer water and associated disease susceptibility.[21] Presently, sea bass culture in the Eastern Adriatic is among the best in the Mediterranean, due to excellent water conditions that include lower temperatures. Temperature increases in the Adriatic will no doubt result in a necessary shift to growing gilthead sea bream, a species tolerant to higher temperatures. Alternatively, the cages with sea bass may have to be moved to colder zones or deeper nets, up to 10 metres in depth, may need to be used. This would substantially increase the costs of sea bass production.

[X] *Sparus aurata*

[XI] *Mytilus galloprovinciallis*

[XII] *Dicentrarchus labrax*

[XIII] *Ostrea edulis*

The scenario for sea bass is similar for the flat oyster. The dangerous/ lethal temperature for the flat oyster is 26°C, which has already been measured along the coastline and in the traditional culture grounds in Mali Ston Bay.[22] Incidents of summer mortality of the flat oyster in some areas of Mali Ston Bay[XVI] have already been reported.[23] As the Integrated Developmental Strategy of Mali Ston Bay calls for a significant increase in the production of this lucrative species, water temperature increases will be a major obstacle for long-term planning. As with the sea bass, as sea temperatures rise, oyster production should be transferred to deeper water during critical summer months, which will result in associated new costs. For most farms, this should mean the simple addition of a few metres of rope, but for other farms this change will involve changing the production site completely. While this is not a complicated adaptation measure, it will increase the costs of flat oyster production. However, the flat oyster should similarly benefit from a prolonged growing season, an earlier and longer reproduction season, and a reduction in the length of the rearing cycle.

In general, the effects of global warming on the shellfish culture should be positive, but some changes in culture practice will probably be necessary.

> "In general, the effects of global warming on the shellfish culture should be positive, but some changes in culture practice will probably be necessary"

9.5.3. Future impacts: Invasion of new species

As fish respond to warming waters – as evidenced by the northerly advance of southern species in a systematic way – they may provide a useful index of the effects of warming in the Adriatic. The incoming north-westward current along the eastern Adriatic coast carries food and plankton organisms and pro-

[XIV] This is part of the COAST project being coordinated by UNDP Croatia.

Table 9-3: Important commercial fish in Croatia and the likely impact of climate change

Type of fish	Mariculture or Fishing?	Economic Importance	Likely Impact of Climate Change	Potential Adaptation Mechanism? (if needed)
Tuna	Mariculture	High – especially for export	Positive due to increased temperatures	None needed
Flat Oyster	Mariculture	High – around Mali Ston Bay	Negative – especially if temperature is over 26.5 C	Transfer to deeper water in production if temperatures rise.
Sea Bass	Mariculture	Medium	Negative due to increased temperatures	Culture in deeper cages or colder sites
Sea Bream	Mariculture/ Fishing	Medium	Positive- faster growth, prolonged spawning season	None needed
Sardine	Fishing	High- for tuna farming and canning industry	Moving of spawning centres, expanding of spawning period, negative according to effects of predators	None
Anchovy	Fishing	High- for salting industry	Moving of spawning centres, prolonged spawning season, negative according to effects of predators	None
Hake	Fishing	High for canning industry and fish markets	Moving of spawning centres, prolonged spawning season	None
Norwegian lobster	Fishing	High for markets	Effects on boreal species, changes in bathymetric distribution	None

"The introduction of new species into the Adriatic Sea is environmentally problematic, since these new species threaten indigenous species"

vides more favourable conditions for species from the southern areas. The northward spread and increase in abundance of southern species occurs in several phases. At first, only a single adult individual appears. Subsequently, more adult individuals are observed. Reproduction then begins and larval and juvenile stages occur in the area. Finally the southern species achieves the status of a new settler. It can be concluded with certainty that in the Adriatic Sea, warm-water species are extending their range northward. Two factors may be causing this migration:

1. Demographic expansions, which affect individual species; and
2. Climatic fluctuations, which shift the bio-geographical boundaries.

Historical temperature data and hydrological information favour the second factor. Examples of invasive species in the Adriatic include the following: the common dolphinfish,[XV] the grey triggerfish,[XVI] bluefish,[XVII] parrotfish,[XVIII] round sardinella,[XIX] the Atlantic lizardfish,[XX] the Atlantic pomfret,[XXI] and the European barracuda.[XXII] Some species, such as the bluefish, could affect local fisheries due to their significant impact on the food chain. In the Adriatic, the bluefish feeds mainly on mullets, anchovy, and atherinids. However, bluefish could become an alternative species in local fisheries. There are four categories of biological response to climatic change:

- The appearance of indicator species,
- The appearance of new populations,
- The increase or decrease in fish stocks, and
- Structural changes in the ecosystem – including demographics of fish populations and interactions inside the food chains.

Species introductions into the Adriatic Sea have yet to be studied systematically, although existing data imply the existence of new species. The settling of new species in the environment has caused a progressive decline in biodiversity in general, but at present there are no studies regarding the impact on the diversity of fish species. Most occurrences of new species were recorded during two recent warm periods - 1985-1987 and 1990-1995, for which there were positive temperature anomalies of 0.15ºC and 0.30ºC, respectively – demonstrating that when the water is warmer, fish migrate and new species invade the Adriatic.[24]

Extensive research has been undertaken on the phenomenon of species migration in neighbouring ecosystems. After the construction of the waterway between the eastern Mediterranean and the Gulf of Suez – the Suez Canal – in 1869, hundreds of Erythrean species traversed the channel and settled in the Mediterranean. This process is called Lessepsian migration and is considered to have been an important factor in the increase of Mediterranean fish diversity. Twelve Lessepsian fish species were recently recorded in the Adriatic Sea. Temperature again is the most important non-biological factor in determining the dispersal of Lessepsian fish. Although the impact of the Lessepsian migrants on the Adriatic environment is still not known in detail, some of the newcomers could potentially affect the environment, since data shows that some have established populations in the Adriatic. Their quick spread in the Adriatic followed by rapid population booms in the invaded areas could impact the local fish populations.[25]

Existing invasive species: threats and opportunities

The introduction of new species into the Adriatic Sea is environmentally problematic, since these new species threaten indigenous species. However, economically the impact can be both positive and negative as, despite the decrease in indigenous species, new species can become commercially viable in the market.

XV *Coryphaena hippurus*
XVI *Balistes capriscus*
XVII *Pomatomus saltatrix*
XVIII *Sparisoma cretense*
XIX *Sardinella aurita*
XX *Synodus saurus*
XXI *Brama brama*
XXII *Sphyraena sphyraena*

Groupers and bluefish are two examples where the effects on fish populations and the industry were mixed or negative.

Groupers[XXIII] were rare fish in the Southern Adriatic and non-existent in the Middle and Northern Adriatic before the 1990s. In the 1990s, they began to migrate and, in the last 10 years several additional grouper species have been identified for the first time in the Middle/ Northern Adriatic.[26] The overall impact on commercial fishing has been positive: they are lucrative, marketable fish. However, from a biological and ecological standpoint, there have been negative effects: the abundance of some native species[XXIV] is now significantly lower due to competition with groupers.[27]

While the introduction of groupers had a positive economic impact, the introduction of bluefish did not. Bluefish[XXV] were first recorded in the Northern Adriatic in 2004.[28] The fish is a typical predator, preying mainly on grey mullets. It appeared several years ago in the Neretva River estuary, where grey mullet fisheries are the most important segment of the fishing industry, and decimated the grey mullet population in only a few years. They also destroyed the nets particularly adapted for the traditional grey mullet industry. As the local fishermen have not developed the necessary tools to catch the bluefish, the traditional grey mullet fishery is close to collapse, while the economic benefits that might have been gained by catching bluefish have not materialised. In fact, most suggestions for addressing the crisis focus on eradicating the bluefish.[29]

Two potentially poisonous fish species have also been recorded in the Adriatic Sea[30] – the oceanic puffer fish and the blunthead puffer fish.[XXVI] These fish have toxins (tetrodoxin) in their body and if not prepared properly their consumption can lead to death, as observed in Lebanon and Egypt. Although still rare fish in the Adriatic, their presence should become the subject of a public education campaign – especially amongst subsistence fishermen – to raise awareness about the potential danger of these fish to the public.

9.6. Potential socio-economic impacts of climate change on fisheries and mariculture

More research is necessary before determining the likely net effect of climate change on the fishing sector, particularly because increased sea temperatures affect species differently. However, certain relationships are already emerging.

9.6.1. Changes in revenue

First, changes in the distribution of species in the Adriatic will result in changes in revenue for the fishery sector, and benefits and losses may not be distributed equally. Invasive species provide an illustrative example. The destruction of the grey mullet population in the Neretva River estuary by bluefish represented an acute economic loss for the fishermen. On the other hand, reductions in the populations of some coastal fish due to the arrival of groupers were offset by the ability to catch and sell this newer invasive species, which resulted in a net economic benefit. However, due to the illegal marketing of these lucrative species, in both cases it is hard to estimate the present revenue loss or benefit. This example also indicates the importance of adaptive capacity. In the case of the groupers, the fishing sector was able to adapt to the arrival of the new species by catching it and selling it. In the case of the bluefish, the inability to capitalize on its presence commercially meant that losses in the grey mullet population were not offset by new revenue.

[XIII] *fam. Serranidae*

[XIV] These species are mainly sparids, such as white sea bream Diplodus sargus

[XV] *Pomatomus saltatrix*

[XVI] *Lagocephalus lagocephalus lagocephalus* and *Sphoeroides pachygaster.*

"The location of the fishing sector along the coastline and on islands where there are very limited opportunities for employment means that the fishing sector may be particularly vulnerable to climate change"

The observed changes in habitat also affect revenues in the fishing sector. Species that thrive in cold water will require more expensive farming methods or may leave their current habitats entirely. Species that thrive in warm water will have a longer growing season and may grow more quickly. Again, these are relationships that need to be quantified both in terms of magnitude and terms of revenues gained or lost. Finally, it will be important to look at indirect revenues in the tourism sector. Both coastal and inland tourist destinations have used fish as a means of attracting tourists. Changes in the composition of the catch and the populations of fish will undoubtedly affect these communities as well.

9.6.2. Changes in employment

The location of the fishing sector along the coastline and on islands where there are very limited opportunities for employment (and where alternative employment is seasonal and contractual, as in the tourism sector) means that the fishing sector may be particularly vulnerable to climate change. If the costs of raising demersal species or the damages of invasive species, such as bluefish, become prohibitive, problems in the fishing sector will affect entire communities. Individuals who are currently selling fish caught with a licence for personal consumption may also be vulnerable to change, as they probably have a limited income and little adaptive capacity.

Institutional problems could also affect individuals in the industry. For example, poor economic performance in the sector and a failure to modernize (and behind that a lack of financial support and limitation on credit availability) could threaten to close enterprises and increase the unemployment rate. This could be a particular risk factor as Government subsidies are reduced and eliminated due to EU accession. Again, increased unemployment would in turn hinder the development of coastal and continental rural areas, which depend significantly on this branch of agriculture.

Table 9-4: Conceptual framework for linking estimated climate changes to environmental conditions in marine habitats and estimating biological resources

Climate scenario ↓	- Changed air temperature - Changed sea temperature - Precipitation, salinity - Solar radiation, wind speed
Link climate changes to marine environmental conditions ↓	- Estimate surface sea water temperature from air temperature - Develop thermohaline profiles - Quantify physical changes in habitats due to changes in sea levels using topographic information - Estimate changes in currents and up-welling zones
Identify habitat parameters vulnerable to estimated changes in marine conditions and collect appropriate biological and fisheries data ↓	- Physiological parameters (thermal niche and tolerance) - Habitat requirements (flow, substrate, depth) and other life history information. - Individual process rates (growth and mortality rates). - Using historical fish yield or catch estimates, develop temperature-process relationship
Implement assessment approaches	- Develop empirical models to estimate fish yields from historical data and climate estimations. - Develop habitat suitability models and estimate fisheries response to changes in habitat quality.

9.7. Addressing climate change/ climate variability in the fisheries/ mariculture sector

As has been stated in previous chapters, adaptive capacity is the ability of a natural system, human community or an individual, to adjust to existing climate variability and future changes in climate conditions. Some adaptation will occur autonomously, but for much of it a number of measures have to be taken into account in order to reduce the negative effects on systems, communities or individuals. Within the fisheries and mariculture sector, we can examine the current level of knowledge available to decision-makers (including firms and people involved in the industry), the resources available for adaptation, as well as potential adaptation options. Finally, we can make some recommendations for next steps.

9.7.1. Information availability for decision-makers to assess vulnerability and adapt to climate conditions and climate change

Before making concrete recommendations for adaptation, more information and analysis will be necessary in this sector. Most research studies on the influence of global climatic changes on Adriatic ecosystems, fishery and mariculture are performed in Split (at the Institute of Oceanography and Fisheries) and Dubrovnik (at the University of Dubrovnik). However, most of the collected data are not products of straightforward projects on this subject and subsequently issues of climate change and the fisheries/ mariculture industries are still not a priority in national scientific and technological projects. Although a significant amount of information and data have been collected in the last 10 years, this has not resulted in coherent material for use by decision-makers in Governmental bodies or in the business community. An in-depth survey of all available data is essential in order to perform a broader analysis and compare the situation in Croatia with other Mediterranean areas. It would then be possible to locate priorities for future research and identify ways for decision-makers to launch potential adaptation oriented measures. This analysis should also include the potential economic costs resulting from physical changes in the fishery/ mariculture industries as well as the costs and benefits of adaptation options.

Due to a lack of knowledge or their focus on other priorities, major stakeholders in the ministries and in the various companies engaged in the sector do not place much importance on the issue of climate change. The only areas where stakeholders and the public seem concerned are those areas where damages are already visible, significant and attributed to climate change (in the Neretva River estuary and Mali Ston Bay). In these areas the general perception is that changes involving the invasion of bluefish have had a negative impact on the sector and local lives. The recognition of invasive fish species (bluefish and gilthead sea bream) as a source of present and future potential damages, by local fishery and shellfish communities, led the Dubrovnik-Neretva County Government to finance two projects executed by the University of Dubrovnik.[XXVII] The projects started in 2008 but have wide research targets focusing only partly on the impact and effects of these two fish species. The results should be available to the public in 2010.

In order to develop adaptive fishery management and adequate measures to prevent losses and to promote the benefits of the potential impact of climatic changes on the Croatian fishery and mariculture sectors, more funding must be provided for fundamental and applied research.

The following activities are recommended:

- Multidisciplinary oceanographic and hydrographic research into Adriatic research and identification of the process of interaction between the climate and marine ecosystems,
- Ongoing investigation of changes in the composition, number and food web structure of Adriatic fish and other marine organism populations,

[XVII] See http://www.unidu.hr/projekti.php for more details on the projects.

- Monitoring of fluctuations in commercial catches for the purpose of preparing an action plan for the adaptation of Croatia's fishing sector to climate changes,
- Establishment of a permanent monitoring system for fish species that are biological indicators of changes in the hydrographic properties of the sea, with the ultimate goal of understanding their biology and ecology. It will be necessary to analyse the links to global climate changes and their atmospheric and oceanographic consequences further, especially the increased temperature observed worldwide, which can strongly influence fish species,
- Promotion of adaptive fishery management in order to initiate a faster response to dramatic local changes, such as those reported in the Neretva River estuary,
- Analysis of previous studies on the impact of global climatic change on the fishing sector of southern Mediterranean countries (such as Turkey and Greece) in order to prepare scenarios for the Adriatic Sea and to learn from their experiences and management strategies.

9.7.2. Resource availability for adaptation and adaptation studies and the role of institutions and decision-making authorities

Once the full impacts of climate change are understood, adaptation plans can be developed and implemented. Currently, Croatia's 2006 National Climate Change Action Plan contains the objective of mainstreaming climate change issues into all national policies. This should apply to the national strategy on the development of the fishing industry. However, there are no currently available resources specifically allocated for adapting to climate change and performing adaptive fishery management. The present level of knowledge on this issue is insufficient and therefore no management scheme can yet be developed.

At present, stakeholders have minimal knowledge and little concern with regard to climate change and its impact on the fishery sector. They are more occupied by the existing problems of gasoline prices, the marketing of their products, adaptation of production to EU legislation, and financing their activities - frequently a subject on TV and in the newspapers. This makes it difficult to incorporate climate change as a factor in their businesses. Additionally, the various ministries dealing with this sector have not recently called for projects dealing with climate change's impact on the industry.

Although damages have been caused by either invasive species or by population increases of native warm water species, this has not been recognized as an impact of global warming among various Governmental bodies.

An insurance programme was recently developed in Mali Ston Bay for damages inflicted by predator fish species on shellfish installations. The insurance payment scheme is similar to other agricultural cases in Croatia, where shellfish farmers only pay for 25% of the insurance fee, as the rest is paid by the Ministry of Agriculture and Fisheries and Rural Development, Dubrovnik-Neretva County and the local municipalities on an equal basis.[31] Such an insurance scheme may become necessary for other fisheries should invasive species begin to cause more damage in other areas. However, care should be taken in designing such schemes, to ensure the scheme does not stop necessary adjustments being made in the fisheries sector.

9.7.3. Analysis of available technological options for adaptation

Neighbouring countries with warmer climates, such as Turkey and Greece, have already developed the technological options necessary to manage the influence of global warming on the fishery and mariculture sectors. Their experiences in fishing techniques and catching invasive species should be transferred to the Adriatic, as should their methods of culturing sea bass and sea bream under warmer conditions.

The IPARD programme was developed to raise Croatian fishery activity to the level of EU standards during the pre-accession period. The plan includes the following objectives:[32]

- To strengthen and expand marine and fresh water farming and secure the sustainable management of animal resources, while at the same time increasing the competitiveness of producers through marketing and structural mechanisms and the establishment of appropriate administrative institutions.
- To target investments to the modernisation of existing farming facilities, the construction of new farming facilities and their environmental performance, in order to increase product quality and diversity.
- To pay special attention to meeting all EU requirements concerning quality, environmental protection and sanitary conditions in fish-processing companies and to diversify production both in farming and processing.

The IPARD programme and policies should help improve the situation in the Croatian fishery and mariculture sector. This restructuring represents a good entry-point in the industry for climate change adaptation issues. The policies and measures being developed should take into account the potential impacts of climate change and should include the transfer of knowledge from adjacent marine areas where such changes have already occurred . It should also include increasing the knowledge within the sector about the fundamental biological and ecological changes that will occur under new environmental conditions. For example, it will probably be necessary to begin farming sea bream rather than sea bass, a species tolerant of higher temperatures. Alternatively, the cages with sea bass could be moved to colder zones or deeper nets up to 10 metres in depth may need to be used. This will undoubtedly increase the costs of sea bass production such as: purchase of nets or the cost of moving of cages, but the level of costs is difficult to estimate due to the specificity of each location. As a result of these activities adaptive fishery management should become established, which will involve all fishery sectors, from scientific institutions, governmental organizations and bodies to the individuals in the fishing community.

Additionally, in areas where new species negatively impact the overall performance of the fishing industry, compensation mechanisms or intervention strategies should be proposed. The strategies could include the following measures:

- Compensation for damaged nets caused by invasive species, such as bluefish,
- Purchase of new fishery tools for fishing new species,
- Eradication or population control of the most dangerous invasive species, and
- Education of the fishing community on the potentials and threats of new fish species.

In conclusion, the fisheries and mariculture sector is likely to face some challenges due to climate change and be provided with some opportunities to expand production and increase competitiveness. It is critical that adaptive management practices be implemented, combined with an increased level of knowledge about the likely impacts of climate change in the short- and long-term, to ensure that opportunities are taken advantage of and threats are minimized.

“The policies and measures being developed should take into account the potential impacts of climate change and should include the transfer of knowledge from adjacent marine areas where such changes have already occurred”

Chapter 10

Vulnerable Groups

Chapter 10 Summary

Vulnerable Groups

Though climate change is a global problem, it will not affect all people equally. Just as global climate-related impacts are distributed unequally and disproportionately among the poor, impacts at the national level mirror this trend. Vulnerability to climate change depends greatly on the geographic, sectoral and social context. Poor communities can be especially vulnerable to climate change – especially those concentrated in higher-risk areas. Poorer communities tend to have more limited adaptive capacities and are more dependent on climate-sensitive recourses. Similarly, the elderly – who are disproportionately poor – are likely to face severer consequences related to health impacts in addition to economic impacts.

Further study is required to determine the vulnerability of specific Croatian regions to the impacts of climate change. Two considerations might be useful for further research.

- First, it would be useful to better understand the importance of weather-dependent economic activities in the poorest counties and among the poorest people.
- Second, it would be useful to explore additional vulnerability where weather-dependent industries form the primary source of jobs in certain regions (e.g. fishing/ tourism on the coast, farming in rural areas).
- Regional differences between counties are already large in terms of income, employment, quality of life and development opportunities. Thus, special attention needs to be given to regions that are already disadvantaged and could be in an even worse position.

10.1. Introduction

While climate change is a global problem, it does not affect all global citizens equally. The UNDP 2007/2008 Global Human Development Report states: "in today's world, it is the poor who are bearing the brunt of climate change."[1] This is not limited to the world's poorest regions. Just as global climate-related impacts continue to be distributed unequally and disproportionately among the poor, impacts at the national level also mirror this trend.

Vulnerable groups in Croatia are no different, and this section summarizes some of the key trends from this Report. First, climate change will differ in its effect on communities because of *different regional climatic impacts*, and their subsequent economic impacts. Second, climate change will act as a *threat multiplier* that may increase the pressures and problems of 'at-risk' groups.

10.2. The different faces of vulnerability to climate change

Vulnerabilities to climate change depend greatly on geographic, sectoral and social contexts.[2] Vulnerability to climate variability results from the combination of *exposure to the effects* of climate and the *inability to adapt*. For example, vulnerable groups such as the elderly, or those with chronic respiratory problems, are directly exposed to threats to their well-being during heatwaves. Other vulnerable groups are indirectly exposed to threats through climate-related impacts that result in unemployment, such as drought, that threatens the agricultural industry or the loss of certain species of fish in the fishing and mariculture industry.

10.2.1. Regional disparities

Globally, "poor communities can be especially vulnerable [to climate change], in particular those concentrated in relatively high-risk areas. They tend to have more limited adaptive capacities, and are more dependent on climate-sensitive recourses such as local water and food supplies."[3] Further study, however, is required to determine the vulnerability of Croatian regions to the impacts of climate change, independent of other variables. Two considerations might be useful for further research.

First, it would be useful to ascertain the importance of weather-dependent economic activities in the poorest counties and among the poorest people. In 2006, for example, a household survey found that in high-income regions, people were least likely to grow food for their own consumption.[4] Essentially, poorer regions may therefore be more exposed to climate threats in agriculture – both in terms of employment and in terms of impacts on household food yield. In Croatia, as in other transition countries, a lower level of disposable income is compensated by large-scale self-subsistence. Therefore, self-subsistence is more prevalent than in the EU15.[I] Self-subsistence takes place in rural areas and in the lower income quartile. These data point to the fact that in transition countries, non-monetary income is an important factor for the standard of living. In Croatia, self-subsistence is more prevalent in the northeast, and less in the Adriatic counties and the Zagreb region.[5]

[I] While a comparison with Balkan countries or the Mediterranean region would be more apt, data on comparative rates of self-subsistence in households in those regions were not available.

"There is clear evidence that regional differences between counties in terms of income, employment, quality of life and opportunities for development are already profound. Thus, special attention needs to be given to regions that are already disadvantaged and could be in an even worse position due to climate change"

Second, it would be helpful to explore the phenomenon of additional vulnerability where weather-dependent industries form the predominant source of jobs in certain regions (fishing/tourism on the coast, farming in rural areas), increasing the barriers to finding alternate sources of employment.

Counties in the war-affected areas have recovered unevenly. Those in areas on the Adriatic have shown strong economic recovery in recent years due to increases in income generated from tourism, while those in central and north-eastern Croatia are still lagging behind. The lowest median household income is in the counties of central and eastern Croatia (Bjelovar-Bilogora, Virovitica-Podravina, Pozega-Slavonia), while the highest median household income is in Istria County and the City of Zagreb. The difference is dramatic. The ratio of median household income between the counties with the highest and lowest income (2.9) is identical to that of the ratio of median household income between Croatia and Denmark (the country with the second highest median household income in the EU).[6]

The 2006 survey also found that regional disparities were even worse when factors in addition to income level were considered. Multiple deprivations on an individual level are important. When measuring the proportion of socially excluded citizens,[II] the differences between counties were 16 to 1. In six counties (Bjelovar-Bilogora, Osijek-Baranja, Vukovar-Srijem, Slavonski Brod-Posavina, Virovitica-Podravina and Pozega-Slavonia) approximately one quarter of the citizens could be considered socially excluded. All these counties are in the Central-Eastern region of Croatia.[7] A recent Regional Competitiveness Index report also pointed out that the Central-Eastern region is at the bottom of the scale.

There is clear evidence that regional differences between counties in terms of income, employment, quality of life and opportunities for development are already profound. Thus, special attention needs to be given to regions that are already disadvantaged and could be in an even worse position due to climate change. In the Central and Eastern regions, that are dependent on farming, or in Adriatic areas, where tourism is the main source of income, the impacts of climate change could be more damaging than in other areas.

10.2.2. Low-income households

While less than 5% of Croatia's population lives below the absolute poverty line of USD 4.30 per person per day,[8] a 2006 survey indicated that nearly one third of all Croatian households had difficulty meeting basic living expenses.[9]

Croatia is at the lower end of median income distribution in comparison to EU countries. Only two new EU country members (Bulgaria and Romania), three Baltic countries (Lithuania, Latvia and Estonia) and Poland have lower average household incomes than Croatia.[10]

Income distribution within Croatia is uneven. Counties in the Slavonia region that could be additionally damaged by increased climate variability are at the lower end of income distribution.

Exposure to threats: Low-income households face greater exposure to climate threats than their high-income counterparts, primarily because of the concentration of low-paying jobs in climate-dependent industries, such as those in agriculture, tourism, and fishing. In addition, 44% of Croatian households "grew vegetables or fruit in that period, or kept livestock or poultry to help them satisfy their nutritional needs"[11] in 2006. While only certain households may be growing crops that are vulnerable to changes in temperature or events such as droughts, this number may still be substantial. However, the net effects of climate change on these households have not been researched. For lower-income households growing their own food, decreased yields due to drought would di-

[II] An individual is considered socially excluded if his/her income is below 60% of the national average and if he/she is unemployed and deprived of socio-cultural relationships.

rectly impact their nutritional resources. On the other hand, they might be relatively insulated from rising food prices due to decreased yields. The costs and impacts of adaptive measures for self-sustaining households, such as crop switching, would also require study to determine the ultimate impacts.

Further, as Chapter 8 on agriculture examines, present climate variability has already caused economic damage equal to over EUR 176 million per year. Some of this damage was probably incurred by non-vulnerable groups, such as major agribusinesses. However, considering that rural and agricultural households are generally poorer than urban households, it is likely that the damage incurred – and future expected damages – have a greater impact on poorer people. Lower levels of agricultural production also drive food prices up for the urban and rural poor.

In addition to its impact on agricultural production, water shortages could potentially threaten groundwater resources, which would affect poorer households that use well water. These wells already have trouble with contamination, which may be exacerbated by a drier, hotter climate. Wells could even dry up, forcing people to dig new wells. Finally, poorer people who already have difficulty paying their electricity and water bills may be hurt by a drier Croatian climate. Chapter 7 concludes that hydroelectric production is expected to drop significantly in the future, which would in turn lead to an increase in electricity prices.

Capacity to respond: Unfortunately, low-income households are also less able to adapt to climate threats and the eventual potential effects of climate change. Increased prices for food and water, a likely effect of climate change, would have a greater relative effect on low-income households. A survey conducted in 2006 found that 13% of Croatian households had lacked money for food in the year prior to the survey.[12] Rising food prices due to damages to the agricultural sector and higher energy prices would increase this figure.

Increased prices for energy – caused by, among other things, a drop in hydroelectric power production – would also comprise a larger relative proportion of the household budgets of lower-income households. In 2006, 20% of Croatian households surveyed reported difficulties in paying their utility bills on time.[13]

In agriculture, lower-income households that farm "outside of the system" have reduced access to the social benefits and training that might allow them to adapt farming practices to changes in climate.

In the tourism sector on the coast, the prevalence of seasonal and "grey market" jobs means that the lower-income segment of the workforce may lack access to social safety-net programmes, such as pensions and other benefits, making them more vulnerable to the impacts of unemployment, should tourists stop coming to Croatia. Similarly, small-scale entrepreneurs who rely on sales to tourists would suffer from a decrease in tourism.

In all sectors, the poor are less able to save and less likely to have access to credit from the banking system or from sources outside their families.[14] Reduced access to savings and/or credit limits the available choices to adapt to climate effects. Using new equipment, changing businesses, or relocating for new jobs are all adaptive measures that require an up-front investment.

While climate variability is generating risks in the lives of the poor, social protection programmes can help people cope with those risks while expanding opportunities for employment.[15] However, low-income workers, seasonal workers, and workers "outside of the system" in the agricultural, fisheries, and tourism sectors may face more barriers in accessing social protection programmes.

Income levels are also closely correlated with education and regional disparities. Low-income workers are more likely to have lower levels of education, and will face more difficulty finding jobs if displaced by climate-induced trends. Additionally, they may face reduced access to training and re-training programmes because of regional disparities and unawareness of their choices. These workers are also more likely to live in communities where there are few viable means of employment (more remote rural areas for farmers, and islands or coastal communities for workers in the fishing and tourism sectors).

In addition, Croatia is among the countries with the greatest difference in "self-evaluation of health and access to health services" according to income quartiles.[16] This implies that income limits people's access to health services. This lack of access could become more profound considering climate-related weather threats and risk factors, such as low income, age and poor health.

10.2.3. Low education levels

As mentioned above, education levels are closely linked to income and employment. A 2007 living standards assessment conducted by the World Bank found that secondary education reduces the risk of poverty in Croatia to one third of the national average.[17]

Exposure to threats: Workers with lower levels of education are also more likely to be unemployed. If employed, they are more likely to have jobs that are not full-time salaried positions. They may also be disproportionately represented in industries that are exposed to climate threats (e.g. agriculture). Here, climate change may act as a threat multiplier by placing added economic stress on these groups.

Capacity to respond: Developing human capacity among less educated people appears particularly important within the agricultural and tourism sectors. While this recommendation would provide general benefits for less educated workers in these sectors, it would provide specific benefits to the sector in terms of transmitting information about adaptation measures at the local level. Farmers and actors within the fishing and mariculture industry can be educated about better farm management, which better addresses current and future climate challenges. Workers in tourism can provide better, more competitive service and gain stronger positions in the workplace. Workers with low levels of education may face increased difficulty in finding jobs, if they become unemployed, as a result of changes in the economy due to climate trends. It will be important to consider how training programmes can reach workers with low education levels who may have lacked access to professional education earlier in their lives. It should be taken into account that lifelong learning programmes are under-developed in Croatia so opportunities for retraining are not widely available. On average, only one in ten Croatian citizens attended a training or qualification course in 2006: 6.7% of all people in rural areas and 13.6% of those in urban areas.

10.2.4. Gender issues

The relationship between gender and climate change vulnerability in Croatia has not yet been researched. Gender issues may play an indirect role in vulnerability to climate change because of the overrepresentation of female-headed households in poverty in Croatia. This affect is also correlated with age (see the section below on the elderly). Twenty six percent of individuals living in households headed by women over 65 live in poverty – the highest incidence of poverty of any household grouping.[18] Determining how the direct and indirect impacts of climate change may be differentiated by gender would require further study.

Exposure to threats: Additional research on the gender breakdown of employment in weather-sensitive industries would provide important data on the potential exposure of women and men to the effects of climate change. In addition, it would be useful to study the indirect effects that climate change may have on households. For example, increases in commodity prices will disproportionately affect female-headed households, as they are overrepresented in Croatian households living in poverty.

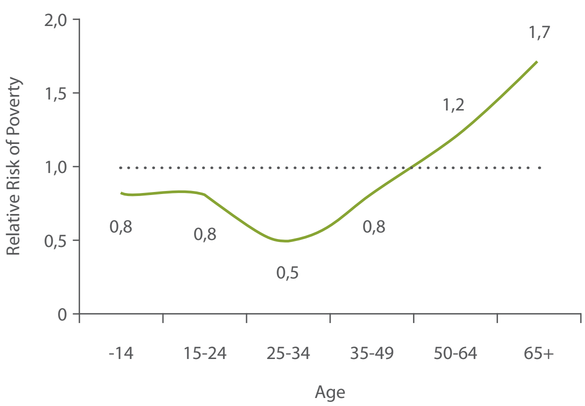
Capacity to respond: The gender wage gap in Croatia is such that women in the same jobs as men receive less pay. This situation places greater limitations on their ability to respond to unemployment or to make adaptive changes in their work that require investments. One study estimates that men in Croatia earned 12.5% more than women in 2005.[19] The resultant pension gap is also an issue among elderly women, who already face an increased incidence of poverty due to age. Gender differences in access to credit would have similar effects.

10.2.5. The elderly

The elderly in Croatia face a direct threat to their health due to climate events such as heat waves (see Chapter 6). The vulnerability of the elderly to climate change is also related both to age itself and to the correlation of advanced age with the incidence of poverty in Croatia. Elderly Croatians face a higher risk of poverty than the national average (See Figure 10.1 below).[20]

Exposure to threats: The elderly face direct threats to their health as a result of the increased temperatures during heat waves. While there are gender differences in the incidence of deaths due to circulatory disease (women are more likely to die of circulatory disease in Croatia than men),[III] research has not yet been published on the relative risk of heat-related death by gender. There is also no available research on how warmer winters might affect mortality patterns in elderly Croatians.

Figure 10-1: Relative risk of poverty* in the Croatia by age.



*Relative risk of poverty represents the proportion between the rate of poverty of a specific (age) group and the general rate, which refers to the entire society. When the risk of poverty is higher than 1, this means that a specific group has an above average risk of poverty, and if it is lower than 1, then there is a below average risk of poverty . For example, if the risk of poverty of a group is 1.7, it means that this group has a 70% higher risk of poverty than the entire population.

Source: UNDP Croatia 2007: 121.

The 2006 Quality of Life survey showed that the economic situation of people older than 65 in Croatia is considerably worse than the national average.[21] Considering that such differences do not exist in most European countries, special attention was given to the analysis of this age group.

Almost half of the elderly population has difficulty in making ends meet. Household equivalent income for households consisting of elderly people depends significantly on the area where they live: in rural areas reported average income was HRK 1250 (EUR 170) and in urban areas it was HRK 2250 (EUR 308). The national average for all age groups in 2006 was HRK 2200 (EUR 301).[22] Elderly people living without pensions and without compensatory family support are in especially difficult positions. [23]

Capacity to respond: Elderly Croatians living in poverty face additional difficulties in adapting to extreme weather events, such as heat waves (e.g. they lack the means to travel to a cooler place or to afford air conditioning in a heat wave). In addition, the elderly may have to stretch pensions (or – in households not receiving a pension – other savings or resources) to cover increased prices for food, electricity and other products that may result from climate change.

10.2.6. Migration

The potential for migration related to climate change is an issue that has been discussed primarily at global and regional levels. Research and policy discussions to date have focused on the potential immigration of environmental refugees to Europe from other parts of the world,[24] general migration issues in other countries due to extreme climate events,[25] and on the potential trade and development implications of instability in other world regions due to climate-induced migration.[26] However, there has been no research on internal migration within Croatia – or on internal migration within Europe – due to the environmental or economic effects of climate change.

[III] Crostat, 2008: 21. However, other country-specific reports on heat-related deaths have identified more male deaths – further study is clearly needed.

"Vulnerable groups in Croatia are also particularly vulnerable to the effects of climate variability and to the potential effects of future climate change"

10.3. Next steps

Perhaps not surprisingly, vulnerable groups in Croatia are also particularly vulnerable to the effects of climate variability and to the potential effects of future climate change . Vulnerable groups are essentially caught in a vicious circle. They are disproportionately exposed to the effects of climate impacts through their work in weather-dependent industries, their reliance on subsistence farming, or their increased sensitivity to heat waves. At the same time, they are the least able to adapt to the effects of climate impacts -- by changing employment, moving to a different area, participating in re-training programmes, or gaining access to credit or savings.

Further research could address the following issues:

- An assessment of weather-dependent industries, their employment structures, and their regional distribution, to provide a better understanding of potential climate impacts
- The impact of weather-dependent industries on income and relative access to benefits
- The direct health effects of climate extremes on vulnerable groups such as the elderly and how to prevent these effects
- Gender implications in industry, health, and among the elderly

In the meantime, policy-makers should act now to ensure that regional development strategies, particularly in regions where weather-dependent industries are prevalent, take climate-related considerations into account. In addition, they can incorporate the current findings on climate variability and projected trends in climate change into poverty reduction strategies.

Chapter 11

Vulnerability to Climate Change in Croatia - a Summary of Section 2

Chapter 11
Vulnerability to Climate Change in Croatia – a Summary of Section 2

11.1. Potential vulnerability

Climate variability and perhaps climate change is already impacting human development in Croatia and the choices that people can make to improve their lives. The analysis in the previous chapters has shown that significant portions of society and the economy are vulnerable to variability in the existing climate and to changes in the climate in the future. As shown in previous chapters, the vulnerable parts of the Croatian economy account for almost 25% of the Croatian economy – EUR 9.226 billion per year. Furthermore, many of these sectors have a direct impact on human development – especially among vulnerable groups. Existing climate variability – some recent aspects of which may be due to climate change, but are difficult to distinguish – has already had a large impact on Croatia. In the agricultural sector alone, climate variability (including droughts and floods) already cost farmers an average of EUR 176 million during 2000-2007. The drought in 2003 cost Croatia approximately EUR 63-96 million in compensation for the losses in electrical production due to less river flow.

- Future climate change has the potential to result in increased negative impacts on various systems in Croatia, though some positive impacts may also emerge. Climate models predict changes during 2040-2070 and again towards the end of the century.
- Foreign tourists may decide not to come to Croatia because of increases in hot weather, heat waves and other extreme weather events. Furthermore, some 'natural-beauty' tourist sites, such as Krka National Park and Plitvice Lakes National Park may be vulnerable to climate impacts either due to warmer temperatures and decreased precipitation or sea-level rise.
- On the other hand, the tourism season may extend further into the spring and autumn, resulting in more income for coastal tourism based communities.
- Sea-level rise may cause flooding in coastal areas – perhaps submerging over 100 million square metres of land if the sea rises over half a metre. This area includes urban areas such as Krapanj Island, some areas of Split and others. It also includes agricultural land – for instance the entire Neretva River Delta. Freshwater resources such as Vrana Lake, near Biograd, and the Krka River may also be affected. This may require significant adaptation investment, but over a long period of time, as the sea level will rise gradually and the level of rise is uncertain – which will allow for gradual planning.
- Both positive and negative health impacts are also possible because of climate change – including cardio-vascular impacts on the elderly due to heat waves and less mortality due to milder winters. There may also be shifts in allergy patterns.
- Hydropower production will probably drop (perhaps by as much as 50%) due to reduced river discharges caused by decreases in precipitation.
- Ecosystem services provided by wetlands – such as pollution removal, flood control, and the scenic value of forests – may be reduced because of decreased precipitation.
- Drinking water and groundwater supplies – while unlikely to face significant immediate risks – may be vulnerable in some areas.
- Agricultural yields of maize, and undoubtedly a number of other crops, may drop due to increased droughts, decreased soil moisture, and increased evapotransporation due to higher temperatures, even if management practices are adjusted.

> "Existing climate variability – some recent aspects of which may be due to climate change, but are difficult to distinguish – already has a large impact on Croatia"

"The potential impacts on the economy may be larger than the sum of each sector due to multiplier effects from impacts on specific sectors"

- The fishing and mariculture industries may face challenges due to changing sea temperatures. These changes may mean increases in invasive species and changes in the ideal locations for mariculture and fishing practices. However, the positive impact of increased productivity of fish and better economic conditions may also occur.

Additionally, the potential impacts on the economy may be larger than the sum of each sector due to multiplier effects from impacts on specific sectors. Increases in energy costs, food costs, and other economic impacts may have ripple effects on the Croatian economy, though this cannot be measured with the current information available.

Most of these impacts will have a particularly strong effect on the more vulnerable groups within Croatia. This includes poorer people who may have difficulty paying for energy and food; rural poor who are dependent on agriculture for nourishment; elderly people, due to their higher rates of poverty and vulnerability to health impacts; and low-income wage earners who are supported by the tourist economy. On the other hand, if food prices rise, those dependent on subsistence agriculture may be relatively better off, as they do not buy their food.

Climate change has the potential to have significant negative impacts on the Croatian economy and society – making human life more difficult and decreasing human development opportunities. While it is not possible to assess the economic impacts in terms of its effect on Croatia's GDP, some impacts in some sectors can be roughly estimated. This Report's analysis does not explore the likely projected values of economic goods in the future. However, if priced in 2008 terms, it can be seen that the impact is potentially quite large in various sectors – see Table 11-1.

11.2. Underlying framework for adaptation strategies

Given that current climate variability is already affecting human development in Croatia and the impacts may increase due to future climate change, action will need to be taken to reduce current risks and prevent future damage. However, this Report shows that there are a number of limiting factors in assessing future vulnerability. First, little work has been carried out to downscale changes in climate to relevant spatial and temporal scales. Second, little work is being carried out to simulate the physical and economic damages of climate change in the sectors investigated. Third, little is being done to evaluate the benefits and costs of alternative adaptation policies and measures. The lack of knowledge results in the limited ability of national and local governments to formulate and implement policies to help reduce the damages from climate change. These shortcomings need to be addressed first.

In the meantime, both the Croatian Government and the private sector should recognise that many of the activities they undertake today, to cope with climate variability, economic development pressures and environmental quality, can also improve the adaptive capacity of the country and make it less vulnerable to climate change . At the same time, the databases and tools they need to develop to analyse policies dealing with climate variability are not very different from those needed to evaluate alternatives for adapting to climate change. This "no regrets" approach to developing both the technical capacity to simulate the impacts of climate change and to evaluate adaptation measures, and the institutional capacity to formulate and implement adaptation policy, will produce positive dividends in coping with a wide range of current stress factors and future climate change.

Table 11-1: Different systems and their climate impact – current variability and potential due to future change.

Sector	Total GDP/ GVA value per year (million Euros)	% of Croatia's Economy	Number of People Employed	Source of Impact (positive + or negative -)	Total economic impact (EUR per year)	Time period
Agriculture	1750	5.80%	272,000	(-) Existing extreme weather	176 million in damage	2000-2007
				(-) Changes in average temperatures, seasons, etc. in the future causing decreases in maize yields	a. 6-16 million in damage b. 31-43 million in damage	a. 2050
				(+)Lengthened growing season and higher carbon concentrations helping in crop production	Unknown	
Fresh Water	164.4	0.62%		(-) Decreased Hydro-power due to previous drought conditions	63-96 million	2003 drought - estimated
				(-) Decreased Hydro-power in the longer term future	16-82 million	By 2070
	238	0.90%		(-) Loss of wetlands	Unknown	
	Not measured			(-) Floods in agriculture and cities	9 million - mostly in agriculture	2001-2007
	317.7	0.85%		(-) Problems with drinking water	Unknown	
Tourism	6700	17.91%	336,000	(-) Tourists not coming to Croatia because of poor climate	Unknown	
				(-) Damage to infrastructure and image due to extreme weather events	Unknown	
				(+) Potential benefit from lengthened tourist season	Unknown	
				(+) Potential benefit from less rain during the peak tourist season (better for tourist enjoyment)	Unknown	
				(-) damage to unique ecosystems and natural attractions	Unknown	
Sea-Level Rise	Not measured			(-)Sea-level rise covering urban coastal areas/ marinas/ beaches with economic value according to value per square metre covered	30.4 million - 78.1 million annual average with sea-level rise 0.50 - 0.88 metres	by 2100
				(-)Contamination of fresh-water/ brackish resources near coast (Neretva Valley, Vrana Lake)	Unknown	
Fisheries/ Mariculture	56	0.25%	20,000	(+)/ (-) Invasive species	Unknown	
				(-)Problems with sea water temperature causing fishing and mariculture losses	Unknown	
				(+) Increased productivity and production from fisheries and mariculture	Unknown	
Health	Not measured			(-) Heat waves causing respiratory failure, allergy changes, ground level ozone causing breathing problems	Unknown	
				(+) Milder winters decreasing health problems due to cold weather	Unknown	
Totals	9226.1	24.67%	628,000			

"The Croatian Government and the private sector should recognise that many of the activities they undertake today, to cope with climate variability, economic development pressures and environmental quality, can also improve the adaptive capacity of the country and make it less vulnerable to climate change"

"Efforts should begin with adaptation to short-term climate variability and extreme events, which then would form a basis for reducing vulnerability to longer-term climate change"

Thus, efforts should begin with adaptation to short-term climate variability and extreme events, which would then form a basis for reducing vulnerability to longer-term climate change . This means addressing the current occurrences of drought, storms, floods, heat waves, etc. Some 'autonomous' adaptation will be carried out by private actors, regardless of any policy recommendation, whilst other measures will need Government involvement both at the local and national level.

Both current efforts and future adaptation policies and measures should be assessed in a developmental context, emphasizing human development as a fundamental aspect of adaptation. Therefore, climate change impacts and adaptation should be fundamentally integrated into key policy and planning processes, especially for areas such as coastal zone management, agriculture and water management, tourism, energy planning and the fisheries/ mariculture sector.

It is also important that adaptation occurs at different levels in society, including at the local level. Therefore, while the national Government should be involved in policy making, a proactive "bottom-up" risk management approach should also be taken. This way, adaptation policies and projects will be formulated for local development needs and thus more sustainable. This also means that stakeholder involvement is critical in each part of the adaptation process.

11.3. Recommendations for future action, including research, projects and institutional framework

11.3.1. No regrets options

No regrets adaptation options are measures that can be justified today, in economic and social terms, which cope with current climate variability, developmental pressure, environmental degradation, etc., and which will also reduce climate change damages in the future. Examples generally include measures to improve the economic efficiency of industries that depend on climate-sensitive natural resources and to internalize external costs regarding pollution and environmental degradation. This section has only begun the process by identifying some of the probable vulnerabilities to climate change. Further research is necessary before implementing actual adaptation projects. However, some no regrets measures should be implemented, regardless of climate change.

Within the tourism sector, continued development of marketing and hosting abilities – especially for tourist activities not affected by climate - will aid in the further development of the sector and decrease the risks associated with climate variability and change. Furthermore, planning for new buildings should be energy efficient ensuring the buildings are more comfortable and cheaper to keep cool, especially on the coast.

For coastal zone management, it is recommended that current regulations on construction near the coast-line be enforced and that potential sea level rise be considered when formulating future major infrastructure projects, such as sewage systems. Furthermore, Integrated Coastal Zone Management principles should be included in the governance of coastal areas along with the provision of indicative planning information to the private sector.

In the health sector, continued public education and preparation for extreme heat events and – if necessary – bad ozone days is both a necessary and "no regrets" option that should be adopted.

For the fresh water resources sector, important no regrets options include decreasing water losses in distribution systems, improving flood-plane zoning and flood-proofing practices to reduce current flooding damages, installation of flood warning systems in areas now prone to flash flooding, continuing to streamline disaster risk planning and management, improved wetlands management to preserve ecosystem services and developing future electrical generating capacity plans to account for the effects of droughts under the current climate. All of these measures represent major no regrets options that would help reduce future climate change damages.

In agriculture, developing crop models that show how different crops respond to climate and management variables would help with crop management under existing conditions. Furthermore, developing an economic model for the sector, to include better information about the inputs and outputs of the sector – including crop production, crop mixes and prices, as well as gross and net margins for various crops – would help formulate better agricultural policy and assess the management and technology options for coping with climate variability/ climate change issues in soils and would help change other management practices.

One aspect of climate vulnerability and climate change that should be pursued is preparation for extreme weather conditions. This would include heat waves, fires, "bora" wind events, floods, etc. Coordination between the DHMZ and other emergency management systems should continue to be enhanced. This should also include regional integration and harmonization of warning systems.

11.3.2. Further research

Without first developing the capacity to simulate climate change impacts and to evaluate the benefits and costs of policies and measures to adapt to climate change, it is very difficult to say what measures are needed in Croatia. Also, the uncertainty associated with both global climate policy and existing climate change projections at the local level, is currently so great that Croatia must be cautious about either doing too little or doing too much, if these projections turn out to be wrong. As such, adaptation measures that do not have a "no regrets" component will require additional research and investigation, once the capacity to do this has been developed in Croatia. This includes developing the capacity to project climate change at the regional/local level; to transform these climate changes into physical impacts; to estimate the economic value of these damages; and to evaluate the benefits and costs of alternative adaptation measures.

The tourism sector is currently very important because of the amount of foreign spending it generates within Croatia. The sector is quite decentralised and market forces have driven most of the post-war economic developments that have occurred. However, if tourists stop visiting Croatia in large numbers in the summer, due to the extreme heat, the options for recovering these tourist visits by Croatia alone are somewhat limited, consisting primarily of developing less-climate sensitive recreation alternatives and working collectively with other nations to allow greater flexibility for vacation travel in the off- and shoulder seasons. Moreover, it is possible that, under the worst-case scenario, adaptation efforts will comprise public sector damage control to limit the adverse economic impacts of coastal decline and migration away from the coast. In other cases, for example in critical tourist areas such as Plitvice Lakes National Park and Krka National Park, it may be possible to manage aquatic and terrestrial ecosystem resources differently, to preserve the natural environments that attract tourists. However, this might adversely affect other segments of the population, if, for example, surface and groundwater usage has to be drastically curtailed to maintain water flow levels. Again, it will be necessary to obtain more information about the future physical impacts on certain tourist locations before any adaptation processes can be implemented.

Coping with sea-level rise is the most unpredictable area in which adaptation to climate change will take place in the future. This is due to the uncertainty of sea-level rise projections and the lack of the necessary databases and models to not only simulate physical and economic damages, but also to evaluate the costs and benefits of adaptation actions. A great deal of attention has been focused on investing in protective measures for sea-level rise. However, the literature on the benefits and costs of "retreating" from sea-level rise has failed to address the role of the public sector in facilitating, or actively influencing, the abandonment of existing property and structures, and investment in and relocation of new structures. Instead, the process is treated as if it were occurring autonomously. Faced with the high cost of protecting some areas and not protecting others, governments may need to become involved in assessing what other actions they can take to move economic activity and people away from the sea. In this regard, coping with sea-level rise challenges national and local governments to find ways to combine the existing legislative, regulatory and fiscal policy tools currently used to influence economic development, and use them to cope with some of the more extreme shocks of climate change.

To manage health risks, further research must be undertaken to establish the link between climate conditions and health impacts. This will aid in advancing measures to protect the health of Croatians due to climate change and extreme weather.

In considering water resources, it is currently very difficult to determine the adaptation measures Croatia should take for water resources, apart from the no regrets approaches indicated above, due to substantial uncertainty about the expected impacts. The one major impact that was investigated in this Report involves the reduction in hydropower generation due to reduced river discharges and runoff. As previously mentioned, this is potentially a major development issue and one that is also related to current climate variability. Thus, long-term adaptation to climate change and present day issues coincide very closely, with the only major change being the need for the Government to base its hydro-electric capacity plans on runoff projections that include the risk of climate change. The potential for the Government to be involved in strategic adaptation in the water resources sector is also very high when it comes to flooding and water quality, which can be heavily influenced by climate change. However, once again, without better information about the physical impacts of climate change on peak flows and runoff, it is difficult to say what adaptation options the Government should be considering. As this Report has repeatedly stressed, the most important effort the Government should make in the near future is to improve its capacity to analyse these issues and to develop the additional institutional capacity for planning and managing water resources that might be needed in the future. Since hydro dams, flood control structures, waste water treatment and purification facilities represent relatively large outlays of public funds for infrastructure that will last many decades, the need to integrate climate change into current infrastructure planning becomes more acute.

In agriculture, much of the adaptation will comprise changes in management practices that will generally be autonomous in nature, based on private market incentives. However, the Government may have a role to play here by sponsoring and disseminating the results of research about management techniques for coping with climate change and climate variability to farmers. Moreover, as agricultural regions in Croatia are already suffering from a lack of moisture, irrigation is becoming a more attractive alternative. As mentioned earlier, the Government is sponsoring a major initiative aimed at irrigating farmland and the public sector is in the process of helping to finance related projects. However, the cost/ benefit analysis of irrigation is currently unavailable. Any irrigation projects designed to cope with climate variability will probably take the form of strategic adaptation and will need to be thoroughly researched – especially the links between planned actions and ones taken by the private sector. In Chapter 8, several measures, including irrigation, were identified for increasing soil moisture. The private sector is often unwilling to finance this type of research, preferring to wait to acquire the research results, at a low cost, instead of undertaking the research at a high cost. Therefore, it may be prudent for these options to be investigated further by the Government and the results passed on to farmers at a very low cost.

To address the risks and capitalize on opportunities within the fisheries and mariculture sector, further research into probable changes in fish populations, migration patterns, and primary productivity is needed.

It is also important to note that risks to biodiversity may have an impact on fisheries, tourism, and other sectors. This risk to biodiversity has not been analysed in this Report, but it could be a very important impact of climate change.

11.3.3. Adaptive capacity

While this Report has not carried out a full analysis of the adaptive capacity of each sector to deal with climate change, it has identified a number of issues that should be addressed. The first issue is that current climate variability and future climate change should be further integrated into the strategic planning of the various sectors. Currently, most plans and ministries have just begun to think about the impact of climate change on Croatia, as with most countries. However, this Report has shown that climate variability is already having an impact and climate change may cause dramatic impacts in the future. The real challenge, as outlined above, will be for the public sector to take the existing capacity it has developed to cope with developmental pressure, climate variability, environmental quality issues, etc. and apply this to coping with climate change. This will mean enhancing the existing capacity to enable society to cope with the more significant climate variability that will be experienced due to climate change.

Section 3

What can Croatia do to Change the Climate?

3

Chapter 12

Reducing Emissions in Croatia - the Costs of Mitigation

12

Chapter 12 Summary

Reducing Emissions in Croatia – the Costs of Mitigation

In order to avoid dangerous climate change resulting from an increase in temperature of over 2ºC, global GHG emissions must be cut by 50-85% by 2050. Croatia's trajectory for emissions growth in the Business as Usual (BAU) case is estimated to result in 42 million tonnes of CO_2e in 2020 – a significant increase from today. The EU has committed to reducing emissions by 20% by 2020. Croatia has committed to reducing emissions by an average of 5% for the period 2008-2012 from a baseline level of 36 million tonnes under the Kyoto Protocol. Croatia will also share at least part of the EU commitment for 2020, especially with respect to emissions from major point sources such as power plants and industrial sources.

The energy sector is the largest source of GHG emissions in Croatia (73% in 2006). There are many potential measures to reduce emissions from the energy sector by 2020. It is estimated that by implementing the measures in the Energy Efficiency Master Plan, 1% of the national GDP could be saved. Emission reductions from households and the service industry could amount to almost 2 million tonnes by 2020 with a net economic benefit from energy cost savings. Industrial efficiency measures could also have a positive financial impact on companies. Producing electricity from renewable resources, increasing the efficiency of conversion and transmission, and – more controversially – moving to more nuclear power and electricity generated from burning waste, could yield significantly fewer emissions. Reducing fuel consumption in transportation through fuel-efficient vehicles, lower-carbon fuels, using biodiesel or other biofuels, or reducing car travel through better urban planning, public transportation, and traffic systems are also potential areas where emissions can be cut.

The agricultural sector accounts for almost 11% of Croatian emission (2006). Agriculture can play a role in reducing direct emissions from agricultural soils and improved livestock and manure management. Agriculture also has an indirect impact on emissions due to fertiliser production and emissions from transport. Finally, agriculture can have an impact on mitigation due to land use, land use changes and forestry (LULUCF) activities related to converting arable land to grassland or forests, converting drained arable land back to wetlands, or increasing soil in carbon storage management practices.

Industrial processes were responsible for approximately 13% of Croatia's emissions in 2006. Within the industrial processes sector, cement-related emissions reductions can be achieved using measures, such as increasing the amount of clinker in cement to EU standards and through indirect measures, such as incinerating waste materials for energy and building concrete rather than asphalt roadways. Additionally, changing the industrial process for manufacturing nitric acid can also lead to significant reductions. Reducing the emissions from fertilizer and lime production may also be an option, but no information is available on the potential savings in Croatia.

The waste management sector was responsible for a little under 2% of total emissions in 2006. Emissions can be reduced in the sector by utilising landfill methane as a source of energy/ electricity.

LULUCF measures in Croatia also present significant possibilities for reducing net emissions. In 2006, land use changes amounted to an estimated net reduction of 7.5 million tonnes – almost a quarter of Croatia's emissions. However, only approximately 1 million of this can be counted in international negotiations. Further, carbon sequestration in soils due to agricultural practices could have significant impacts, both on soil quality and on the net emissions from Croatia.

According to this chapter's estimate, if all measures are fully and successfully introduced – excluding reductions from land use changes – Croatia could theoretically achieve a 30% cut in emissions by 2020, from the baseline of 36 million tonnes per year. The economic costs of achieving this reduction in 2020 are estimated to be EUR 115-536 million in that year. While this calculation needs further analysis, it shows major reductions are possible with relatively moderate economic costs, given the likely future price of carbon. However, while potential does exist and seems achievable at a relatively low cost, there are many political, institutional, technical, and other considerations that would have to be resolved to reach these reduction levels.

12.1. Introduction

As shown in Section 2, Croatia may face serious consequences from climate change that will affect individual economic sectors and human development as a whole. Croatia will also be required to reduce its emissions of greenhouse gases. In order to avoid dangerous climate change – an increase of more than 2ºC – world experts believe that the CO_2e[I] concentrations

[I] CO_2e is an abbreviation for carbon dioxide equivalent, which includes both CO_2 and other greenhouse gases (by reflecting the relative impact that the other gases have on global warming compared to CO_2). All gases have been expressed in terms of CO_2e for this chapter for the sake of simplicity and to reflect international practice.

[II] The OECD is the Organisation for Economic Cooperation and Development and represents 30 of the largest economies of the world that comprise over 60% of global GDP. See www.oecd.org.

Figure12-1: Windmills on the island of Pag.

Source: Josip Portada.

Box 12-1: Croatia's emissions in comparison to other countries and obligations upon entering the EU

Croatia is somewhere in between the "developed" and "developing" classification in terms of emissions. OECD countries[II] – which can be described as "developed countries" – had an average emissions level of 11.4 tonnes per person in 2005 (10.8 tonnes/ person in 1990).[4] In contrast, developing countries had emissions rates of 2.4 tonnes per person in 2005 (1.7 tonnes/ person in 1990).[5] With a population of 4.44 million people,[6] Croatia emitted 6.94 tonnes per person in 2006 – not including land use changes. When land use changes are considered, Croatia was responsible for 5.26 tonnes per person in 2006 because of the growth of forests.[7] In order to avoid dangerous climate change, Croatia, along with the rest of the world, will have to be a part of the solution. Without a successful global effort to drastically reduce emissions, Croatia and the world will face more severe consequences.

Croatia's obligation once it enters the EU is not yet known. It will probably constitute part of the final accession negotiation. The EU has a new burden sharing methodology for reaching the 20% reduction target collectively. This imposes different individual targets for EU countries, taking into account the economic strength of the country. For sources of GHGs not covered by the European Trading Scheme (ETS) the range of obligation in the EU is +20% to -20% - i.e. some countries will be allowed to increase emissions up to 20% and some will be required to cut emissions by as much as 20%. Croatia will be allowed to increase its GHG emissions in the non-ETS sector by 15-17%, compared to 2005.

In the EU-ETS sector mostly major emitters at one location (such as power plants, oil refineries, etc.) there will be a single EU-wide cap instead of different caps for each member state. In total, a 21% reduction compared to 2005 emissions will be required in the ETS sector. The basic principle for allocation will be auctioning, which will be open to all member states equally. The power sector will have to buy all allocations to emit GHGs through an auction process and industry sources will have some free allocations. Exceptions, possibly higher levels (up to 100%) of free allocation to industries particularly vulnerable to international competition ('carbon leakage') will be determined in 2010.

in the atmosphere must not exceed 450 parts per million (ppm). Currently, the levels are at 380 ppm and rising by 1.9 ppm per year. Pre-industrial levels were approximately 275 ppm.[1]

The IPCC states that, in order to accomplish this, by 2050, global emissions must be cut by 50%-85%. Because of population growth, this will mean that emissions throughout the world must be cut to a maximum of 2 tonnes per person.[2] The Stern analysis, along with the most recent global HDR,[3] outlines two different paths for countries striving to reach this goal. The first path would be taken by "developed countries" – required to reduce emissions by 25-40% by 2020 and by 80% by 2050. The European Union has already committed to reducing emissions by 20% by 2020, but is ready to increase this reduction to 30% if other industrial countries will agree to cut their emissions.

Croatia has already begun the process of reducing emissions – having committed to reducing emissions by 5% compared to 1990 levels by 2012 under the Kyoto Protocol. In 1990 Croatian emissions were 32.527 million tonnes of CO_2e.[8] However, because much of its electricity was imported from other parts of the former Yugoslavia, these were very low emissions rates that did not allow for economic growth. Croatia has therefore negotiated that the base-year level be set at 36.027 million tonnes of CO_2e – 3.5 million tonnes more than the actual levels.[9] This means that Croatia has a target of 34.225 million tonnes for 2012, not including land-use changes.

Croatia's GHG emissions in 2006 (the last year for which data is available) amounted to 30.834 million tonnes CO_2e, (a 14.4% reduction compared to the agreed-upon baseline value under the Kyoto Protocol and a 5.2% reduction in emissions in comparison to actual 1990 emission levels). This number does not include the amount of GHG emissions removed by carbon sinks – mostly increasing forest biomass. For the last five years the average increase in GHG emissions has been 1.7 % per year, the main reason for this being the increase of emissions from the energy sector.[10]

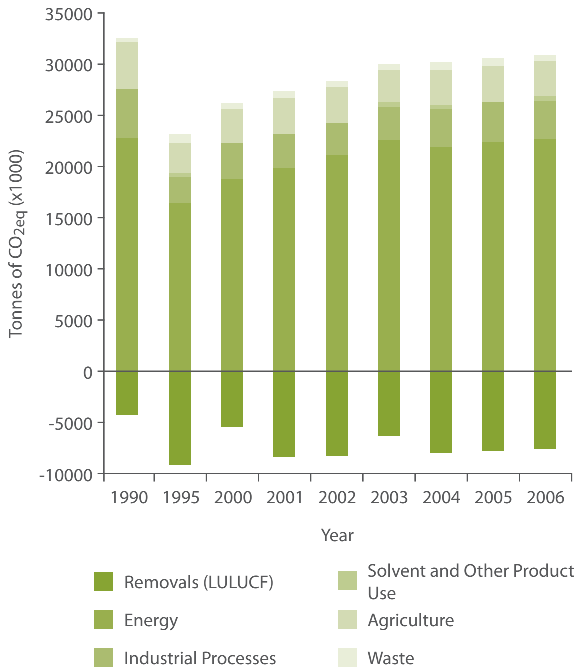
While many different aspects affect Croatia's emissions, the primary sectors are:

- The energy sector (73.13% of 2006 emissions) – including transportation, production of electricity, manufacturing and industry energy production, and fugitive emissions from oil/ natural gas/ coal production.
- The agricultural sector (11.37% of 2006 emissions) – including from livestock, manure management and soil management.
- Industrial processes (12.99% of 2006 emissions) – including mostly cement production, lime production, ammonia production, nitric acid production and consumption of chemicals that are potent GHGs in refrigeration and air conditioning equipment.
- Emissions from waste sites (1.92% of 2006 emissions) – mostly methane gas released from landfills.[III]
- Land use changes (-24.29% of 2006 emissions) – creation of carbon sinks due to the expansion of forests.

However, this is the current situation. In analysing what Croatia can do to reduce emissions by 2020, it is necessary to have a basic idea of what could happen if no steps are taken to reduce emissions – the BAU scenario. Under this scenario, the MEPPPC estimates that emission levels (not counting changes in land use and sinks from forests) would reach approximately 42 million tonnes of CO_2e by 2020 – an increase of 16.6% from the agreed upon 1990 baseline of 36 million tonnes.[11]

[III] These four sectors that emit GHGs represented over 99% of all emissions in Croatia in 2006.

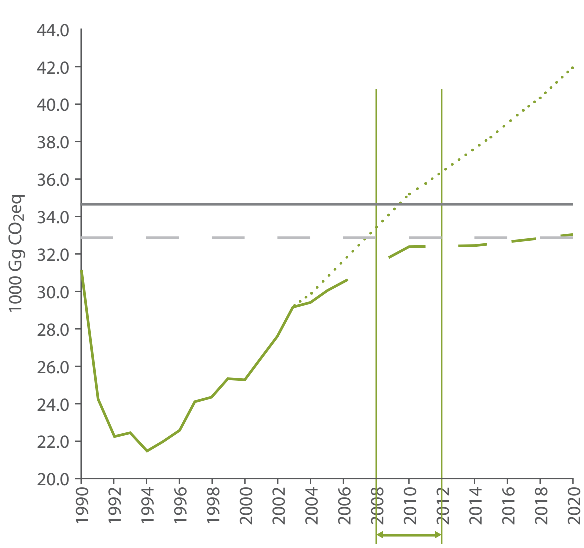
Figure 12-2: GHG emissions from various sectors in Croatia.



Source: MEPPPC 2008b.

Figure 12-3: Likely emissions scenario for Croatia until 2020 – 2008 to 2012 is the period for the Kyoto Protocol.

The dotted line represents the current projections of emmissions under BAU scenario. The dark striped line represents the projections of emmissions if Croatia introduces measures to reduce emmissions and stabilise them by 2020.



Source: MEPPPC 2007: 73.

There are many measures that can be introduced to reduce emissions, and the latest National Communication on Climate Change suggests that emissions can be stabilized by 2020.[12] No estimates are given within this document for how much this stabilization would cost Croatia. Furthermore, no estimate is given for the maximum amount of emissions reductions that would be possible, if the best-case scenario occurred and all reduction measures were introduced successfully.

In order to analyse the economic impacts of mitigation measures, this chapter uses the available information on the likely costs of various emissions reductions in Croatia. Most of this analysis was undertaken using research carried out under the LIFE-funded project, which analysed the marginal costs for various measures to reduce emissions in various sectors.[13] The costs per tonne of reduction represented are derived mostly from Ekonerg's analysis of marginal costs for 2012. Although these costs are likely to change for 2020, this chapter uses those costs to provide a general range of reduction costs, rather than a definitive number (See Box 12-2 for more on the methodology of calculating costs). It is important to note at the outset that for certain measures, there may be other economic benefits from participating in the European Trading Scheme (ETS), which has an average value of EUR 25 per tonne of carbon. There are also other international voluntary schemes where financial resources may be made available for mitigation measures. This would mean that any measure with a marginal cost of less than EUR 25 per tonne of reduction might actually be profitable for actors that implement them if they can sell the credits on the market.

The purpose of this chapter is to give a basic outline of the types of measures that could be introduced to reduce net emissions, how many net emissions could be reduced by 2020 under a "best case scenario," and what the general range of costs for those emissions reductions would be. No single number can answer the question – how much would it cost Croatia to reduce its emissions by 20-30% by 2020. However, this chapter provides suggestions for moving forward that would not overly burden the economy and restrict human development.

Box 12-2: Methodology for calculating emissions reduction potentials and costs

To calculate the likely costs/ benefits of reducing emissions, this analysis focused solely on 2020. The basic concept is to take how much CO_2e can be reduced by a certain measure in that year. Then multiply the total potential reduction by the cost of reduction per tonne of emissions (marginal cost of reduction of CO_2e). If the measure actually has a net benefit – i.e. it is cheaper than carrying out a process that emits more carbon – then the marginal cost of reduction is negative. Energy efficiency measures are a good example of this. Owning a fuel-efficient car or using compact fluorescent light-bulbs (CFLs) saves money over a short time span. On the other hand, if a measure costs extra money – such as replacing coal fired power plants with solar photovoltaic cells – the measure has a positive marginal cost for reduction of CO_2e.

Most of the numbers for potential emissions reductions were taken from Ekonerg's series of top-down models and studies for the LIFE project in 2006 and 2007. In some areas the potential of the reduction measures were only available for either 2015 or 2012. The annual marginal costs of reduction for most measures were calculated in the Ekonerg studies utilizing capital costs, operational costs, and a discount rate of 4%. In those cases, the reduction potentials from previous years were assumed to be the same for 2020 – though they may be larger.

The costs associated with these measures should be considered as rough estimates only. This is because the initial model was based on a timeframe until 2012, whereas this analysis is looking at 2020. Additionally, these estimates did not include the administrative and institutional costs associated with implementation – which may be large in the households and services sector. Because of this and other uncertainties in cost, this analysis took the estimated values plus/ minus EUR 10 per tonne. In certain cases where the initial capital costs would be significant, the timeframe for overall use, once the measure becomes operational, would be more important (such as solar, wind, and nuclear energy production), estimates were taken from the IPCC's most recent assessment of likely costs of mitigation for economies in transition.[14] For the agricultural sector an independent analysis was carried out for the purposes of this Report.

While exact numbers have been calculated for most measures, it is better to provide a range of potential values that reflect the uncertainty of costs – grouping them in terms of whether the measures might have a net economic gain, be close to cost neutral, be economically advantageous in the case of a cost of EUR 25 per tonne, or be more expensive.

All costs are listed in terms of current value, as calculating inflation and Euro or Croatian Kuna values in 2020 is complex and superfluous to the core message of this chapter.

12.2. Reducing emissions due to energy use

The energy sector is the largest source of GHG emissions in Croatia – covering emissions from all activities, including fossil fuel consumption and fugitive emissions from fossil fuel production, transport, processing, storage and distribution (See Figure 12-4).

Energy consumption in general is rising in Croatia, though in 2006 total energy consumption was slightly lower than in 2005. Within the energy sector, there are many important, new developments. First, energy efficiency can potentially play a vital role in Croatian energy policy. One of the goals of energy policy in the Republic of Croatia, defined in the Strategy of Energy Sector Development[15] is to improve the overall efficiency of energy production, central transformation/ conversion, transmission/ transport, as well as energy consumption. However, as no implementation strategy for energy efficiency currently exists, energy savings and improved energy efficiency have not yet been achieved. Consequently, the total primary energy consumption intensity (energy used per Euro of GDP) in Croatia is 20.1% higher than the EU-15 average.[16] This is a burden to both the national economy and physical environment. It is estimated that approximately 1% of national GDP is wasted as a result of low energy efficiency. [17]

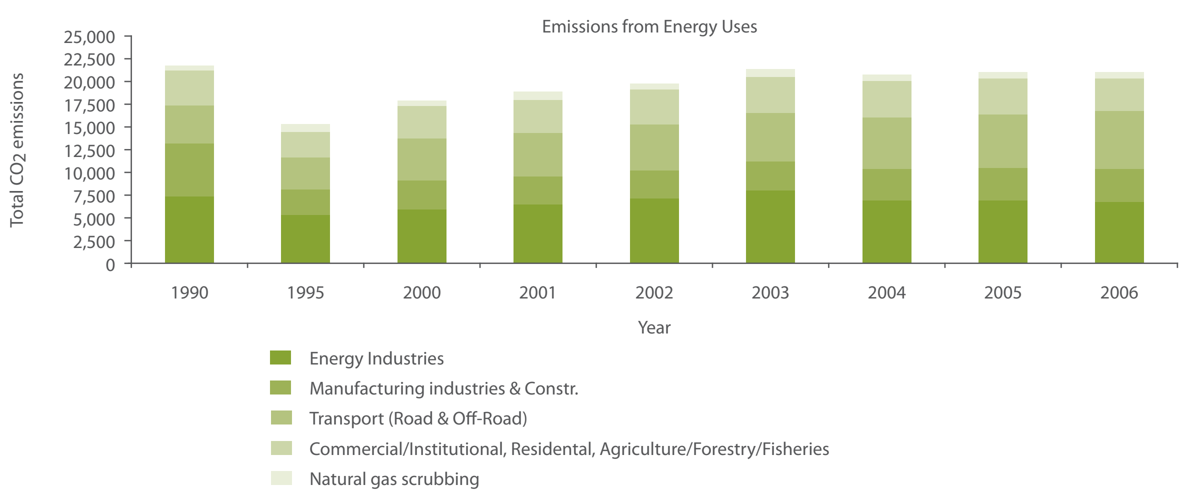
As part of the EU accession process, Croatia is swiftly moving forward with its energy efficiency and renewable energy plans. According to the EU Directive,[IV] member states must adopt and aim to achieve an overall national energy savings of 9% in the ninth year of application of the Directive. The Croatian national target is calculated based on the average consumption of energy for 2001-2005. Therefore, Croatia must immediately begin to move forward with energy efficiency measures (See Chapter 13 for more on energy efficiency activities in Croatia).

Furthermore, Croatia has committed to producing at least 5.8% of all its electricity from renewable energy sources other than major hydropower plants, by the end of 2010.[18] This begins to put Croatia on the path towards efficiency and greener energy. Croatia's new energy strategy will identify numerous goals for renewable energy production in order to meet predicted 2020 energy requirements. However, at the time of drafting this Report, this strategy had not been finalised. Emissions by energy sub-sectors are presented in Figure 12-4. Many potential measures exist to reduce emissions from the energy sector, which can be divided into the following categories: electricity production, energy use for industrial use, energy used by households and the service sector, and energy used for transport.

[IV] Directive 2006/32/EC on energy end-use efficiency and energy services.

> “The energy sector is the largest source of GHG emissions in Croatia
>
> It is estimated that approximately 1% of national GDP is wasted as a result of low energy efficiency”

Figure 12-4: CO_2 emission by sub-sectors from the energy sector in the period 1990-2006 (x 1000 tonnes CO_2)



12.2.1. Measures in reducing emissions from electricity production

Electricity production generates GHG emissions through the burning of fossil fuels. The consumption of energy from electric and heat power production in thermal power plants, public heating plants and public cogeneration plants resulted in approximately one fifth of all emissions in Croatia in 2006. The basic ways to reduce emissions from production are to change the fuel, which drives electricity production, or to increase the efficiency of the production system. Changing the fuel involves shifting some electricity production to sources that do not emit GHGs (such as nuclear fuel), emit less GHGs (such as natural gas), or renewable sources (such as biomass that does not involve cutting down trees, solar electricity, wind energy, etc.). Reductions due to decreased demand are also possible and discussed in section 12.2.2 and 12.2.4. The list of potential emissions reduction measures, their potential for GHG emissions by 2020 and the associated costs per tonne of reduction are listed in Table 12-1. As can be seen, numerous measures can be taken that have net costs close to zero, though this does not include implementation costs.

If all these measures were implemented, it would result in a GHG reduction of 7.848-7.890 million tonnes. However, the majority of this reduction (5,500,000 tonnes) results from the construction of a new 1000 MW nuclear power station. This may not be the most sustainable or politically acceptable option, even if it would result in significant reductions. Where to put a nuclear plant and what to do with the waste are important questions that must be addressed using the principles of fairness and sustainability. Indeed, this is an issue being discussed for the recently proposed Energy Strategy. It should also be noted that the use of biomass for electricity production is very expensive.

Table 12-1: Potential emissions reductions and costs per measure for the year 2020 from changes in electricity production[19]

Emissions reduction measures in electricity production	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Reductions in losses from the distribution grid and potential reductions in emissions of CO_2 (4,5% decrease in losses)	56,300	-EUR 10	EUR 10	-563,000	563,000
Reduction of emissions due to electricity produced from biomass[20]	700,000	EUR 76	EUR 145	53,200,000	101,500,000
Cogeneration potential delivered onto the public electricity grid	297,000	EUR 10	EUR 30	2,970,000	8,910,000
Increasing central district heating systems and cogeneration	39,000	EUR 10	EUR 30	390,000	1,170,000
Reduction of emissions from building small hydropower[21]	71,000 to 113,000	EUR 20	EUR 50	1,420,000	2,260,000
Reductions from usage of wind power[22]	1,125,000	EUR 24	EUR 50	27,000,000	56,250,000
Reductions from usage of nuclear fuel (by building one 1000 MW nuclear power station)[V]	5,500,000	-EUR 14	EUR 14	-77,000,000	77,000,000
Reductions from usage of geothermal[23]	60,000	-EUR 11	EUR 20	-640,000	1,200,000
Total possible emissions reduction from electricity production	7,848,300-7,890,300			6,777,000	248,853,000

[V] Cost estimates from IPCC (Sims et al. 2007) estimate for Economies in Transition for 2030.

12.2.2 Measures in reducing emissions due to energy use in industry

Another area within energy where emissions can be reduced is in industry – by changing the way energy is produced or increasing efficiency. The possible measures are outlined in Table 12-2. If all measures were introduced, the total emissions reduction during the year 2020 would be 1.785 million tonnes. Most of these measures are either cost neutral or would actually have a positive impact on the balance sheets of industries. This is because most use waste as a fuel (which does not have as high a purchase cost as, for instance, natural gas) or involve increasing energy efficiency.

It should be noted that the last measure noted in the table – pumping CO_2 underground for Enhanced Oil Recovery (EOR) purposes or into water, after production – needs further analysis in Croatia, as its use as a long-term solution is questionable: Underground CO_2 might seep out at a later date, essentially a postponement of emissions. However, if this seepage occurs over a few centuries, this would not be a problem, as CO_2 is not toxic if it leaks slowly. Additionally the emissions problem might be solved in the next century. If it is proven as viable, the EOR might be considered a CCS (Carbon Capture and Storage) technology. CCS technology is regarded as one of the most promising in terms of curbing GHG emissions in the future. Reducing GHG emissions to levels that will not cause catastrophic changes will not be possible without breakthrough technologies such as this one. Some of these technologies do not yet exist, while others (including CCS) are available, but need to be tested and become commercially available.

Table 12-2: Potential emissions reductions and costs per measure for the year 2020 from changes in energy use in industry [24]

Emissions reduction measure in industry	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Use of biomass for energy use for industry and construction	100,000	-EUR 45	-EUR 25	-4,500,000	-2,500,000
Increased energy efficiency in industry and construction (including cogeneration)	800,000	-EUR 30	-EUR 10	-24,000,000	-8,000,000
Use of biologically-based waste products for energy use for industry - especially refuse derived fuel (re-used materials) of biological and fossil origin and dried sludge - especially in the cement industry	202,000	-EUR 10	EUR 10	-2,020,000	2,020,000
Increasing the energy efficiency of the process of clinker production	53,000	EUR 0	EUR 20	0	1,060,000
Reduction of emissions of CH_4 by using waste as an alternative source of energy in the production of cement and other industrial goods (removing the source of CH_4)	130,000	Unknown	Unknown	Unknown	Unknown
Pumping CO_2 underground after production (technology unproven)	500,000	Unknown	Unknown	Unknown	Unknown
Total possible emissions reduction from energy use in industry	1,785,000			-30,520,000	-7,420,000

12.2.3. Measures in reducing emissions through changing energy use in households and the service industry

Better energy use within households and the service industry reduces emissions through a variety of mechanisms. The first and most economically advantageous way to reduce emissions is through energy efficiency. Energy efficiency measures can be used in the construction of new buildings, redesigning the building envelopes (e.g. installing more insulation) and roofs, and introducing technology such as efficient light-bulbs (CFLs – compact fluorescent light-bulbs) and appliances, in both offices and in households. Additionally, there are relatively inexpensive (in the long term) measures such as installing solar collectors and biomass heating systems. Finally, the installation of photovoltaic solar systems and advanced solar systems is the most expensive measure, though the potential exists for its implementation.

In total, emissions reductions from this sub-sector could be up to 1.981 million tonnes by 2020, with a net benefit of between EUR 57.8 million and 102.9 million for that year. This is mostly due to savings in energy use. However, while energy efficiency in households may have the significant potential to reduce emissions and be economically advantageous, the associated

Table 12-3: Potential emissions reductions and costs per measure for the year 2020 from changes in energy in households and services [25]

Measures in households and the service sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Savings of electricity in households – due to lighting changes (CFLs)	416,000	-EUR 145	-EUR 125	-60,320,000	-52,000,000
Savings of electricity in households – energy efficient appliances	282,000	-EUR 145	-EUR 125	-40,890,000	-35,250,000
Savings of electricity in households due to reduction of consumption of electricity for heat	28,000	-EUR 145	-EUR 125	-4,060,000	-3,500,000
Reduction of heat losses - due to complete reconstruction of building envelopes	26,000	-EUR 40	-EUR 20	-1,040,000	-520,000
Reducing heat losses from roofs	4,000	-EUR 40	-EUR 20	-160,000	-80,000
Reducing heat losses from windows	22,000	-EUR 40	-EUR 20	-880,000	-440,000
Energy Efficiency in offices	461,000	-EUR 25	-EUR 5	-11,525,000	-2,305,000
Reducing heat losses on new buildings	134,000	-EUR 25	-EUR 5	-3,350,000	-670,000
Solar collectors for water heaters	20,000	-EUR 10	EUR 10	-200,000	200,000
Renewable energy use in offices	109,000	-EUR 10	EUR 10	-1,090,000	1,090,000
Use of biomass in small heating systems and households	379,100	EUR 10	EUR 30	3,791,000	11,373,000
Use of fuel cells and Photo-voltaic cells[VI]	39,000	EUR 40	EUR 192	1,560,000	7,488,000
Solar energy - advanced systems	61,000	EUR 250	EUR 275	15,250,000	16,775,000
Total possible emissions reductions from measures in the households and services sector	1,981,100			-102,914,000	-57,839,000

[VI] Cost estimates from IPCC (Sims et al. 2007) estimate for Economies in Transition for 2030.

implementation costs (such as subsidies for CFLs, for construction costs, etc.) make this less economically attractive – though still beneficial. These savings will also rely on policies and energy efficiency standards for appliances and isolation materials, including building codes for new buildings with specific energy efficiency requirements. In addition, public information on energy efficiency will assist people in making the right choices. Product labels that clearly indicate energy consumption (and money saved) is one of the key tools. Most of these measures are underway to some extent in Croatia (see Chapter 13 for more on existing activities related to this).

12.2.4. Measures in reducing emissions through changing energy use in transport

As Croatia develops economically, more people are buying cars and driving. There are also more emissions from air and sea travel. Thus, the transportation sector represents a significant and growing portion of emissions – mostly from road transport. In 2006, transportation emissions were one fifth of all emissions in Croatia. Transportation emissions grew from 4.266 million tonnes per year in 1990 to 6.226 million tonnes in 2006 – which was largest increase for any sub-sector within energy during that period.[26]

Table 12-4: Potential emissions reductions and costs per measure for the year 2020 from changes in the transport sector

Measures in the transport sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Using vehicles with less emissions (140 gCO_2/km)	200,000	-EUR 60	-EUR 40	-12,000,000	-8,000,000
Using fuels with less carbon - LPG and CNG versus diesel or gasoline	100,000	-EUR 10	EUR 10	-1,000,000	1,000,000
Using biodiesel	370,000	EUR 90	EUR 110	33,300,000	40,700,000
Using bioethanol and hydrogen cells	270,000	EUR 90	EUR 110	24,300,000	29,700,000
Measures in inter-city passenger transport - improving roads, encouraging railroad travel, sea and intermodal transport, decrease of traffic jams	96,000	Unknown	Unknown	Unknown	Unknown
Measures in city passenger travel-building bike lanes, encouraging public transport, decrease of traffic jams	81,000	Unknown	Unknown	Unknown	Unknown
Measures in goods transport - ensuring efficiency of motors/ low emissions, putting "spoilers" to decrease air resistance on vehicles, encouraging fuel efficient driving	460,000	Unknown	Unknown	Unknown	Unknown
Total possible emissions reductions from measures in the transport sector	1,577,000 (940,000 in the cost analysis)			44,600,000	63,400,000

Reductions in emissions from transport will require using vehicles (including public transportation vehicles and goods transport vehicles) that are more fuel efficient, changing fuels to less carbon intensive fuels, using biodiesel or other biofuels, or by reducing the amount of kilometres travelled by cars in general. Reducing the emissions per kilometre travelled by personal vehicles to 140 gCO_2/ km (from 2003 levels of approximately 164 gCO_2/km)[27] would achieve large cost effective savings.[28] This level 140 gCO_2/km is approximately the emissions for vehicles that use 4.5 litres per 100 km of regular gasoline and 5 litres of diesel per 100 km.

While Croatia does not produce cars, the Government can have significant influence over the type of cars that are bought and sold through fees on carbon and other emissions, requiring better labelling of fuel economy, encouraging fuel efficient driving habits, etc. Additionally, there is a large level of potential emissions savings by switching fuels from gasoline or diesel to compressed natural gas (CNG) or liquid petroleum gas (LPG) – both of which are produced in relatively small amounts in Croatia but can be imported. The same is true for biodiesel – for which there is a production capacity of 20,000 tonnes per year in Croatia.[29] It should be noted that in this analysis, the costs for utilising biodiesel, bioethoanol, and other biofuels is considered the same. This is probably not actually the case,[30] but given the level of uncertainty in future price, it is the estimate used in this calculation.

In total, implementing all measures would lead to reductions of over 1.5 million tonnes per year in 2020 (See Table 12-4). It is important to note that the measures for which the cost is unknown are probably good practices for the sustainable development of cities and transportation in general. Encouraging alternative (non-auto) transportation and effective inter-city/ intra-city traffic flows is desirable regardless of climate change.

12.3. Reducing emissions in the agricultural sector

12.3.1. Global GHG emissions from agriculture

One sector where emissions reductions are only just beginning to be examined in Croatia is agriculture. Agriculture is a significant source of nitrous oxide and methane emissions – both GHGs.[31] Agricultural soils and livestock directly emit GHGs, while indirect emissions come from fossil fuel use in farm operations, the production of agrochemicals and the conversion of land from forests to fields.[32] In 2004, direct emissions from agriculture represented 13.5% of all global anthropogenic GHG emissions.[33] The total global contribution of the agricultural sector, including all direct and indirect emissions, is estimated at 8.5-16.5 billion tonnes of CO_2e – 17% to 32% of all global man-made GHG emissions.[34] In the EU (excluding Bulgaria and Romania), agricultural direct emissions contributed to 9.2% of the total GHG emissions in 2004.[35]

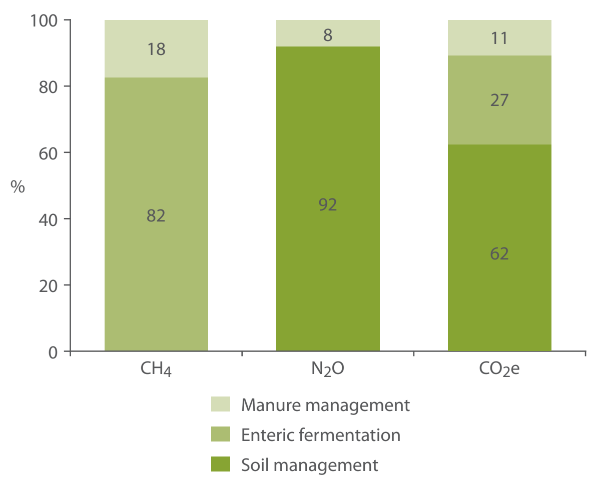
Livestock farming and fertiliser use are by far the two most significant sources of GHGs from agriculture, while enteric fermentation and ruminant livestock (cattle, sheep and goats) produce methane, contributing to about 60% of all global methane emissions.[36] Manure usage, storage and decomposition also produce GHG emissions, of both methane and nitrous oxide, while fertilisers applied on agricultural land emit nitrous oxide, a major direct emission source. Besides livestock farming and fertilisers, agriculture emits GHGs through the production of legume crops, residue burning and land use change (e.g. conversion of carbon-rich grassland soils or forests into farm land).

To date, carbon losses from agricultural soils have not been reported in the national GHG inventories. However, these are substantial and in the EU-15 have been estimated at 10-20 million tonnes of CO_2e per year, adding 4-8% to GHG emissions in the EU-15.[37]

12.3.2. GHG emissions from Croatian agriculture

In 2006, the Croatian agricultural sector emitted 3.5 million tonnes of CO_2e – 11.4% of the country's anthropogenic GHG emissions in that year.[38] In the period 2001-05, livestock farming was responsible for a little over half of the direct GHG emissions from agriculture, while crop production produced the rest.[39] Most methane is produced from enteric fermentation (of which cattle produce the most – see Figure 12-5). The vast majority of nitrous oxide emissions resulted from current soil and manure management practices.

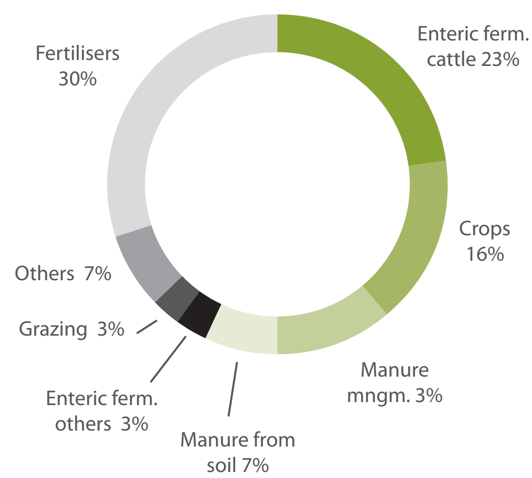
Figure 12-5: GHG emissions by gas and management/ natural process.



Source: modified after Znaor 2008.

The biggest single source of GHGs in agriculture was from fertilisers applied to agricultural land, followed by the enteric fermentation from cattle, crops (nitrogen-fixing crops, crop residues and related nitrogen leaching), and manure management (See Figure 12-6 for all of the categories). Besides the emissions presented in Figure 12-6, two additional sources of GHGs result from agriculture: the burning of residues and carbon losses from agricultural soils. Burning agricultural residues is prohibited in Croatia and is thus not included in the national GHG inventory.[40] While some farmers still practise this, these emissions have been estimated at about 1000 tonnes of CO_2e per year – a very small amount. The UNFCCC does not require carbon losses from agricultural soils to be reported in the national GHG inventories. These have been estimated at 1.179 million tonnes per year in Croatia, adding an additional 35% to emissions from farming.[41]

Figure 12-6: GHG emissions by source.



Source: modified after Znaor 2008.

12.3.3. Croatian GHG agriculture emissions forecast

Future GHG emissions from the Croatian farming sector are very difficult to estimate for a number of reasons:

1. Croatian agriculture is still at a crossroads, struggling to accommodate both numerous small-scale family farms and large-scale agricultural companies. Its future development is unclear.
2. In 2000, Croatia had half the livestock of the 1980s.[42] The Government has initiated several programmes aimed at increasing livestock numbers[43] and this policy is likely to continue. Consequently, GHG emissions – notably methane – would increase.
3. The consumption of fertilisers decreased by almost a third during 1999-2006. By subsidising the price of natural gas for fertiliser production[44] and by forcing the sole domestic fertiliser manufacturer (Petrokemija) to sell fertiliser below the market price,[45] the Government has stimulated higher consumption. As this policy will probably continue, fertiliser consumption is likely to remain the same or increase – resulting in similar or increased nitrous oxide emissions.
4. The EU Nitrates Directive forces Croatia to improve its manure management and to reduce nitrogen losses. With the assistance of the World Bank, the Government has already started related pilot projects.[46] It is very likely that in the near future manure management in Croatia will be substantially improved, resulting in lower GHG emissions from manure.
5. The Croatian organic farming sector has expanded rapidly in recent years. During 2000-2007 the area farmed organically increased from 13 to 7,577 hectares, but this still represents only 0.62% of all agricultural land in Croatia. Increasing the practice of organic farming could reduce GHG emissions (See Box 12-3).

Croatia's latest report to the UNFCCC[47] presents an assessment of the mitigation potential for Croatia and GHG emissions scenarios until 2020. Overall, in the BAU scenario, GHG emissions are projected to increase 13% by 2020 – up to around 3.9 million tonnes in agriculture.

12.3.4. Possible mitigation measures

Agriculture can play a role in climate change mitigation through three mechanisms:

1. By reducing GHG emissions from agricultural soils, livestock and manure management (e.g. reduced or more efficient use of fertilisers, prevention of nitrogen leaching from soil, improved manure management, reduction or replacement of ruminants

Box 12-3: Mitigation potential of organic farming

Organic farming contributes to the reduction of greenhouse gas (GHG) emissions because it reduces the consumption of fossil fuels (notably those used in fertiliser manufacturing), reduces emissions of CO_2, methane and nitrogen oxides and reduces the vulnerability of soils to erosion, while at the same time increasing carbon stocks in the soil.[48] Consequently, conversion to organic farming is considered a viable way of reducing GHG emissions. Depending on the commodity produced, organic farming emits 6-31%,[49] 18%,[50] 29-37%,[51] or 48-60%[52] less GHGs than non-organic farming. Average CO_2 emissions per unit area from organic beef are 57% lower than for non-organic production.[53] However, if there are substantially lower yields, organic farming results in higher GHGs per kg of product.

Numerous studies have shown that, despite their reliance on frequent mechanical weed control, organic farming systems can increase soil organic matter stocks.[54] One study[55] also found that besides the total carbon, organic farming results in more particulate organic matter (fine fraction of soil organic matter which is difficult to form) than conventional farming. Various long-term trials have shown that the annual carbon increase in soil from organic farming is 12-28%.[56] Surprisingly, the "biodynamic"[VII] treatment accumulated the most amount of carbon in the soil despite the fact that it was supplied with about 20% lower organic matter in manure than other manure-based treatments.

[VII] The oldest organic farming method, established in 1924 by Dr. Rudolf Steiner- an Austrian philosopher born in Croatia.

with other livestock, a less nitrogen-rich diet for livestock, less burning of crop residues, etc.).

2. By reducing its indirect emissions, notably those arising from fertiliser production, transport and application.

3. By restoring natural vegetation (e.g. converting arable land to grassland or forests or converting drained arable land back to wetlands), or by enhancing carbon storing management practices (e.g. the inclusion of grassland crops in arable rotations, reduced soil disturbance, avoiding bare soil, etc.). This mechanism can be regarded as a change in "Land Use, Land Use Changes and Forestry" which must be officially recognized in international negotiations for Croatia to gain credits for this reduction. However, the analysis in this Report demonstrates the tremendous mitigation possibility of this measure. (See Section 12.6)

In Croatia, all three mechanisms are likely to have a positive mitigation effect. The second measure, however, cannot be regarded as a direct mitigation measure of the agriculture sector, since the mitigation action has to be tackled primarily by the industrial sector and the transport sub-sector of energy.

12.3.5. Possible mitigation scenarios for agriculture

This Report presents seven possible mitigation scenarios. They are based on different approaches and technologies that could theoretically be applied to realise mitigation effects:

1. The "BAU (business as usual)" scenario assumes the continued gradual development of high-input agriculture, resulting in a 20% increase in livestock numbers and a 20% increase in fertiliser consumption by 2020.

2. The "Manure 50%" scenario assumes improved manure management, complying with the requirements of the EU Nitrates Directive by 2020 and emitting 50% less GHGs from manure than in 2005.

3. The "Fert -70%" scenario, envisages a 70% reduction in fertiliser consumption by 2020. This is based on a World Bank assessment suggesting that a 63-78% cut in nitrogen fertiliser use would be required to ensure that nitrate content in Croatian waterways falls below the Maximum Admissible Concentrations (MAC).[57]

4. The "Ruminants reduced 25%" scenario, projecting a substitution of 25% of ruminant livestock with non-ruminant livestock (e.g. swine and poultry) by 2020, but maintaining the same livestock unit value (body weight) as 2005.

5. The "Organic 25%" scenario, assumes the conversion of 25% of agricultural land to organic farming by 2020. It envisages the same crop and livestock mix as in 2005 and the calculation is based on a study commissioned by the UNFAO[58] and a follow-up study.[59] It does not take into account the carbon sequestration effect of organic management.

6. The "Best available technology (BAT)" scenario assumes adopting the best available practice to reducing GHGs by 2020. It assumes the manure management efficiency of the "Manure 50" scenario and fertiliser inputs in the "Fert -70%" scenario. In addition, it assumes a 30% reduction of non-fertiliser related leaching and a 30% reduction of emissions from applied organic manures. It has the same crop and livestock mix as in 2005.

The measures that are evaluated in the cost-benefit analysis are:

- Business as Usual.
- Implementation of the Best Available Technologies including better manure management, decreased fertilizer use, a 30% reduction of non-fertiliser related leaching and a 30% reduction of emissions from applied organic manures.
- Implementation of changes in the livestock mix towards non-ruminant livestock, keeping the same level of total livestock units.
- Conversion to 25% organic farming.

12.3.6. Cost-benefit analysis of agriculture measures

The analysis of the costs and benefits of reducing emissions from the Croatian agricultural sector is difficult to carry out and is currently unavailable. Croatia lacks the standard gross margins for crops and livestock and the data on agricultural investments are scarce and often location-specific. Additionally, there is very little quantitative information on organic matter turnover, its decomposition and humification that specifically relates to the situation in Croatia. As a sound cost-benefit analysis of each mitigation measure is beyond the scope and resources of this Report, we can only present a tentative cost-benefit calculation. Although this gives a likely order of magnitude, it should be treated with caution.

Figure 12-7 shows the average annual net benefits of mitigation measures. "Ruminants reduced 25%" and "Organic 25%" are the only scenarios showing a positive net benefit (= benefits minus costs). The high benefit (low cost) arising from the "Ruminants reduced 25%" scenario is because the gradual replacement of ruminants with non-ruminants does not involve significant costs and because non-ruminants produce a gross value-added nearly two times that of ruminants per Livestock Unit, while at the same time reducing methane emissions by almost 90%. However, a possible repercussion from this shift may be a loss in milk production. The organic farming scenarios benefit from the fact that the organic farming GVA per hectare is comparable with that of non-organic production and because it saves public money invested in fertiliser manufacturing and transport.

Box 12-4: Information on the cost-benefit analysis for agriculture

A cost-benefit assessment must first establish which and whose costs and benefits are to be assessed. Is it only the direct costs linked with the introduction of mitigation measures? And should the assessment also include related public investments and environmental costs arising from GHG emissions. Similarly, it should be known who should pay these costs, why, and to what extent. Should it be society (from public money), the food processing and tobacco industry, consumers or farmers themselves? There are justifiable arguments for and against all of these options, but discussing these is beyond the scope of this Report.

Based on the available data, the following factors were considered to calculate the cost of mitigation:

1. The investment and costs of technological changes required to implement mitigation measures (e.g. purchase of new machinery, livestock, etc.).
2. Lost opportunity costs linked with the introduction of mitigation measures (e.g. lost revenue resulting from the replacement of highly profitable crops with carbon-building grasses/legumes).
3. Public investments – hidden and direct subsidies, legislation and informative/capacity building programmes preventing climate-destructive practices and/or facilitating the adoption of mitigation measures.
4. The costs of implementing the changes.

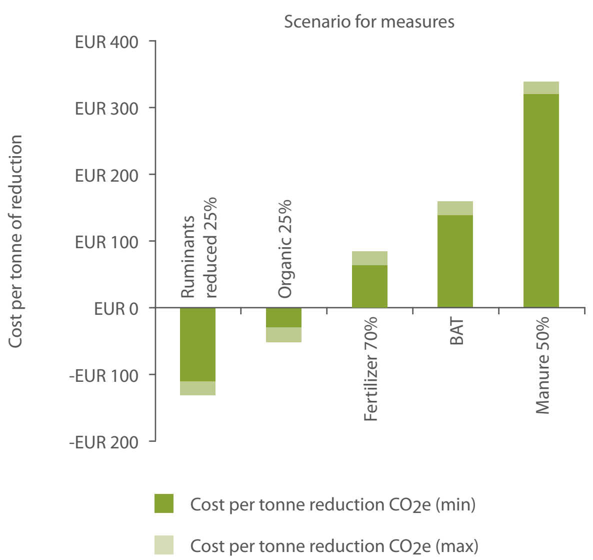
The benefits calculated included:

1. Extra profit generated by the introduction of the mitigation measure (e.g. increased yield, reduced cost of fertiliser use, etc.).
2. Saved public money (e.g. reduced subsidies for fertiliser manufacturing and transport).

The crop and gross-margin calculations are based on the information provided by the Croatian Agricultural Extension Institute[60] and Znaor (2008). Public investments are taken from Znaor (2008). The cost of manure management compliance with the EU Nitrates Directive and subsidies required for the introduction of measures are taken from a World Bank (2008) study on the topic. The soil carbon calculations are based on Znaor (2008) and assume a net sequestration of 0.7 tonnes of carbon per hectare per year.

The "Fert -70%" scenario leads to reduced yields but benefits from the money saved from less fertiliser purchase. The "Manure 50%" scenario involves significant investment and adaptation costs related to stables and manure facilities. The BAT scenario combines the costs and benefits allocated under "Fert -70%" and "Manure 50%", though there would be additional benefits from reduced non-fertiliser induced nitrogen leaching. It should be noted that some form of fertilizer reduction and manure management might be necessary and will probably be implemented under EU regulations, though it is unclear exactly how much.

Figure 12-7: Estimated marginal costs per tonne of CO_2e reduction in 2020.



12.4. Reducing emissions from industrial processes

With the collapse of industry in Croatia in the early 1990s, emissions from industrial processes dropped by more than a third. Since then, industrial processes have increased gradually and were responsible for approximately 13% of Croatia's emissions in 2006.[61] Most of those emissions were from either cement production, lime production, ammonia production (for fertilisers), or nitric acid production. These processes emit CO_2 and other GHGs such as methane and nitrous oxide.

The first industry examined is the cement industry. For each tonne of cement produced, ¾ of a tonne of CO_2 is emitted through the chemical process. This does not include the energy needed to produce and distribute the cement (discussed earlier). There are four manufacturers of cement in Croatia producing mainly Portland cement with a dry process (which leads to fewer emissions).[VIII] In 2006, 3.7 million tonnes of cement were produced, however, this is increasing. Production of cement is expected to grow to 4.43 million tonnes in 2020. The value of the Portland cement sold in 2007 was EUR 225 million.[62] A second type of cement called "Aluminate cement," is also produced, though its emissions are negligible compared to those related to the

[VIII] Dalmacijacement d.d., Holcim Hrvatska d.o.o., Našicement d.d. and Istra Cement d.o.o.

Table 12-5: Potential emissions reductions and costs per measure for the year 2020 from changes in the agriculture sector

Measures in the agriculture sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Ruminants reduced 25%	578,000	-EUR 110	-EUR 90	-63,580,000	-52,020,000
Organic 25%	515,000	-EUR 30	-EUR 10	-15,450,000	-5,150,000
Fert -70%	840,000	EUR 65	EUR 85	54,600,000	71,400,000
Best Available Technologies	1,084,000	EUR 140	EUR 160	151,760,000	173,440,000
Manure 50%	303,000	EUR 320	EUR 340	96,960,000	103,020,000
Total possible emissions reductions from measures in the agricultural sector: Ruminants reduced 25% + 25% organic + Best Available Technologies	2,177,000			72,730,000	116,270,000

production of Portland cement. In total, the industry employs a little over 2000 people who are directly involved in the industry.

During cement production, CO_2 is released into the atmosphere as a by-product of clinker production. Clinker production has increased 42.8 % since 1990. According to trends, emissions will increase by 538,000 tonnes CO_2 by 2020 (to 3,100,000 tonnes) if no actions are taken. This emissions projection includes emissions from energy consumption, which is covered in Section 12.2 above. By reducing the amount of clinker in cement to EU standards, it would be possible to reduce emissions significantly in 2020, for a net cost close to zero. This means that it may be economically beneficial to do this for the companies if regulations allow it. Considering the upcoming impact of the ETS system and the current carbon fee in place in Croatia, the option seems particularly economically viable. However, certain legal and technical issues must be resolved before this option can be implemented.

Other potential indirect CO_2 emissions reduction measures in other sectors related to cement production (energy, waste management, transport) include:[63]

- Preventing emissions of GHG at waste collection sites. This means mostly burning fuel from waste materials (already included in Table 12-2) and consequently reducing emissions from the waste that would otherwise lie in the waste storage site.
- Building concrete roadways that uses less energy than asphalt roadways. These roadways emit less CO_2 directly and indirectly. Concrete roads are more enduring and need less maintenance than asphalt roads. Concrete roads also affect fuel savings. Cargo vehicles could save up to 10% of fuel driving on concrete roads. In some EU countries (Germany, Belgium, and Austria) 25% of the roads are concrete, whereas, in Croatia they are rarely built.

A second industry examined is nitric acid production. In the production of this chemical – which is used for a variety of processes – the GHG nitrogen oxide is released. By changing the industrial process that produces nitric acid, it would be possible to decrease emissions significantly. By assuming the same emissions levels and same reduction potential for 2020 as for 2012, the potential reduction would be 820,000 tonnes of CO_2e in 2020. The cost would be minimal, and, similar to changing the amount of clinker production, may actually be economically beneficial (less than EUR 1 per tonne of reduction), which would be worth reducing if those emissions reductions can be sold on the carbon market.[64]

Fertiliser and lime production are also important sources. The fertiliser industry is particularly important: the Petrokemija fertiliser manufacturer alone accounts for 30% of Croatia's natural gas consumption and 5% of Croatia's anthropogenic GHG emissions.

Table 12-6: Potential emissions reductions and costs per measure for the year 2020, resulting from changes in industrial processes

Measures in industrial processes	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Reduction of the share of clinker in cement from 77% on average by max 14% by 2020 because of changes in defined norms and characteristics of cement.	364,000	-EUR 10	EUR 10	-3,640,000	3,640,000
Production of nitric acid – non-selective catalytic production in the process – a chemical reaction to eliminate 80-90% of GHGs by converting N_2O to just nitrogen.	820,000	-EUR 10	EUR 10	-8,200,000	8,200,000
Total possible emissions reductions from measures in industrial processes	1,184,000			-11,840,000	11,840,000

However, no data is available regarding reduction potentials in these industries.

By changing industrial processes, it appears possible to reduce emissions from cement and nitric acid production by over 1 million tonnes in 2020. The economic impacts of these reductions are unclear as the marginal costs of reduction are close to zero. The current air pollution fee assessed by the Croatian Government will become 18 HRK (EUR 2.46) per tonne in 2009. This fee increase will mean that the marginal costs of introducing measures would decrease by EUR 2.46 per tonne for both industries.

12.5. Reducing emissions from waste management

The final emissions source analysed is waste management. The waste management sector was responsible for 591,000 tonnes of CO_2e in 2006 – a little under 2% of total emissions. These emissions are primarily from the escape of methane gas from waste sites after the decomposition of waste material. Therefore, emissions reduction is possible by:

- Reducing the amount of waste that goes to waste sites – either by reducing the actual amount of waste or taking some of the waste and using it as a fuel source in other processes, such as heat generation for industry
- Treating the waste through thermal waste treatment (essentially burning waste), or
- Burning the escaping methane gas – potentially using it as an energy source.

While costs were not available for all these measures, the likely marginal costs for the reduction of emissions by burning methane at the sites is estimated to be close to zero – or between EUR -10 and 10 per tonne.[67] This measure could reduce emissions by 175,000 tonnes per year in 2020 (see Table 12-7). Thus, the net cost-benefit would be somewhere between EUR -1,750,000 million and EUR 1,750,000 per year for 2020.

The costs for the other measures are not available, but are likely to be low – and might result in a net benefit. HEP is already undertaking preliminary planning for a plant which uses waste as the fuel for producing energy – essentially burning waste for fuel.

Table 12-7: Potential emissions reductions and costs per measure for the year 2020 resulting from changes in waste management processes[68]

Measures in the waste management sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Reduction of emissions by burning CH_4 from flaring	175,000	EUR -10	EUR 10	-1,750,000	1,750,000
Reduction of emissions of CH_4 by thermal waste treatment – burning waste	180,000	Unknown	Unknown	Unknown	Unknown
Total possible emissions reductions from measures in the waste management sector	355,000 (175,000 estimated for costs)			-1,750,000	1,750,000

12.6. Reducing net emissions due to land-use, land use changes and forestry (LULUCF)

Carbon can also be absorbed by the environment in a number of ways. A major "carbon sink" in Croatia is the changes in land use. Significant portions of Croatian land have gradually become forested and are included as a reduction in CO_2e. In 2006, this amounted to an estimated net reduction of 7,490,000 tonnes – or almost a quarter of all Croatia's emissions. Forests cover 37% of the mainland of Croatia, 81% are owned by the State and the rest are privately owned.[69] Essentially, this means increasing the amount of forests, shrubs, or the thickness of trees in forests. Interestingly, the current level of almost 7.5 million tonnes of reductions has occurred, not as a result of climate change concerns, but rather because of other factors such as abandoned farmland and nature protection measures. The average amount of reductions due to land-use changes from 1990-2006 was 7.75 million tonnes.[70] It is unclear whether this amount of forest biomass growth will continue into the future, but it seems probable.[71]

However, as no cost-benefit analysis is available for these reductions in Croatia, it cannot be included in this analysis in terms of the likely costs of this measure. While cost-benefit analyses are available for other countries,[72] it is unlikely that the results transfer well to the situation in Croatia, where land use changes are contributing to mitigation without specific climate change policies encouraging this. Furthermore, it is likely that only part of the total sink belonging to forest management activity will be counted in the post-Kyoto period. Under the current Kyoto Protocol allocations, Croatia has a cap for what can be counted as a sink - 0.97 million tonnes CO_2e.

An additional change in land use that could have a significant impact is increasing the carbon content in soils. Through changes in farm management – the use of grass-clover crops, the application of green manures/green cover crops and under-sowing of cereals – carbon can be absorbed by the soil which produces better farming conditions including guarding against water loss (see Chapter 8). An annual carbon sequestration of 700 kg C per hectare over a 15-year period is possible with the right management techniques. A linear annual increase of the agricultural area under this type of management could amount to 943,000 hectares (all arable and land under orchards and vineyards) by 2020.[IX]

This practice is estimated to cost EUR 65-85 per tonne of removal if 700 kg of carbon is mitigated per year per hectare. This calculation is based on the public money (subsidies) envisaged to stimulate farmers to practice this measure – an average annual cost of approximately EUR 101 million. This subsidy is, however, questionable. One could argue that the application of green manure and other carbon/building measures constitutes a good farming practice and as such should not be paid for by public money. If the cost of practising these measures were transferred to farmers, the net cost to the Government would be greatly reduced, though the cost would still exist. Furthermore, there are advantages to increasing the level of carbon in soils related to retaining moisture – which is already a problem in Croatian soils. This estimate of costs deserves further review, as the IPCC estimates that significant reductions through this methodology would be possible for under EUR 13 per tonne.[73]

[IX] Numerous studies report sequestration rates of 400-1,800 kg C per hectare per year in temperate regions (Hepperly, Moyer et al. 2008, Hülsbergen and Küstermann 2008, Pimentel, Hepperly et al. 2005, Raupp, Pekrun et al. 2006, Teasdale, Coffmann et al. 2007). At the USA Rodale Institute's experimental farm for instance, legume-based organic farming systems in 14 years increased soil carbon by 35% (from 1.8% to 2.4%) (Petersen, Drinkwater, et al. 2000).

Table 12-8: Potential carbon reduction and costs per measure for the year 2020 from changes in LULUCF

Land Use, Land Use Changes and Forest Cover	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Soil sequestration of carbon (700 kg per hectare per year)	2,533,000	EUR 65,00	EUR 85,00	164,645,000	215,305,000
Increased forest mass	7,000,000	Unknown	Unknown	Unknown	Unknown
Total possible CO_2e reduction for LULUCF	9,533,000			164,645,000	215,305,000

Currently Croatia only receives "credit" for its international commitments under the Kyoto Protocol of a little less than one million tonnes of CO_2e reduction, due to LULUCF. Since the potential appears to be drastically more than that – up to an astounding 9.5 million tonnes, it is important to further examine the cost/ benefit of implementing these changes and the methodology for accounting for them in international reporting. In the "post-Kyoto" negotiations, these could play an important role in Croatia's position.

12.7. Economic analysis of measures

12.7.1. Measures that are likely to be economically beneficial to Croatia

As a first step in reducing emissions, Croatia should move forward with any project that is likely to yield a negative marginal cost (or a net economic gain).

Table 12-9: Likely "No Regrets" measures for mitigation that will have an economic benefit.

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Agriculture - changes in farming techniques	Switching to 25% organic farming	515,000	EUR -15,450,000	EUR -5,150,000	MAFRD/ farmers
Agriculture - Livestock changes	25% of ruminants replaced by non-ruminants	578,000	EUR -63,580,000	EUR -52,020,000	MAFRD/ farmers
Energy - for industry use	Use of biomass for energy use for industry and construction	100,000	EUR -4,500,000	EUR -2,500,000	MELE/ MEPPPC
Energy - for industry use	Increased energy efficiency in industry and construction (including cogeneration)	800,000	EUR -24,000,000	EUR -8,000,000	MELE/ MEPPPC
Energy - use for Transport	Using vehicles with less emissions (140 gCO_2/km)	200,000	EUR -12,000,000	EUR -8,000,000	Individual citizens/ MELE/ MEPPPC/ Ministry of Transportation
Energy - use in households and services	Savings of electricity in households – due to lighting changes (CFLs)	416,000	EUR -60,320,000	EUR -52,000,000	Individual citizens/ MELE
Energy - use in households and services	Savings of electricity in households – energy efficient appliances	282,000	EUR -40,890,000	EUR -35,250,000	Individual citizens/ MELE
Energy - use in households and services	Savings of electricity in households due to reduction of consumption of electricity for heat	28,000	EUR -4,060,000	EUR -3,500,000	Individual citizens/ MELE
Energy - use in households and services	Reducing heat losses from roofs	4,000	EUR -160,000	EUR -80,000	Individual citizens/ construction firms/ MELE/ MEPPPC
Energy - use in households and services	Reducing heat loss from windows	22,000	EUR -880,000	EUR -440,000	Individual citizens/ construction firms/ MELE/ MEPPPC
Energy - use in households and services	Reduction of heat loss - due to complete reconstruction of building envelopes	26,000	EUR -1,040,000	EUR -520,000	Individual citizens/ construction firms/ MELE/ MEPPPC
Energy - use in households and services	Energy Efficiency in offices	461,000	EUR -11,525,000	EUR -2,305,000	Individual firms/ MELE/ MEPPPC
Energy - use in households and services	Reducing heat loss on new buildings	134,000	EUR -3,350,000	EUR -670,000	Construction companies/ Individual citizens/ firms/ MELE/ MEPPPC
	Total reduction due to "no regret" options that have a net economic gain once implemented	3,566,000	-241,755,000	-170,435,000	

Table 12-10: Measures that may be neutral in terms of marginal cost per tonne of reduction

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - electricity production	Reductions from usage of nuclear fuel (by building a 1000 MW nuclear power stations)	5,500,000	EUR -77,000,000	EUR 77,000,000	HEP/ MELE/MEPPPC
Energy - electricity production	Reductions from usage of geothermal	60,000	EUR -640,000	EUR 1,200,000	Individual firms/ MELE
Energy - electricity production	Reductions in loss from the distribution grid and potential reductions in emissions of CO_2 (4.5% decrease in loss)	56,300	EUR -563,000	EUR 563,000	HEP/ MELE
Energy - for industry use	Use of biologically-based waste products for energy use for industry - especially refuse derived fuel (re-used materials) of biological and fossil origin and dried sludge - especially in the cement industry	202,000	EUR -2,020,000	EUR 2,020,000	Individual industries/ waste management companies
Energy - use for transport	Using fuels with less carbon - LPG and CNG versus diesel or gasoline	100,000	EUR -1,000,000	EUR 1,000,000	MELE/ Ministry of the Sea, Transport, and Infrastructure
Energy - use in households and services	Renewable energy use in offices	109,000	EUR -1,090,000	EUR 1,090,000	Individual firms/ MELE
Energy - use in households and services	Solar collectors for water heaters	20,000	EUR -200,000	EUR 200,000	Construction companies/ Individual citizens/ firms/ MELE/ MEPPPC
Industrial processes - cement production	Reduction of the share of clinker in cement from 77% on average by max 14% by 2020.	364,000	EUR -3,640,000	EUR 3,640,000	Cement Companies/ MEPPPC
Industrial processes - nitric acid production	Production of nitric acid - non-selective catalytic production in the process - a chemical reaction to eliminate 80-90% of GHGs by converting N_2O to just nitrogen.	820,000	EUR -8,200,000	EUR 8,200,000	Nitric acid producers
Waste treatment	Reduction of emissions by burning CH_4 from flaring	175,000	EUR -1,750,000	EUR 1,750,000	Waste management companies
	Total reduction of emissions resulting from possible "cost neutral" options	7,406,300	-96,103,000	96,663,000	

These potential measures are outlined in Table 12-9 and would account for just over 3.5 million tonnes of reductions in 2020 if fully implemented – saving EUR 170-241 million in costs. It should be noted that the reductions from changing from ruminant livestock (cattle) to non-ruminant livestock may not be carried out to this extent, but some level of the measure may be effective at reducing emissions and increasing economic gains. Furthermore, many of these measures will depend upon the active involvement of citizens. While public education may help in this arena, it is likely that regulation and prices will have a greater impact.

12.7.2. Measures with minimal cost

Table 12-10 outlines the various measures that are expected to either cost a small amount or save money. Those that are eligible may be profitable for businesses if sold on the carbon market – such as the burning of CH_4 from landfills or the non-selective catalytic production of nitric acid. In total, these measures could reduce emissions by 7.4 million tonnes of CO_2e in 2020 for a minimal marginal cost. However, it should be noted that the majority of these reductions (5.5 million tonnes) result from building new nuclear facilities – which is problematic in terms of environmental sustainability and political feasibility.

12.7.3. Measures that are unlikely to cost more than EUR 25 per tonne of CO_2e reduced

The next group of measures may not have a net economic benefit but might be economically cost-effective when considering the costs of the EU ETS and other carbon offset programmes – including the voluntary market. For the purposes of this estimation, the price of CO_2e per tonne is assumed to be EUR 25, thus

Table 12-11: Measures which might cost something but which may be profitable with carbon offsets through either the ETS or voluntary emissions reduction schemes, at EUR 25 per tonne of reduction

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 Cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - for industry use	Increasing the of energy efficiency of the process of clinker production	53,000	EUR 0	EUR 1,060,000	Cement industry/ waste management companies/ MELE/ MEPPPC
Energy - electricity production	Cogeneration potential delivered onto the public electricity grid	297,000	EUR 2,970,000	EUR 8,910,000	HEP/ MELE/ MEPPPC
Energy - use in households and services	Use of biomass in small heating systems and households	379,100	EUR 3,791,000	EUR 11,373,000	Individual citizens/ MELE
Energy - electricity production	Increasing central district heating systems and cogeneration	39,000	EUR 390,000	EUR 1,170,000	City governments/ MELE/ energy producers/ MEPPPC
Energy - electricity production	Reduction of emissions from building small hydropower	71,000 to 113,000	EUR 1,420,000	EUR 2,260,000	Individual firms/ MELE
Energy - electricity production	Reductions from usage of wind power	1,125,000	EUR 27,000,000	EUR 56,250,000	HEP/ MELE/ MEPPPC
	Total emissions reductions due to options that are justifiable with a carbon cost of EUR 25 per tonne	881,100	8,571,000	24,773,000	

any measure which has a probable marginal cost below EUR 25 would be cost-effective, if it can utilise reduction funds or prevent Croatia and Croatian businesses from having to spend money buying credits elsewhere. The sum of all of these measures has the potential for reducing emissions by an additional 881,100 tonnes in 2020.

In examining the possible measures that would either have a net positive economic impact or that may have a price for reduction less than the cost of buying credits on the open market, the total amount of reductions possible would be 11.85 million tonnes of CO_2e. If taken from the projected emissions of 42 million tonnes, this leads to an emissions total of 30.15 million tonnes – which would mean a significant reduction (16%) from the baseline levels of 36.03 million tonnes. This assumes a relatively high price of carbon (EUR 25). However, much of this reduction (5.5 million tonnes) would result from nuclear power production, which may not be viable for environmental and/ or social acceptability reasons.

12.7.4. Measures that are more expensive for reducing emissions

The next level of emissions reduction measures are likely to be more expensive than the market price of carbon but may be good to implement regardless. This is because these measures may:

1. Be required to meet EU obligations – such as the use of biodiesel and bioethanol and the implementation of Best Available Technologies in agriculture;
2. Be more acceptable to the public – such as solar power – or;
3. Have alternative benefits to the sectors that implement the measures. Increasing carbon

[X] This measure would need approval within international negotiations to be included in the national emissions statistics.

Table 12-12: More expensive measures for reducing emissions

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 Cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - use in services	Use of fuel cells and Photo-voltaic cells	39,000	EUR 1,560,000	EUR 7,488,000	MELE/ MEPPPC
LULUCF in agriculture	Soil sequestration of Carbon (700 kg per hectare per year)[X]	2,533,000	EUR 164,645,000	EUR 215,305,000	MAFRD/ farmers/ MEPPPC
Energy - electricity production	Reduction of emissions due to electricity produced from biomass	700,000	EUR 53,200,000	EUR 101,500,000	HEP/ MELE/ MEPPPC/ MAFRD
Energy - use for transport	Using biodiesel	370,000	EUR 33,300,000	EUR 40,700,000	MAFRD/ biodiesel producers/ MELE/ MEPPPC/ retail sellers
Energy - use for transport	Using bioethanol and hydrogen cells	270,000	EUR 24,300,000	EUR 29,700,000	MAFRD/ biodiesel producers/ MELE/ MEPPPC/ retail sellers
Agriculture - changes in farming techniques	Implementation of Best Available Technologies - reducing fertilizers and better manure management	1,084,000	EUR 151,760,000	EUR 173,440,000	Farmers/ MAFRD/ MEPPPC
Energy - use in services	Solar energy - advanced systems	61,000	EUR 15,250,000	EUR 16,775,000	HEP/ MELE/MEPPPC
	Total emissions reductions due to options that are more expensive, but may have additional benefits/ be popular	5,057,000	444,015,000	584,908,000	

content in soils, for example, would not only be a mitigation measure, but may also help agricultural actors in reducing problems with the lack of moisture in soils.

In total, these measures could account for an additional 5.06 million tonnes of reduction – though at a significant cost of EUR 444 – 585 million for the year 2020 (See Table 12-12). This is equivalent to EUR 100 to 132 per person in Croatia per year.

12.7.5. Measures that should be economically feasible but have unknown costs

The final measures that could be taken to reduce emissions by 2020 are those for which data is currently unavailable, in terms of cost of emissions reduction per tonne. Some of these measures may not be politically popular – such as building a waste incinerator plant. Some measures will require significant cross-sector cooperation and public involvement – such as mea-

Table 12-13: More expensive measures for reducing emissions

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 Cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - electricity production	Reductions from switching to lower carbon content fuels (natural gas, etc) - unmeasured, but, says, 5% reductions	Unknown	Unknown	Unknown	HEP/ MELE/MEPPPC
Energy - use for Transport	Measures in city passenger travel - building bike lanes, encouraging public transport, decrease of traffic jams	81,000	Unknown	Unknown	Individual citizens/ city governments/ Ministry of Sea, Transport and Infrastructure/ MEPPPC
Energy - use for Transport	Measures in goods transport - ensuring efficiency of motors/ low emissions, using "spoilers" to decrease air resistance on vehicles, encouraging fuel efficient driving	460,000	Unknown	Unknown	Individual firms/ Ministry of Sea, Transport and Infrastructure/ MEPPPC
Energy - use for Transport	Measures in inter-city passenger transport - improving roads, encouraging railroad travel, sea and intermodal transport, decrease of traffic jams	96,000	Unknown	Unknown	Individual firms/ Ministry of Sea, Transport and Infrastructure/ MEPPPC
Waste treatment	Reduction of emissions of CH_4 by using waste as an alternative source of energy in the production of cement and other industrial goods (removing the source of CH_4)	130,000	Unknown	Unknown	Cement industry/ waste management companies/ MEPPPC
Waste treatment	Reduction of emissions of CH_4 by thermal waste treatment	180,000	Unknown	Unknown	HEP/ Waste management companies/ MEPPPC
Energy - for industry use	Pumping CO_2 under ground after production (technology unproven in Croatia)	500,000	Unknown	Unknown	HEP/ MELE/MEPPPC
Land use changes	Increasing forest cover and growth of forests	7,000,000	Unknown	Unknown	Farmers/ landowners/ forest managers/ Croatian Forests/ MAFRD
	Total emissions reductions resulting from options that could be economically viable, but which do not have cost information available	8,447,000			

sures to increase public transportation and decrease transportation emissions. Others will require a better understanding of the technology (such as pumping carbon underground in the oil production sector) or the introduction of a better methodology for measuring the offsets and its acceptance by the international community – such as credit for land-use changes. The potential exists to reduce CO_2e emissions by a tremendous 8.45 million tonnes by 2020. Most of this reduction comes from continuing the reductions associated with forest cover and the growth of forests – though such a large amount is not likely to be recognised in international negotiations.

12.8. Conclusions and recommendations

As the Government of Croatia decides the commitments it can make in terms of reducing emissions, the above type of analysis is critical. According to these estimates, if all the measures mentioned here are implemented, the total emissions reduction for Croatia for 2020 would be approximately 16.9 million tonnes. The costs for this reduction are estimated to be between approximately EUR 114.7 million and 535.9 million for that year – equivalent to 0.31-1.43% of 2007's GDP.

If the final set of measures – including land use changes, were implemented, the total emissions reduction potential would be approximately 25.36 million tonnes – 7 million from land use changes in forestry if current growth patterns continue. Thus in 2020 from a total of 42 million, the total net emissions from Croatia would be a little over 16.6 million tonnes – or approximately 3.81 tonnes per person per year, if the population decreases to 4.37 million.[74] However, this reduction is unrealistic for a number of reasons.

- First, the numerous carbon sinks created by land use change are not expected to be implemented or counted fully.
- Second, many programmes require public action and involvement. This will require major institutional engagement.
- Third, many emissions reductions measures are controversial such as building nuclear power plants, incinerators, and reducing clinker requirements in cement.

Figure 12-8: Reductions for 2020 and level of emissions sorted by level of costs of the measures

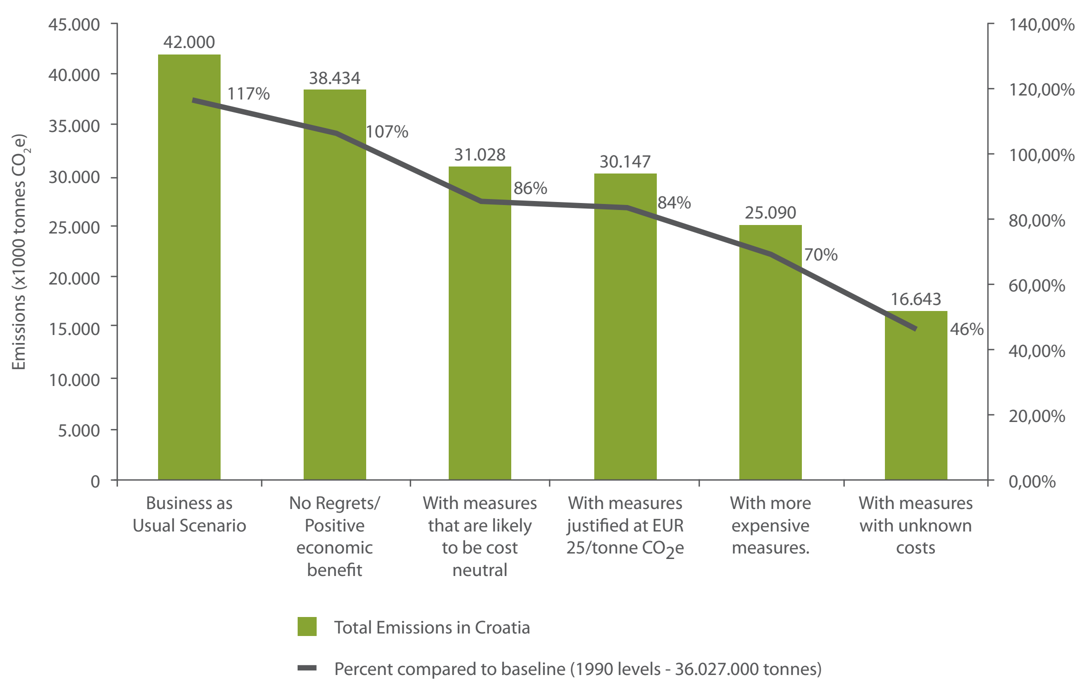
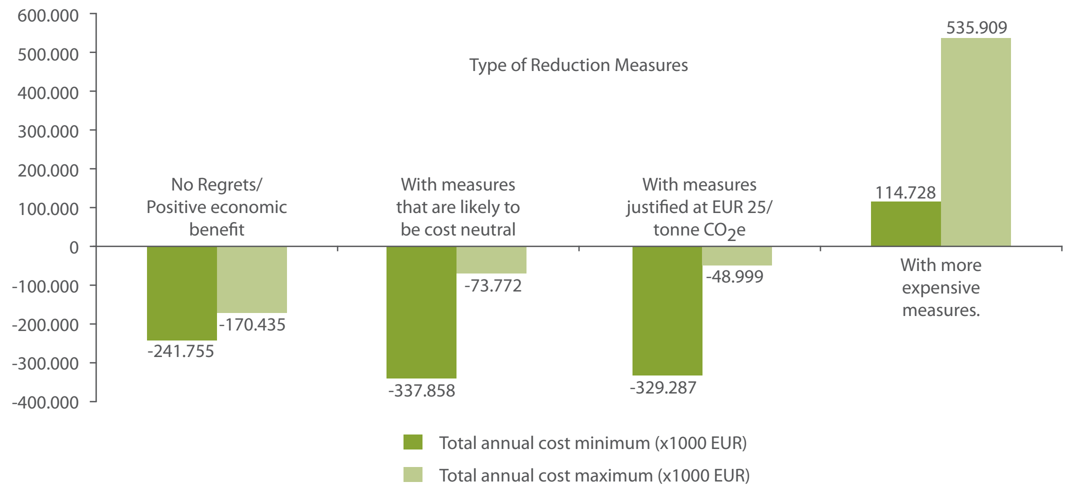


Figure 12-9: Projections for total costs for various types of measures for 2020



In order to achieve the 'absolutely best case scenario' described above, a number of issues must be addressed:

- The public and businesses must play a large role in implementing energy efficiency measures. This is the most economical way to reduce emissions in transportation, the households and services sector and in many industrial areas.
- All public and private institutions – especially in the energy, industrial, and agricultural sectors – need to streamline processes for ensuring that carbon emissions are reduced where possible and in a non-controversial manner.
- A number of outstanding technical issues will have to be resolved – for example the amount of cement in road construction, the amount of fertilisers that farmers should use, the crop rotations for agriculture that might include carbon sequestration, the amount of ruminants versus non-ruminants kept on farms, the placement of small hydro plants, and many others.
- A number of questions about potentially socially-unpopular measures which account for major portions of carbon reduction would need to be addressed.
- The use of bio-fuels needs further discussion – especially as biodiesel has come under fire in the past year because of the possibility that it leads to food shortages and price increases.
- Issues related to the thermal processing of waste – or incineration – need to be resolved. They could potentially lead to political conflict among communities near any waste treatment plant.
- Building nuclear plants instead of coal or gas fired plants accounts for 5.5 million tonnes of reductions. However, nuclear power is not the most popular investment and it is questionable because of its social acceptance. Participatory decision-making must occur and proper precautions must be taken.

In conclusion, this analysis shows that the theoretical potential for reductions in emissions in Croatia is high, if the price of GHGs is set at EUR 25 per tonne. However, while this potential does exist and seems to be achievable at a relatively low cost, the actual capacity of various actors to implement all the measures is much less certain. There are many political, institutional, technical, and legal considerations that must be taken into account before moving forward with any of the measures. These are discussed in more detail in Chapter 13. However, numerous measures have been identified as no-regrets measures that can have a significant impact. These are primarily oriented towards the following:

1. Improving energy efficiency in the households and services sector,
2. Increasing efficiency and decreasing emissions in industrial processes,
3. Burning methane from landfills for energy,
4. Encouraging organic farming,
5. Continuing land use changes that promote the sequestration of carbon in forests, along with improving the monitoring and calculation of carbon stock change
6. Increasing the efficiency of transport systems, including the fuel efficiency of cars, the efficiency of traffic flows, and alternative transportation (walking, biking, carpooling, public transport).

Additionally, there are many other measures that may become cost-effective with a higher price on GHGs. Finally, there are measures that may have a net positive economic cost but are potentially helpful in addressing other problems, such as increasing the carbon content of soils to retain moisture and decreasing the use of fertilisers to protect water quality.

Chapter 13

Evaluation of Current Activities to Mitigate Climate Change – Institutional Analysis

13

Chapter 13 Summary

Evaluation of Current Activities to Mitigate Climate Change – Institutional Analysis

To reduce GHG emissions without undermining human development goals, numerous actors must be involved and must work together effectively. These include Government institutions, businesses, research institutions, Non-Governmental Organizations (NGOs) and the donor community. Croatia can remove barriers to the implementation of mitigation measures if a proper regulatory environment exists; information is available for people and institutions; and sufficient funding is available to pursue emission-reducing technologies and practices. Croatia has taken significant steps towards establishing an institutional framework that can lead to emissions reduction and foster human development.

The regulatory framework set out by the Government sends a clear message that energy efficiency, renewable energy and reduced emissions are important. A fair amount of technological capacity and knowledge exists to address climate change mitigation demands and to ensure human development is enhanced rather than undermined by mitigation efforts. Finally, opportunities for financing emissions reductions exist and are increasing. This capacity is likely to continue to grow as Croatia moves towards EU accession.

Specific recommendations that can be made to ensure that mitigation efforts aid rather than hinder human development are:

- The Government should form an inter-ministerial working group on climate change coordinated by MEPPPC. This group should involve both technical and political representatives working together to ensure improved communication and coordination among governmental actors. This coordination could prevent the waste of public resources and could ensure that ministerial strategies and plans consider climate change. The mandate of the group could address adaptation as well as mitigation.
- Data and best practice measures should be made more publicly available when funded by the Government. Progress that is currently being made in promoting energy efficiency in the Government sector should also be encouraged in the industrial and SME sectors.
- Further development of the stakeholder process may be necessary to involve business representatives in discussions regarding the implementation of new policies.
- Revenue from carbon fees should be used either for emissions reductions programmes or for tax reductions for fee-payers.
- Businesses and technical consultancies may have a competitive advantage in promoting mitigation measures at the regional level. Croatian companies should continue investigating the possibilities of marketing mitigation measures in other countries. These services can also constitute a part of Croatia's official development assistance.

13.1. Introduction

Climate change mitigation must be compatible with human development. Croatia faces a unique challenge - in addition to developing its economy, it must also reduce its emissions to meet international obligations and meet the accession requirements of the EU. As Chapter 12 shows, the potential exists to reduce emissions, but succeeding will take significant political, social and institutional involvement. To reduce GHG emissions without undermining human development goals, Croatia must involve many diverse actors in the issue and ensure they work together effectively. As the Stern Review[1] notes, emissions must have an appropriate price and technologies must be available. However, even when these conditions exist, there may still be barriers to energy efficiency, renewable energy and other mitigation options. Croatia can address these barriers if it has the proper regulatory environment, makes information available for people and institutions to reduce emissions, and identifies sufficient funding to pursue emission-reducing technologies and practices.

Institutions that must be involved in the effort include Government institutions, businesses, research institutions, Non-Governmental Organizations (NGOs), and the donor community (see Table 13-1, Table 13-2, and Table 13-4 for lists involved organizations). This section describes the current activities of numerous stakeholders and the level of coordination among the various actors. While the Second, Third and Fourth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change[2] addresses some institutional issues, this chapter addresses institutional capacity in a broader sense, using the framework set out by the Stern Review; i.e., the regulatory environment, the level of information available and distributed, the financial context for reducing emissions, and carbon pricing. Finally, it makes recommendations for improving coordination and identifies areas where more overall engagement would help move Croatia forward in reducing GHG emissions.[I]

13.2. Development of the legal/ regulatory environment to establish carbon prices and to make technology available

Perhaps the most important factor for climate change mitigation is government regulation and the legal environment. The national government sets the agenda, provides direction for the market, and provides the regulatory backdrop for addressing climate change. Because climate change affects almost all sectors, it will require a coordinated approach by various governmental entities to reduce emissions in a way that does not undermine human development. This approach must involve the incorporation of climate change into strategic documents and plans.

The Croatian National Government is aggressively working to reduce emissions. Parliament has ratified the Kyoto Protocol and, as an Annex I country, Croatia has committed to a 5% reduction from 1990 levels by 2012.[3] As part of the EU accession process, Croatia is already planning to enter the EU Emissions Trading System (ETS) and is working towards increasing energy efficiency, expanding renewable energy production and reducing overall emissions. Accession to the EU is probably the central driving factor in pricing carbon and implementing new technologies.

The Croatian Parliament has been proactive in adopting laws that deal with climate change, ratifying the Kyoto Protocol[4] and passing the Air Protection Act[5] and the Environmental Protection Act.[6] Both the Air Protection Act and the Environmental Protection Act directly mention preventing GHG emissions within their texts. The Croatian Parliament is also the deciding body for the adoption of the Energy Strategy, the Energy Efficiency Master Plan, and a number of other issues that are directly related to climate change and, in general, has been supportive of climate change mitigation.

[I] This section was prepared primarily using insights gained through interviews and a capacity assessment survey that yielded responses from over 30 organizations.

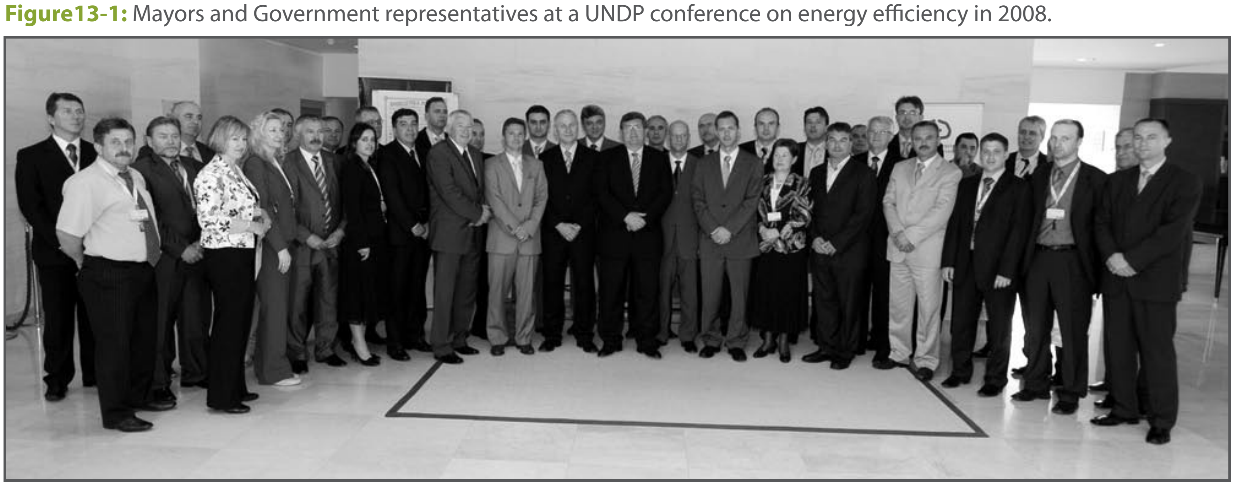
> "Croatia's Government has sent a strong signal to businesses and other actors that emissions reduction is important"

The Central Office for Development Strategy and Coordination of EU funds (CODEF) has been very active in assisting ministries and other governmental administrations with accessing European pre-accession funds, available for legal harmonization and implementation of the EU acquis communautaire. In the area of climate change, the Ministry of Environmental Protection, Physical Planning, and Construction (MEPPPC) is the primary responsible Government ministry. Regulations have been, and continue to be, put into place to address climate change in Croatia and move it into compliance with the Kyoto Protocol and the EU acquis communautaire. Perhaps most interestingly, the Government has introduced a carbon and other air pollutant fee of 14 HRK (EUR 2) per tonne that will become 18 HRK (EUR 2.50) in 2009. There are also rules designed to improve the energy efficiency of new buildings, an ordinance on labelling passenger cars and upcoming legislation that relates to the ETS.[7] Croatia has committed to generating at least 5.8% of all electricity from renewable energy sources by the end of 2010.[8]

In addition to MEPPPC, a number of other government ministries manage programmes that reduce emissions. These include the Ministry of Economy, Labour and Entrepreneurship (MELE), governing issues related to energy production; the MAFRD; and the MSTI. In particular, MELE has taken very proactive steps in dealing with climate change, especially in promoting energy efficiency programmes such as the "Removing Barriers to Energy Efficiency" project undertaken in partnership with UNDP, other initiatives to increase energy efficiency in public buildings/ businesses/ services, and initiatives to increase renewable energy production. The MELE has introduced a "feed-in tariff" to encourage renewable energy measures by allowing small producers to sell electricity from renewable sources to the grid.[9] This tariff has been in place since 2007, and projects that take advantage of this initiative are beginning to commence. Interest in this programme is significant and already more applications for installing wind capacity and receiving compensation for it have been received than can be supported. While the feed-in tariff is a major step forward, its duration is limited and new producers selling electricity to the grid can only receive payment for the next 12 years. In other European countries (Germany, Italy, France, and Spain), payments are guaranteed for at least 20 years.

Croatia's Government has sent a strong signal to businesses and other actors that emissions reduction is important. At the time of writing, the MSTI, and MAFRD are only just beginning to address these issues. The MSTI is improving its baseline assessment of emissions from sea vessels and is interested in becoming more engaged with inter-ministerial cooperation on road transport issues. Croatian Forests Ltd., a state-owned company that manages forests and forest-lands is beginning to think seriously about adaptation to climate change – especially in relation to forest fires. However, they are not considering land use change and its significant potential as a mitigation option. Forests in Croatia are becoming an important and growing carbon sink

Figure13-1: Mayors and Government representatives at a UNDP conference on energy efficiency in 2008.



Source: UNDP.

due to changes in land use patterns. It may be possible to take advantage of and accelerate these changes to reduce net emissions and generate income. However, the MAFRD is not yet engaged in these issues in a substantive way.

In general, the Croatian Government is progressing towards a regulatory environment that reduces emissions. However, institutional relationships and capacity could be improved to facilitate coordination and efficiency. In particular, the ad hoc nature of communication between ministries on climate change issues leads to lost time and opportunities. Ministries appear to consult with each other when planning activities, but there is often confusion as to who is doing what. This is not surprising given that various ministries are undertaking many different activities with limited staff. However, this can lead to needless duplication of effort, such as when one ministry applies for funds for a project without being aware that another ministry or government agency is either already working on that project or is applying for funds for a similar programme. Note that this problem probably results from the Croatian Government's quick pace in addressing climate change mitigation. It can also be solved relatively easily. It seems to be the consensus of most stakeholders that the Government should establish a more structured coordinating group to address climate change issues. The group should be led by MEPPPC – and it should include all relevant ministries that would deal with emissions reduction, including:

- The Ministry of Economy, Labour and Entrepreneurship;
- The Ministry of Sea, Transport and Infrastructure;
- The Ministry of Agriculture, Fisheries and Rural Development;
- The Ministry of Regional Development, Forestry and Water Management;
- The Ministry of Finance; and
- The Central Office for Development Strategy and Coordination of EU Funds.

It may also be helpful to include the Ministry of Tourism, because tourism is a growing sector that will have a substantial impact on energy use in the future. This Ministry is already beginning to address issues related to tourism and sustainability. The Ministry of Science, Education and Sports (MSES) may also be useful because of its role in guiding scientific research and in addressing education. It is critical to begin organising discussions so that different ministries incorporate climate change mitigation (and adaptation) into their strategic plans. This proposed structure is similar to that of countries such as Britain, which has a special Office of Climate Change to support inter-ministerial cooperation,[II] and Brazil, which has an Inter-ministerial Commission as well.[III] A Croatian climate change commission should be consistently staffed and housed within either the Cabinet of the Prime Minister – which includes the Prime Minister, fifteen Ministers and four Deputy Prime Ministers (two of whom are also ministers)[IV] – or within the President's office. Representatives from different ministries should also be consistent at each meeting. If and when a new government is introduced, similar stakeholders can be chosen and even if the names of the ministries or the people change, the sectors represented will remain the same. The formation of the group should be accompanied by continued outreach to political decision-makers about these issues to ensure that climate change is taken into account in high-level planning and debate.

Other challenges to building a strong climate policy infrastructure include attracting and retaining staff sufficiently qualified to cover all the relevant issues. Not doing so poses potentially significant problems, as programmes dealing with climate change are particularly complex and integral. The Government's plans for public sector reform may have some positive impact. Furthermore, mainstreaming climate change into the various ministries and departments may, to some extent, reduce individual workloads and expand the level of expertise available.

[II] For more on the British Office of Climate Change, see the website http://www.occ.gov.uk/.

[III] For more information on the Brazilian Interministerial Commission on Climate Change, see the website http://www.mct.gov.br/index.php/content/view/14666.html.

[IV] The list of members and their roles is available at the Croatian central government website at http://www.vlada.hr/en/.

Box 13-1: Croatia – Becoming a leader in energy efficiency and a greener energy future

As the primary Government ministry responsible for energy issues in Croatia, the Ministry of Economy, Labour and Entrepreneurship (MELE) is actively pursuing policies and programmes to move Croatia towards a better energy future. In working with the business sector, international organizations such as the World Bank and UNDP, and government ministries and representatives around the country, we want to ensure that Croatia continues sustainable development in the energy sector.

In order to save valuable resources as well as reduce emissions that are harmful to the environment, MELE is working to decrease energy use among Government actors, both at the local and national level. MELE is working with UNDP and the Fund for Environmental Protection and Energy Efficiency to introduce systematic energy management into the cities and counties of Croatia[V] – in all local government owned buildings. A pilot project in the city of Sisak (some 50,000 inhabitants) has shown that there can be tremendous savings – up to HRK 2.5 million per year in Sisak alone, out of a total energy budget of approximately HRK 10 million in 2006 – from better energy management and switching to more efficient and cost-effective energy sources. Our goal is that the cities and counties of Croatia will be leaders in saving energy, monetary resources, and reducing emissions. The effort being made in cities and counties is coupled with the "House in Order" project, which aims at increasing energy efficiency in national government buildings. With these two projects, we want to make sure that the Croatian Government acts as a leader in moving towards energy efficiency and reduction of emissions. The savings in monetary resources can then be used for other productive programmes to improve Croatia.

A second area in which MELE is working towards sustainable energy is through stimulating the market for energy efficiency and renewable energy. We are working with our partners to build capacity among firms that can provide energy efficiency services, stimulate the demand for energy efficiency, and implement instruments to encourage renewable energy usage. There is an ongoing public information and education campaign, which aims to raise citizens' awareness of the energy efficiency potential of their homes. This public education campaign has involved television, radio, and billboard commercials as well as a free phone helpline for citizens with questions, and works with the media to highlight the possibilities for citizens to save money and the environment.

Another way of stimulating demand for energy efficiency services is to provide "energy audits" that analyse where savings are possible for organisations and citizens. The organisations and citizens can then follow the recommendations and implement energy saving measures. To increase renewable energy usage, the MELE has also introduced a favourable feed-in tariff to reward those who invest in electricity generation from renewable energy sources.

The third area in which MELE is working towards sustainable energy is in increasing public awareness about energy efficiency and emissions reducing possibilities. MELE, together with the Environmental Protection and Energy Efficiency Fund and UNDP, has issued a "One Ton Challenge" brochure to all Croatians to reduce their energy consumption and therefore reduce their emissions of CO_2.[VI]

The fourth area in which MELE is working is in the development of a long-term Croatian energy strategy that incorporates sustainable development as a core principle. To this end, the Government of Croatia has drafted and adopted an Energy Efficiency Master Plan[VII] and is in the process of updating a long-term Energy Strategy that will ensure that Croatia meets its international obligations, aids in economic development, and moves towards sustainability.

These are just some of the activities that we are undergoing to improve energy efficiency, reduce emissions, and promote sustainable development in Croatia. MELE is proud of the steps it is taking with others in the Government sector, with international organisations, with businesses, and with Croatian citizens to ensure that Croatia's energy needs are met in order to facilitate human and economic development and protect the environment.

Igor Raguzin, Head of the Division for Renewable Energy and Energy Efficiency – Republic of Croatia Ministry of Economy, Labour and Entrepreneurship

V The project is entitled "Energy Management in Cities and Counties of Croatia". More information is available through the website http://www.energetska-efikasnost.undp.hr/show.jsp.

VI More information at http://www.energetska-efikasnost.undp.hr/show.jsp?page=73621.

VII More information at http://www.energetska-efikasnost.undp.hr/show.jsp?page=72499.

Many stakeholders within the business sector have expressed the desire to be included earlier and more purposefully in discussions on new legislation and regulations. If business interests feel excluded from the climate policy process, it may result in significantly more economic hardship than is necessary to achieve reduction goals. Current legislative efforts – including the introduction of the ETS – point to some business involvement, so there may already be some progress on this front. It is important for business voices to be heard in this debate – as well as civil society (through NGOs), citizens groups and unions. Consultation is particularly important given the vulnerability of certain industries to displacement and potential relocation, due to the price of carbon emissions, especially refined petrol, fishing, fertilisers, and air and water transport.[10] The Government should incorporate business opinions into the discussion and make provisions for stakeholder involvement. Stakeholder involvement should be oriented towards finding more acceptable and less expensive ways to achieve reductions. Determining the right mix of policies to price carbon and introduce technologies that help Croatia move towards a low-emissions economy will also be necessary.

Table 13-1: Organisations affiliated with the Government dealing with climate change

Organisation Name	Type of Organisation	Activities Related to Climate Change Mitigation	Contact Person	Website/ Contact
Croatian Environment Agency	Government Agency	Responsible for data gathering for climate change, environmental data, participates in numerous efforts	Tihomir Horvat, Head of Section for Air, Climate Change	www.azo.hr
Croatian Forests Ltd.	State-owned company	Forest management, including reforestation plans	Petar Jurjević, Head of Environment Department	www.hrsume.hr
Croatian Central Office for Development Strategy and Coordination of EU Funds	Government Department	Responsible for distributing EC funds and development strategy for Croatia/ accession to the EU	Damir Tomasović, Head of Section	www.strategija.hr
Environmental Protection and Energy Efficiency Fund	Government Foundation	Promotes RES, EE, and emissions reduction schemes through funding and partnership	Marija Šćulac Domac, EE and RES Projects and Programmes Coordinator	www.fzoeu.hr
Croatian Ministry of Economy, Labour and Entrepreneurship	Government Ministry	Promotes EE in government owned businesses, buildings, feed in tariff system for renewable energy	Igor Raguzin, Head of Division for Reneweble Energy and Energy Efficiency	www.mingorp.hr
Croatian Ministry of Sea, Transport, and Infrastructure	Government Ministry	Analysing data for the transport sector to introduce programmes for emissions reduction	Dubravka Lulić-Krivić, Primary Controller	www.mmpi.hr
Ministry of Environmental Protection, Physical Planning and Construction	Government Ministry	Focal point for climate change in Croatia, deals with the legislative framework	Višnja Grgasović, Head of Department for Atmosphere Protection	www.mzopu.hr

13.3. Information: Availability of information to consumers and major actors on reducing emissions

To overcome the market barriers to mitigation, introduce technology, and set the right carbon price, there must be enough information available to stakeholders, large emitters, large energy users and the public about how to reduce emissions, why, and what the costs/benefits will be. In particular, information on energy efficiency measures, emissions reduction opportunities, and increases in renewable energy use should be available to actors who may utilise these methods for mitigation. Within Croatia, there is a fairly active community engaged in issues related to climate change, ranging from institutions engaged in analysing the effects of climate change on the environment to those assessing how Croatia could incorporate climate change mitigation into its development plans.

13.3.1. Information on emissions sources:

Research into tracking emissions is primarily driven by Government agencies such as the Croatian Environment Agency, which supports efforts including the National Communication on Climate Change,[11] the National Emissions Inventory,[12] and numerous other reporting requirements. The Ministry of Science, Education and Sports is supporting research by universities, through a small grants programme for Croatian Researchers that is open to any topic.[VII] Additional support is available for technical research and research into the economic aspects of reducing emissions in industry, and there is an increasing market for technical expertise in emissions reductions particularly geared towards energy efficiency.

13.3.2. Information available for larger scale energy efficiency, pollution reduction, and renewable energy:

There are positive trends in the availability of information about efficiency measures, pollution reduction measures, and renewable energy technologies. Organisations such as APO – Environmental Protection Services (part of Croatia's national electricity utility HEP), Ekonerg, and Energy Institute Hrvoje Požar have been involved in analysing various segments of industry, including electricity production, cement production, and others. This analysis has included examining the potential for renewable energy. Additionally, private firms have increased the capacity of the market to implement energy efficiency, renewable energy, and emissions reductions projects. These include larger companies such as HEP Energy Services Company (HEP-ESCO), as well as smaller companies that carry out audits and install equipment. The development of these actors is being supported by UNDP and the World Bank, along with EU funds. However, these services are primarily available to the building sector and currently there is little centrally organised activity related to energy efficiency and emissions reduction within the industrial sector, with the exception of internal activities at HEP and, to some extent, within the cement industry. INA, the major oil and gas exploration company and petroleum distributor in Croatia, has – at least in public relations materials – recognised the importance of reducing emissions, and reduced its CO_2 emissions by 7% in 2005.[13] The company is also active in the renewables sector through its activities in the geo-thermal industry, with numerous plants around the country.[14]

VII See the Croatian Ministry of Science, Education and Sports' website for more information. http://www.mzos.hr/.

The Faculty of Electrical Engineering and Computing (FER), at the University of Zagreb, has been carrying out significant research on the costs of various scenarios for the reduction of emissions within the energy sector. Overall, the availability of information for Small and Medium Enterprises (SMEs) and large businesses on energy efficiency, emissions reduction and renewable energy possibilities is improving, but more is necessary to ensure that bankable energy efficiency projects – especially large projects – move forward.

Alongside academic institutions and consultancy firms, regional energy agencies are being established to support energy efficiency and renewable energy in various parts of the country. These include a North-West Regional Energy Agency, an Educational Energy Agency for East Slavonia, and a project in Varaždin County. A new project being carried out by MELE called "Energy Management in Cities and Counties" will also result in the founding of numerous new energy agencies around the country.

Within the agricultural sector, the Faculty of Agriculture of the University of Zagreb is probably the entity most engaged in issues related to climate change, though this involvement is usually manifested in specific activities such as providing inputs for the National Communications on Climate Change to the UNFCCC. There is a fair amount of technical expertise within this institution that could be harnessed in dealing with mitigation issues in the future – especially in examining potential reductions resulting from changes in fertiliser processes, soil usage, etc. The European Commission has already funded some assistance to farmers to meet European standards for methane emissions, but significantly more work on agricultural emissions is possible. Farmers would benefit from additional information about emissions in this area and others, such as potential emission credits from changes in forest coverage, projects that can qualify for the feed-in tariff, and others.

Within the general economic planning realm of technical expertise, the Economic Institute which carries out many regional economic plans has not, to date, been actively engaged in climate change issues. This is probably due to the fact that many of the Institute's activities are oriented towards areas of local development where climate change mitigation is not being considered in planning. However, as the national programme for energy management moves forward in the counties, this could and should change. One major element that would be useful in the analysis of mitigation measures and their economic impact in Croatia is a macro-economic model of the Croatian economy. This national economic input-output model does not exist in an updated form. Once realised, it would make for easier analysis of the impacts of increased energy prices and changes in consumption patterns. This is particularly important for gauging the impact of increased energy prices on the most vulnerable in the population and on human development within Croatia.

One important limitation consistently raised during the research for this section was the lack of access to original data. Many reports on energy use, emissions reductions, and renewable energy systems are only available in document format and the original raw data is not available for later study. This is understandable when the data collection has been paid for by private companies for a specific study, but many studies are paid for through public funds and therefore the original data should remain in the public domain. Data sharing could be done through a website devoted to climate change, administered by the MEPPPC, the Croatian Environment Agency, or the MSES.

Climate change mitigation is potentially very important for human development in Croatia for two reasons. Firstly, Croatia must capitalise on the human development opportunities created by the emerging economy surrounding greenhouse gases, including carbon trading, energy efficiency possibilities and new technologies, such as renewable energy sources. Secondly, technical and economic expertise will be critical to ensure that the costs of emissions reduction programmes do not undermine human development.

Thanks to the relatively high availability of information and knowledge in the country, Croatia has the opportunity to become a regional leader in introducing technology and moving forward with emission trading initiatives. Several regional initiatives already exist to move forward the introduction of energy efficiency measures in countries such as Bosnia and Herzegovina, Serbia, Macedonia and Montenegro. Croatian organisations such as Energy Institute Hrvoje Požar and FER are already expanding their business into nearby countries. Croatian companies and technical institutions have a competitive advantage in the region in the areas of energy efficiency, GHG mitigation, and renewable energy sources due to their geographic proximity, language similarities and cultural histories.

Table 13-2: Consultant organisations, international organisations and research institutes engaged in climate change

Organisation Name	Type of Organisation	Activities Related to Climate Change Mitigation	Contact Person	Website/ Contact
APO – Environmental Protection Services	Consulting Company	Energy, emissions, technology and economic consulting	Vladimir Lokner	www.apo.hr
Economic Institute of Zagreb	Consulting Company	Economic development plans, including energy development and environmental issues	Nenad Starc, Senior Research Associate	www.eizg.hr
Ekonerg	Consulting Company	Energy, emissions, technology consulting; writes the national emissions inventory	Davor Vešligaj, Atmospheric Protection Department Manager	www.ekonerg.hr
Energy Institute Hrvoje Požar	Consulting Company/ Government Agency	Energy, emissions, technology and economic consulting; writes the national energy balance	Željko Jurić, Senior Researcher for Environmental Protection	www.eihp.hr
European Commission Delegation in Croatia	International Organisation	Supports mitigation measures through technical and financial support as requested by the Croatian Government	Davor Percan, Task Manager Energy and Environment	www.delhrv.ec.europa.eu
UNDP - Croatia	International Organisation	Promotes EE/ sustainable development	Sandra Vlašić, Programme Officer	www.undp.hr
World Bank – Croatia	International Organisation	Promotes EE through HEP - ESCO and other means of support; supports heating sector efficiency	Nataša Vetma, Operations Officer	www.worldbank.hr
Heinrich Boll Foundation	International Organisation/ Donor	Work with Zelena Akcija and others on public awareness and political awareness	Vedran Horvat, Head of the Croatia Office	www.boell.de
Faculty of Agriculture – University of Zagreb	University Faculty	Research programmes into mitigation and agriculture; can potentially carry out economic analysis	Milan Mesić, Vice Dean for International Affairs	www.agr.hr
Faculty of Electrical Engineering (FER) - University of Zagreb	University Faculty	Consulting for economic feasibility and technology for RES, EE and emissions reductions; teaches students	Vesna Bukarica, Robert Pašičko	www.fer.hr

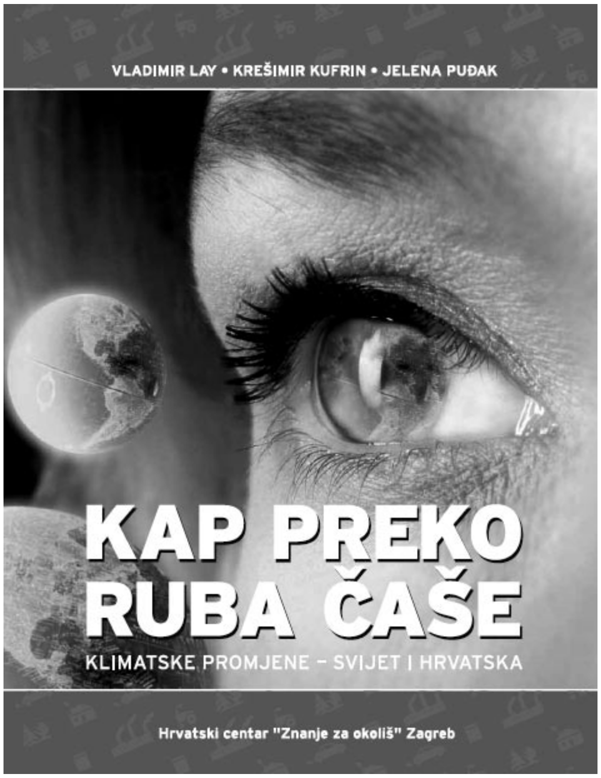
13.3.3. Information available for smaller-scale energy efficiency, emissions reduction, and renewable energy – the public and smaller organisations

In addition to larger-scale efforts to reduce emissions, actions by individuals and small organisations will have an important effect on climate change mitigation within Croatia. International organisations, government entities, NGOs, the education system, and labelling programmes all play a role in this field. To advance human development in terms of knowledge about climate change and taking action to prevent climate change using resources efficiently, information must be made available to the public and smaller organisations.

As has been noted, the Government has moved forward in demanding energy labelling for various products, including automobiles. Further improvements could be made by actually listing the increased costs to the consumer for the extra energy needed for appliances, automobiles, buildings, etc. This will be necessary for fulfilling the requirements of the acquis communautaire and will also help consumers make educated choices about the products they buy.

In addition to mandatory labelling, various NGOs have expertise in spreading information about energy efficiency and RES measures to SMEs and the general population. For example, Green Action, which is affiliated with Friends of the Earth International, runs a summer camp to teach about solar collectors and other such technologies and is a regional leader in this practice among NGOs. ZMAG, an NGO knowledgeable about alternative technologies, has been working with schools and other institutions to install renewable technologies that will reduce emissions. The Regional Environmental Centre (REC) has also been involved in promoting energy efficiency measures and co-generation projects especially oriented towards SMEs around the country. The organisation DOOR works closely with many members of FER and operates a web-portal (www.mojaenergija.hr) that provides information for citizens and organisations about issues related to energy. The Croatia Expert Society for Solar Energy has been encouraging the proliferation of renewable solar energy. In addition to these national level NGOs, the Heinrich Böll Foundation, which is affiliated with the international Green Party, plans to be more involved in climate change issues in Croatia in the future. Support for NGOs in Croatia primarily comes from funds such as the Heinrich Böll Foundation, the World Bank, the EU, various embassies, the National Government and other international donors. Very few NGO development models, based on either membership fees or a business-oriented approach for selling products for revenue are currently being implemented within the NGO community. This may undermine sustainability in the long term. However, with the emergence of the EU as a major donor and Government funding sources such as the Fund for Environmental Protection and Energy Efficiency and MEPPPC,[IX] it may be possible for NGOs to continue to expand their activities.

Figure13-2: Cover of the book "The Drop that Spills Over the Glass: Climate Change – the World and Croatia"



[IX] The Croatian Ministry of Environmental Protection, Physical Planning, and Construction has a small grants programme for NGOs and other actors that is often utilised for public education. See http://www.mzopu.hr/default.aspx?id=5594.

With support from the MEPPPC and the EC LIFE Third Countries project, the NGO "Croatian Centre for Knowledge for the Environment" recently published a book entitled "The Drop that Spills Over the Glass: Climate Change – the World and Croatia" that was distributed across the country to educate teachers and younger students about climate change and what actions they could take.[15] Other organisations, including UNDP, Green Action, DOOR, and ZMAG, have also been contributing to increasing public knowledge about climate change and how to introduce energy efficiency and small-scale renewable energy projects in their homes. Nature protection is already part of the national curriculum in elementary schools and climate change is being introduced as a topic in secondary schools.[16] Furthermore, university level education offers numerous courses on climate change and sustainable development, including a post-graduate Environmental Management Programme run by the University of Zagreb and the Department of Power Systems in the Faculty of Electrical Engineering and Computing.

One area where public knowledge is critical is transportation. The quantity of information related to carbon-dioxide emissions and fuel economy available to buyers of passenger cars is increasing. This includes mandatory CO_2 emissions and fuel economy labelling, though there is no comprehensive campaign to

Table 13-3: National level NGOs engaged in climate change mitigation activities and contributors to this section.

Organisation Name	Type of Organisation	Activities Related to Climate Change Mitigation	Contact Person	Website/ Contact
Croatian Auto-Club	National NGO	Promotes efficient driving	Alan Vojvodić, Head of Public Relations	www.hak.hr
Croatian Business Council for Sustainable Development	National NGO	Organisation with businesses on environmental sustainability	Mirijana Matešić, Director	www.hrpsor.hr
Croatian Chamber of Economy	National NGO	Encouraging EE in SMEs and helping with introduction of ETS	Dijana Varlec, Expert Associate in Industry and Technology Department	www.hgk.hr
Croatian Expert Society for Solar Energy	National NGO	Encouraging the spread of solar energy collectors and PVC in Croatia	Ljubomir Majdandžić, President of the Society	www.hsuse.hr
DOOR	National NGO	Web-portal for energy issues, public education for EE and RES	Maja Božičević Vrhovček, President	www.door.hr www.mojaenergija.hr
Green Action	National NGO	Renewable energy promotion and sustainable transport	Toni Vidan, Director	www.zelena-akcija.hr
Knowledge for the Environment	National NGO	Public education on climate change/ environment	Vladimir Lay, President of Governing Board	vladimir.lay@zg.htnet.hr
ODRAZ	National NGO	EE and rural development, sustainable transportation	Višnja Jelić-Muck, President	www.odraz.hr
Regional Environmental Center (REC)	National NGO	Awareness building for EE among SMEs, local municipalities	Željka Medven, Project Manager	www.rec-croatia.hr
ZMAG	National NGO	Encouraging sustainable development and renewable technologies in schools, small projects	Dražlen Šimleša	drazen.simlesa@pilar.hr

encourage the use of sustainable transport. Green Action has recently begun a campaign focused on urban planning, while INA has developed a public relations campaign entitled "Save More than just Fuel" focused on fuel-efficient driving habits. The Croatian Auto Club (HAK), Croatia's largest membership organisation for drivers, is currently undertaking a campaign called "Make Cars Green" to encourage drivers to change their behaviour and drive more efficiently. The city of Zagreb (where almost a fifth of all Croatians live) is also running an awareness raising campaign on the benefits of alternative transportation, which includes the "European Week of Mobility."

Overall, the Croatian public is relatively well aware of climate change issues and indicates at least some willingness to act. Almost 90% of respondents to the public opinion poll commissioned for this Report (see Chapter 2) expressed a willingness to use environmentally sustainable transportation and over 86% expressing a willingness to cut down on electricity consumption. The next step is to teach people how to reduce their carbon footprint and to make it easy for them to do so.

13.4. Financing mitigation: involvement of businesses and larger emitters

In order to reduce the GHG emissions that cause global warming and climate change financial resources must be made available and earmarked for emissions reductions measures. This can be done by engaging the business community as well as pricing carbon to yield a financial benefit for reductions.

Croatian industries are already involved in climate change issues as a result of the national carbon fee introduced in July, 2007.[17] This form of carbon pricing was identified as an important step towards reducing emissions by UNDP's Global Human Development Report, as well as the Stern Review of the Economics of Climate Change.[18] The 2007/2008 Human Development Report recommends an initial fee of between EUR 7 and 13, increasing to EUR 40 over time, with this revenue being used to reduce taxes on labour and investments and to develop incentives for low carbon technology.[19] While this level of taxation may be de-

Table 13-4: Summary of the types of fees related to carbon, which is allocated to the Environmental Protection and Energy Efficiency Fund

Type of Fee	Amount of Fee	Total Fees Collected
Motor vehicle emissions fee	- 88-150 HRK per year (EUR 12-20) – depending on the size of the engine and age of vehicle	- 2007 – expected HRK 202 million (EUR 27.7 million) - Expected to generate over EUR 35 million per year in carbon fees.
Carbon fees on industry	- 14 HRK (EUR 2) per tonne - Will become 18 HRK (EUR 2.50) in 2009.	- 2007 – expected HRK 53.3 million (EUR 7.3 million)

> "Partially thanks to the carbon fee introduced by the Government and Croatia's impending entry into the ETS, awareness among business leaders is growing"

sirable for developed countries such as Denmark and Norway, it might be too high for Croatia. On the other hand, some believe the amount is too small and concentrates on too few actors to induce actual reductions.

An annual environmental charge already exists for motor vehicles, which generates revenue for the Environmental Protection and Energy Efficiency Fund. The amount is relatively insignificant as a deterrent to using passenger cars (it is essentially the price of 10-15 litres of gasoline – less than half a tank), but it does provide revenue that can be used for pollution reduction measures.

It is worth noting that in the last four years HRK 124 million (approximately EUR 17 million) was allocated to energy efficiency and renewable energy projects.[23] However, only HRK 49 million (EUR 6.7 million) was actually used by energy efficiency and renewable energy projects.[24] This discrepancy indicates a lack of absorption capacity for the implementation of projects that reduce emissions and/or a need for more effective programming to ensure that revenue from carbon emissions fees is spent on carbon reductions or to offset taxes in some other way.

To date, because of the delay in agreeing on baseline emissions levels and its relatively recent (2007) ratification of the Kyoto Protocol, Croatia has not participated in any international carbon trading regime, and no Croatian companies are involved in Clean Development Mechanism or Joint Implementation projects. As a part of the process of harmonising legislation with the EU, Croatia is still preparing the regulation that would allow businesses to participate in these programmes. The business sector is generally very interested in becoming involved in trading mechanisms. This is especially true with regard to the National Allocation Plan for 2010-2012, which is being developed with support from the EU CARDS programme. Under the National Allocation Plan, emissions allowances will be distributed to operators of installations participating in the EU ETS. Concern exists that business representatives will not be sufficiently involved in the development of the plan, which is potentially the most important scheme for dealing with Croatian emissions, given imminent EU accession. Under the proposed plan, sources (that is, companies) will be able to emit a certain amount of carbon under the ETS. If a company emits less than this amount, it will be able to sell its "extra" emissions on the market. If an installation emits more than its allocated amount, it will have to buy emissions on the market. It is a complicated system, and the entrance of Croatia into the ETS will require significant effort by industries – including the aviation industry,[25] which the European Parliament recently voted to include in the system.[X] This is a major market: the ETS system in 2007 was estimated to be worth EUR 28 billion.[26]

Partially thanks to the carbon fee introduced by the Government and Croatia's impending entry into the ETS, awareness among business leaders is growing. Many already consider energy efficiency important for reducing costs in general. There may be further potential to expand energy efficiency beyond the building sector to include actual production systems for SMEs and large firms. However, little baseline analysis has been carried out regarding this issue. A positive development in this direction is that the Croatian Chamber of Economy, the largest organisation representing business members in Croatia, is closely involved in the development of the National Allocation Plan and is planning to expand its involvement in energy efficiency measures.

In addition to trading mechanisms and involuntary financial mechanisms, companies such as Holcim (a major cement company), Croatia Airlines, and HEP are engaging in efforts to reduce emissions through efficiency measures or by using renewable energies. HEP has formed a sub-company whose focus is renewable energy development (HEP- Renewables) and the HEP Energy Services Company (HEP- ESCO), which concentrates on potential energy efficiency projects. The company has also been engaged in projects to analyse the potential for acquiring carbon credits by participating in the project activities of the Kyoto Protocol flexible mechanisms: Clean Development Mechanism (CDM) and Joint Implementation (JI), as well as

[X] For a broader description about the debate over aviation emissions and the ETS, see http://www.euractiv.com/en/transport/aviation-included-eu-co2-trading-scheme/article-174072 which includes numerous viewpoints on the issue as well as links to various stakeholders and their opinions. EurActiv.com 2008.

the introduction of clean technologies, which include cogeneration facilities. Because Croatia is an Annex I country under the Kyoto Protocol and is required to reduce emissions, it cannot participate in CDM project activities as a host country, but it can invest in this type of project in non-Annex I countries in the region or world-wide.

In addition to the mandatory measures that are in place and will come into force following EU accession, other organisations, such as the Croatian Business Council for Sustainable Development, the Croatian Chamber of Economy, the American Chamber of Commerce, the Nordic Chamber of Commerce, and the Global Compact Initiative led by UNDP, can potentially engage the business community in voluntary measures to reduce emissions and improve their competitiveness at the same time.

Financial resources must be made available to ensure climate change mitigation leads to human development. Large savings are possible – especially in energy efficiency – that could improve business performance and economic development as well as reduce pollutants and aid other aspects of human development. The potential exists for Croatian businesses to push forward with new technologies that create new jobs, make the environment cleaner and encourage more education. The Croatian Expert Society for Solar Energy estimates that there are over 500 people working in the renewable energy sector in Croatia, and that number is growing. In Austria, which has invested heavily in renewable energy, approximately 17,600 people worked in the renewable energy sector in 2005.[27]

Overall, Croatia is generating enough capital and providing good financial incentives for emissions reduction. This should continue and more opportunities for financing should be investigated. This could include implementing programmes that use funds from voluntary carbon offsets, utilising opportunities related to Joint Implementation programmes, and directing carbon fees towards feed-in tariffs, energy efficiency, reforestation, and other carbon saving programmes.

“Financial resources must be made available to ensure climate change mitigation leads to human development”

Table 13-5: Businesses engaged in climate change mitigation activities and contributors to this section.

Organisation Name	Type of Organisation	Activities Related to Climate Change Mitigation	Contact Person	Website/ Contact
HEP – DD	Business	Croatian electricity utility; also sells natural gas, combined heat and power; has numerous projects oriented towards climate change	Goran Slipac, Director of Corporate Development and Strategy.	www.hep.hr
HEP – Energy Services Company (ESCO)	Business	Services for EE including providing capital to be paid back with savings	Gordana Lučić, Director	www.hepesco.hr/
HEP – Renewables	Business	Renewable energy production	Zoran Stanić, Director	www.hep.hr/oie/
Holcim Croatia	Business	Cement industry business working to reduce emissions	Žarko Horvat, Director of Industrial Technology	www.holcim.hr

13.5. Recommendations for the capacity needed to address climate change mitigation and advance human development

Croatia has made significant strides towards establishing an institutional framework that could lead to emissions reductions and foster human development. The regulatory framework set out by the Government has sent a clear message that energy efficiency, renewable energy and reduced emissions are important. A fair amount of technological capacity and knowledge exists in Croatia to address climate change mitigation demands and ensure that human development is enhanced, not undermined. Opportunities for financing emissions reductions also exist and are increasing. This capacity is likely to continue to grow as Croatia moves towards EU accession. There are several specific recommendations that can be made to ensure that mitigation efforts aid human development rather than hinder it.

1. The Government should form an inter-ministerial working group on climate change coordinated by MEPPPC. This group should include technical and political representatives who can work together to ensure improved communication and coordination among Governmental actors. This coordination could prevent the waste of public resources, including staff time, and ensure that ministerial strategies/ plans take climate change into account in development planning. The mandate of the group could be more general and also address adaptation as well as mitigation.
2. Data development and best practice measures should be made more publicly available when funded by the Government. Possible channels for making this information available include the Croatian Environmental Agency, further development of the Climate Change web-site at http://klima.mzopu.hr/, or by a website developed and managed by the inter-ministerial working group proposed above.
3. Progress that is currently being made in promoting energy efficiency in the Government sector should also be encouraged in the industrial and SME sectors.
4. Further development of the stakeholder process may be necessary to involve business representatives in discussions regarding the implementation of new policies.
5. Revenue from carbon fees should be used either for emissions reductions programmes or for tax reductions for fee-payers.
6. Business and technical consultancy organisations may have a competitive advantage in promoting regional mitigation measures. Croatian companies should investigate possibilities for marketing mitigation measures in other countries. These services can also be a part of Croatia's official development assistance.

Chapter 14

Conclusions: A Climate for Change - Findings and Recommendations

Chapter 14

Conclusions: A Climate for Change - Findings and Recommendations

14.1. General findings

While this Report is not meant to be a comprehensive overview of all aspects of climate change, it does reflect the breadth and depth of research that has been done in many sectors to date, and it provides a link between a global phenomenon and the everyday human development issues facing Croatia. The research and analysis in this Human Development Report indicates that while climate change is likely to pose serious threats to human development in Croatia, the country's current "climate for change" will inspire Croatia to rise to the challenge. Why?

- **Croatians are concerned about climate change and supportive of the changes that may be necessary to address it.** The public opinion survey of 1,000 Croatians indicated a high degree of concern about climate change and a willingness to act. 96% of Croatians surveyed believe that climate change is a "serious" problem. Over two thirds of respondents indicated they would be willing to pay more money for heat and electricity to ensure that their energy sources were renewable. Furthermore, many Croatians are already taking action – such as reducing energy use – to reduce their carbon footprint.

- **Climate variability is already causing significant damage in Croatia.** Agricultural production, human health, energy supply and other key components of human development are already vulnerable to climate variability, which may be a result of existing climate change. The August 2003 heatwave caused an estimated 4% increase in mortality. The same year, hydroelectric production decreased by almost 20% due to the drought. Between 2000 and 2007, extreme weather events have resulted in average annual costs to agriculture of EUR 176 million – a figure greater than direct payments made to farmers by the Government during that period. Invasive fish species have appeared in the Adriatic - a probably consequence of changes in the sea temperature - and are already affecting the fishing and mariculture industries. Climate events such as heatwaves, droughts and floods provide the opportunity to assess Croatia's readiness for some of the impacts of future climate change and the ability of the Government to respond to these impacts.

- **Future climate change is likely to have an impact on a broad range of sectors, though it is not possible to make definite predictions, as adequate information on the subject is currently unavailable.** However it is probable that changes in the precipitation, temperature, soil moisture, and the frequency of extreme events, will have an impact on some of the most important economic sectors in Croatia. These includes:
  - The tourism sector – particularly where foreign tourists come to the coast during peak times of the year – may face challenges due to uncomfortably hot summers, but also opportunities due to better weather during the spring and autumn. Additional threats may result from damages to particularly important tourist destinations and/or increases in severe weather related events such as heatwaves and forest fires.
  - Many parts of the coastline may be vulnerable to sea-level rise, including the Neretva Delta, some urban areas such as the island of Krapanj, some parts of Split, and natural areas such as Vrana Lake near Biograd and the River Krka.

- Human health – especially among older people – will experience increased risks due to heat waves during the summer. However, mild winter temperatures are likely to reduce the health problems caused by cold weather. Additionally, changes in allergen patterns may also cause problems for certain groups.
- Hydropower production may decrease due to reduced river flow, and wetlands benefits may be endangered due to less precipitation.
- Agricultural production may experience a drop in the yields of various crops.

  The fisheries and mariculture industries should benefit from the increased production of certain types of fish and shellfish, although invasive species and sea temperatures may reduce the number of other species.

- **Climate change will not affect all Croatians equally.** Certain groups in society face a greater risk from future climate change. These include residents of certain regions that face the double burden of low incomes and employment in/ reliance on weather-sensitive industries. They also include the elderly, who face added health risks due to heat waves. Additionally, poorer segments of society may find it difficult to cope with rising commodity prices (including energy and food) because of limited income. For both groups, climate change may be a threat multiplier, making existing difficulties more severe. Groups at greater risk will require special attention.

- **Looking towards 2020, many possibilities exist that will enable Croatia to reduce its emissions.** Preliminary analysis shows that Croatia should be able to reduce its emissions beyond the 1990 official baseline levels – perhaps by as much as 30%. The costs for this reduction are estimated to be between approximately EUR 114.7 million and EUR 535.9 million for that year. This is equivalent to 0.31%-1.43% of 2007's GDP. They include energy efficiency measures, sustainable transportation policies, renewable energy policies, measures to encourage fugitive methane utilization, introduction of more renewable energy and changes in industrial production processes. Furthermore, the potential for GHG "sinks" in Croatia is quite large, though this reduction measure may not be fully eligible for international negotiations. Forest cover and carbon content increases in soils could have a huge impact on emissions reductions, though the costs and benefits need to be further explored. In order to carry out these measures, tremendous public, private sector, and Government involvement will be necessary. Potential, though more controversial, measures also exist, such as the development of nuclear power and the incineration of waste products for energy. These have been identified as potentially cost-effective but may not be feasible for reasons of environmental sustainability and public resistance. See Box 14-1 for more information on how this analysis is related to the current Energy Strategy in Croatia.

Box 14-1: Climate change mitigation in relation to the Energy Strategy

On November 10, 2008, the Vice Prime Minister and Minister of Economy, Labour and Entrepreneurship introduced the Energy Strategy Green Paper of the Republic of Croatia (Green Paper). This launched a 30-day public consultation period on this important document. The final summarized document (White Paper) will be submitted to the Croatian Parliament for discussion and approval.

The Energy Development Strategy is the foundation document of the Energy Act that defines the energy policy and future plans for energy development. The Croatian Parliament adopts the Strategy proposed by the Government for a ten-year period. Based on the adopted strategy, the Government creates an Energy Strategy Implementation Programme for the following four-year period. The Energy Development Strategy of the Republic of Croatia focuses on the period until 2020, and provides a general forecast until the year 2030. Because of the high level of uncertainty in forecasting beyond 2020, the Strategy can only suggest a general direction for 2030.

The main goals, principles and challenges

- The Energy Development Strategy of the Republic of Croatia follows three basic energy objectives:
- Security of the energy supply
- Competitiveness of the energy system
- Sustainability of energy development

The climate change issue is a key element of the Strategy - it forms an integral part of future policy and is one of the pillars for achieving sustainable energy objectives. One goal of the Strategy is to contribute to international efforts to combat climate change. Within this context, Croatia advocates the principle of "joint but differentiated" responsibility. The Strategy goes beyond the full implementation of the *EU acquis communautaire* by formulating its post-Kyoto goals based on the new EU climate change energy package policy. The Strategy adopts the goal of utilising renewable sources to produce 20% of consumed energy by 2020. It also envisages the substitution of 10% of diesel and gasoline with biofuels by 2020. Croatia faces various challenges in the post-Kyoto regime, such as the proposed EU burden-sharing scheme that differentiates two mayor groups of emissions: ETS sector emissions and non-ETS sector emissions. The ETS sector will have a single European cap with emission reduction requirements of 21% compared to 2005 levels. Emission allowances will no longer be free of charge, as in the Kyoto period. Auctions will be organized and open to all member states. In non-ETS areas, a decrease of emissions by 10% by 2020 is envisaged. However, in the countries in which GDP per capita is below the EU average, increases of emissions up to 20% will be allowed. It is clear that Croatia would have been in a significantly more favourable position had it been a member of the EU during the formulation of the burden-sharing agreement. Instead, Croatia must independently negotiate with the UNFCCC.

Given this policy context, the Strategy highlights several challenges related to climate change mitigation that will have a decisive impact on the economy:

- Compliance with Kyoto Protocol obligations;
- Compliance with international environmental obligations after 2012;
- Integration into the EU ETS and the burden-sharing agreement between EU member states;
- Competitiveness in the region;
- Pressure from fast-growing sectors;
- Development and application of technology for carbon capture and storage;
- Application of nuclear energy

Energy projections

The Green Paper provides final energy demand projections for both a business as usual scenario (BAU) and for a Sustainable Energy Scenario (SES). The total primary energy supply (TPES) is provided for the SES scenario only. The Green Paper assumes that the energy supply will need to support stable economic growth, with a long-term GDP increase of up to 5% annually. Croatian per capita consumption indicators are much lower than the EU average, and electricity imports are among the highest in Europe. Convergence towards the EU average means faster growth. In the SES, final energy consumption increases in the period 2006-2020 by a rate of 2.7%, and electricity consumption increases by 3.4 %. In the electricity production sector, a high demand for new capacity is projected, due to growing consumption and the age of current substations and power plants (Figure 14-1).

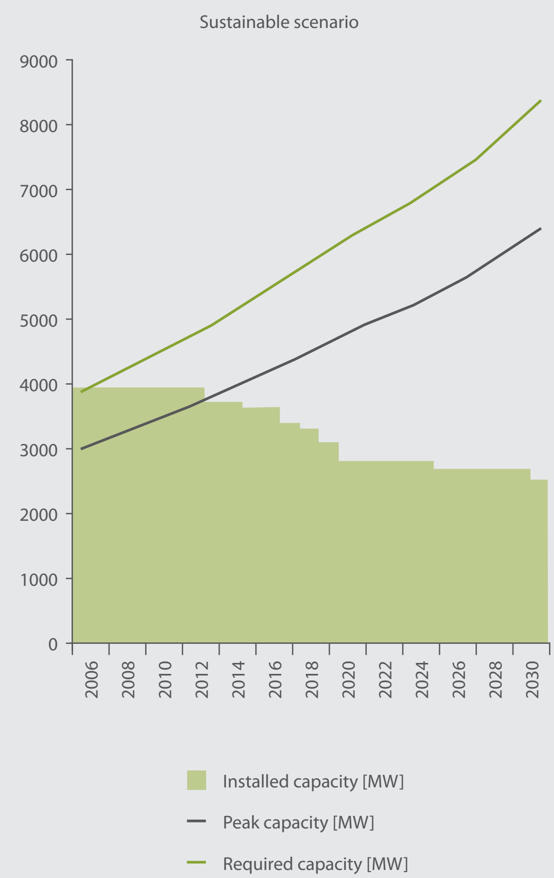
The green paper proposes three scenarios for the development of the power sector:

BLUE SCENARIO (two gas-fired thermo-electric turbines (TEs), two coal-fired TEs)

GREEN SCENARIO (two gas-fired TEs, one nuclear)

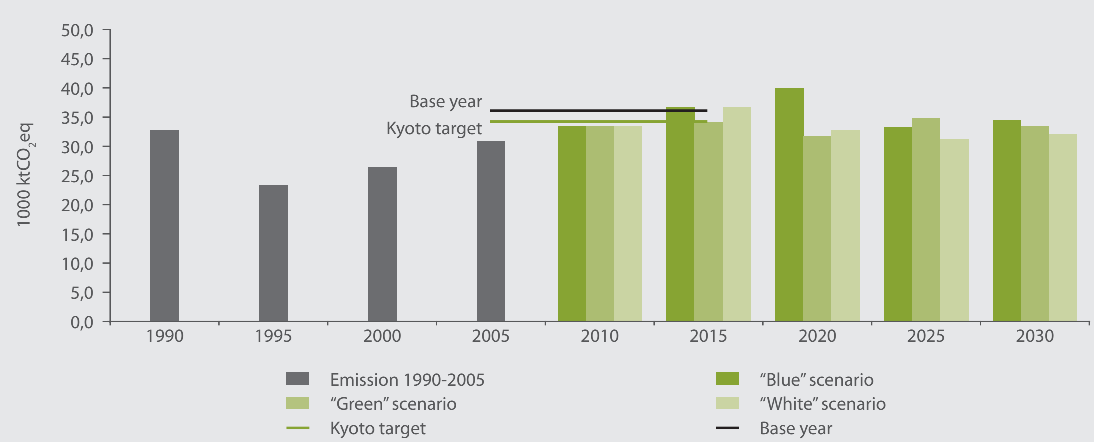
WHITE SCENARIO (one gas-fired TE , 1 coal-fired TE, and one nuclear)

Figure 14-1: Graph indicating the decrease in power generation capacity due to the decommissioning of existing facilities and the required capacity necessary to satisfy demand.



Source: MELE 2008.

Figure 14-2: Total GHG emissions until 2030 in Croatia by scenario



GHG projections

Projections of GHG emissions are provided for the energy sector and for total national emissions levels (Figure 14-2). Emissions in non-energy sectors were assumed to remain nearly constant. Projections are presented for the three SES scenarios described above: Blue, Green and White. BAU scenario projections are not presented.

The main measures implemented in these scenarios are as follows:

- **Renewable energy sources**

  In all scenarios, 20% of final energy consumption is produced by renewable sources. Approximately 35% of electricity in all scenarios is produced from renewable sources by the year 2020. In addition to production from large hydro plants, 4.0 TWh will be produced from new sources. The scenarios also assume a large increase in renewable energy from the production of heat and steam. For industrial energy production, biodegradable waste is introduced in cement production, and communal waste incineration is used for heat. In transport, 10% of energy will be from biofuels.

- **Energy efficiency in the end-use sector**

  By 2016 energy efficiency measures should reduce consumption by 19.77 PJ. This represents 9% of the average consumption from the period 2001-2005. While energy consumption is likely to increase during this period, efficiency should improve. The same increased efficiency rate should continue until 2020.

- **Energy efficiency in production**

  New power plants will be considerably more efficient. A new 400 MW combined heat and power plant is proposed along with 100 MW in micro-cogeneration.

- **Fuel conversion**

  Liquid fuel is replaced by other sources for the production of electricity.

- **Nucelar power**

  Nuclear energy is proposed in two scenarios Green and White, becoming operational in 2019.

- **Carbon Capture and Storage (CCS) technology**

  The Green Paper assumes CCS technology implementation at both new and older coal plants after 2020.

- **Emissions trading**

  Emissions trading and the use of other Kyoto flexible mechanisms are assumed. The use of emissions trading is proposed to bridge the period prior to the commercialization of CCS technology for coal plants.

With the above measures, Croatia would be able to stabilise its emissions between 32 – 34 $MtCO_2/eq$ after 2020 under all three scenarios. The use of CCS technology and the use of nuclear energy pose uncertainties similar to those in many other countries.

It might be concluded that any additional cost-effective measures to reduce GHG emissions in the energy sector and other sectors are very important for Croatia (as analysed in Chapter 12). The economic and technical feasibility is not the only factor in implementation. For many additional measures, implementation depends on how successfully barriers will be removed. Social and environmental factors are related not only to issues such as nuclear energy, but also to measures in agriculture, land use change, waste management and forestry.

- **The fundamental elements of a framework to mitigate climate change are being formulated.** The Government is already moving to address climate change mitigation through instruments such as the carbon fee and the European emissions trading system that is currently being established. Additionally, many companies and NGOs are working to include emissions reductions in their programmes. However, increased coordination is needed at the national level – including the involvement of sectors such as agriculture and transportation - in efforts to reduce emissions. Policy decisions are being considered by the Government, such as sectoral development strategies, however, these do not take climate change issues into consideration.

14.2. Recommendations

With the findings listed above, Croatia needs to continue national dialogue about the net effects of climate change and about opportunities to strengthen the Croatian economy and Croatia's society. The 'next step' recommendations throughout this Report fall into two general groups: recommendations related to research needs and recommendations related to policies and institutions.

14.2.1. Research Requirements

- **Data requirements for the current situation:** In order to address current climate variability – regardless of future climate change- specific data is required to improve the management of specific sectors. In agriculture, better data on crop yields and the economics of individual farms would help decision-makers decide how to spend resources. Additional economic data about the actual gross margins and the impact of various economic factors, such as the price of fertilisers, water inputs, labour and market prices, on agriculture would also be helpful. Continued and improved cooperation among Croatian authorities, as well as among the hydro-meteorological services in various countries in the region, could help by formulating improved, coordinated responses to major natural disasters (such as storms, heatwaves and forest fires), in order to limit the damages to human development. Within all sectors, a more open data sharing structure would benefit the research community and actors, both within and outside the Government, whose plans may depend upon data from other institutions. Research funded by public money must be made available to public institutions and the general public.
- **Modelling needs:** To address current needs – especially in agriculture - crop models that simulate responses to changes in existing climate or inputs would aid Governmental decision-making regarding subsidies and rescue packages. Furthermore, a macro-economic model of the agricultural sector and the entire Croatian economy would help the Government to better understand the impacts of current changes in prices on the economy, employment and poverty levels. In looking at future climate change, efforts to downscale global climate models to regional climate models will be helpful in a variety of sectors. Models can then project changes in agriculture, precipitation patterns that may lead to changes in river flow (thus reducing hydroelectric power), and physical impacts on popular and lucrative tourist destinations, such as Plitvice Lakes National Park, wetlands and fisheries. Physical impact studies coupled with economic analysis could then provide the basis for developing adaptation measures to avoid damages from climate change. Finally, additional analysis related to mitigation is necessary and more stakeholders, beyond the energy and industrial sector, should be engaged in efforts to mitigate the effects of climate change to ensure that emissions reduction measures support the human development process.
- **Understanding causal relationships:** In addition to having the modelling ability to project the impact of climate change on Croatia and an understanding of the economics behind potential adaptation measures, a direct linkage needs

to be made between climate and human development in Croatia. The sectors analysed in this Report have a dramatic impact on poverty alleviation, livelihoods and economic development. Climate-related risks – though not necessarily attributable to climate change – are already apparent in the agricultural sector and to some extent within the health, fisheries, power and even tourism sectors (forest fires and droughts). Policy-makers and planners must incorporate current climate variability and future climate change into their long-term planning processes.

- **Applied policy analysis:** For particular coastal areas that may be vulnerable to sea-level rise, more detailed analysis is advisable in planning any major infrastructure investments. For the agricultural sector, a detailed cost-benefit analysis should be carried out to address current problems related to soil moisture. For the water sector, additional analysis related to the high water losses from leakage and a cost-benefit analysis of measures to reduce leaks would be useful.

14.2.2. Policies and Institutions

To address both vulnerability and mitigation effectively, Croatia must improve coordination among the different actors involved. A high–level, inter-ministerial committee on climate change should be established. This committee could facilitate discussions within the Government and then collaborate with important stakeholders, such as businesses, civil society, and the general public. Tremendous opportunities exist to improve human development in Croatia, through energy efficiency measures, which save public money, and by reducing risks from climate-related disasters. More high-level support will be needed to integrate climate issues into decision-making.

- **Integration:** Because climate change is such a broad-based and multi-sectoral issue, many Government agencies/ ministries as well as private entities/ firms will need to be engaged in the discussion on what Croatia does to address it. The Ministry of Agriculture, Fisheries and Rural Development will need to be involved in decisions related to both adaptation and mitigation measures. Croatian Waters, which is developing plans for the next 20-30 years, should take climate change into account. HEP will need to think about the impact river flows may have on electricity production in addition to the potential increased energy needs for air conditioning in the summer months – especially from tourists. The tourism sector is already beginning to address reducing emissions from tourism activities, but more work is necessary to understand the potential impacts of climate change on coastal and inland tourism in Croatia. The Ministry of the Sea, Transport and Infrastructure, along with spatial planners, should incorporate issues related to the mitigation of emissions from transport into its decisions. While climate change mitigation is already listed in many strategic documents, massive effort will be required by Croatia to reduce its emissions. Many of the steps to reduce emissions can actually save money, but they will require forward thinking and strategic effort to become effective.
- **A national position for post-2012 mitigation issues:** This Report cannot recommend the level of emissions the Republic of Croatia should be willing to commit to under any post-2012 climate change regime. However, emissions reductions from Land Use, Land Use Change and Forestry (LULUCF) – seem to have massive potential for carbon removal in Croatia. This includes sequestration in forests as well sequestration in soils, which may also improve soil moisture. Croatia has the potential to move towards a lower carbon economy, but it will take significant political will and organisational capacity, in addition to bankable energy efficiency projects, public action and continued advocacy from the Government, regarding Croatia's role in the global solution to climate change.
- **An inclusive position:** Because of the broad-based nature of mitigation and adaptation, it is critical that lines of communication with stakeholders are open, including opportunities for stakeholder involvement in planning processes. Many opportunities to forward human development may become apparent, as a consequence of either reducing emissions or by making a sec-

tor less vulnerable to climate variability and/or climate change. Future adaptation or mitigation measures must also take into account the needs of stakeholders and Croatia's technological and economic capacity for change.

- **A proactive position towards public involvement:** Though the public seldom see themselves as responsible for climate change, public involvement and an understanding of climate change is absolutely critical to ensuring that emissions are reduced in a cost-effective way and that current and future climate risks are addressed. More education and fact-based public discussion is needed to educate Croatians of all ages on the effects of climate change and the steps the Government is taking now and in the future. The mass media is the best avenue for this, though the education system should also include topics related to climate change.

As a country that has emerged from the turbulent decade of the 1990s with very bright economic and social prospects and with a strong concern for the environment, Croatia is prepared to move forward as a regional leader in addressing future climate change, by reducing emissions and minimising climate-related risks to human development. The Croatian public is both concerned and willing to act. Croatian institutions have the political will to avoid the worst damages from climate change by taking on the responsibility of reducing emissions. The Croatian scientific and research community has the potential to be a regional leader in understanding and addressing climate risks. The next several decades are critical for the development of methodologies which will help alleviate the dire impacts of global climate change and also protect Croatia from climate-related damages. Croatia is ready to take on this challenge.

Annexes

Annex 1
Statistical Indicators

Human Development Indicators[1]

Human development index[2]	year	data
HDI rank	2006	45 of 179
Human Development Index (HDI) value	2006	0.862
Life expectancy at birth (years)	2006	75.5
Adult literacy rate (% aged 15 and above)	1999-2006[a]	98.6[b]
Combined gross enrolment ratio in education (%)	2006	77.2
GDP per capita (PPP USD)[k]	2006	14,309
Life expectancy index	2006	0.842
Education index	2006	0.915
GDP index	2006	0.828
Demographic trends[4]		
Total population, mid-year estimate (millions)	1975	4.500
Total population, mid-year estimate (millions)	1990	4.778
Total population, mid-year estimate (millions)	2006	4.440
Total population (millions), projected (variance of mid-fertility with mid-migration)	2051	3.714
Water, sanitation and nutritional status		
Population with sustainable access to improved sanitation (%)	1990	100
Population with sustainable access to improved sanitation (%)	2004	100
Population with sustainable access to an improved water source (%)	1990	100
Population with sustainable access to an improved water source (%)	2004	100
Survival: progress and setbacks		
Life expectancy at birth (years)	1970-1975[c]	69.6
Life expectancy at birth (years)	2000-2005[c]	74.9
Infant mortality rate (per 1000 live births)	1970	34
Infant mortality rate (per 1000 live births)	2005	6
Under-five mortality rate (per 1000 live births)	1970	42
Under-five mortality rate (per 1000 live births)	2005	7
Probability at birth of not surviving to age 60 (% of cohort)	2000-2005	12.7
Probability at birth of surviving to age 65, female (% of cohort)	2000-2005[c]	88.5
Probability at birth of surviving to age 65, male (% of cohort)	2000-2005[c]	73.4
Maternal mortality ratio reported (per 100,000 live births)	2005	8
Maternal mortality ratio adjusted (per 100,000 live births)	2005	7
Commitment to education: public spending		
Public expenditure on education (as % of GDP)	1991	5.5
Public expenditure on education (as % of GDP)	2005	4.7
Public expenditure on education (as % of Government expenditure)	2005	10
Current public expenditure on education, pre-primary and primary (as % of all levels)	2005	29[d]

Current public expenditure on education, secondary and post-secondary non-tertiary (as % of all levels)	2005	49[d]
Current public expenditure on education, tertiary (as % of all levels)	2005	19
Literacy and enrolment		
Adult literacy rate (% aged 15 and older)	1985-1994[e]	96.7
Adult literacy rate (% aged 15 and older)	1995-2005[f]	98.1
Youth literacy rate (% aged 15-24)	1985-1994[e]	99.6
Youth literacy rate (% aged 15-24)	1995-2005[f]	99.6
Net primary enrolment rate (%)	1991	79
Net primary enrolment rate (%)	2005	87[g]
Net secondary enrolment rate (%)	1991	63[d]
Net secondary enrolment rate (%)	2005	85
Tertiary students in science, engineering, manufacturing and construction (% of tertiary students)	2005	24
Technology: diffusion and creation		
Telephone mainlines (per 1000 people)	1990	172
Telephone mainlines (per 1000 people)	2005	425
Cellular subscribers (per 1000 people)	1990	(.)
Cellular subscribers (per 1000 people)	2005	672
Internet users (per 1000 people)	1990	0
Internet users (per 1000 people)	2005	327
Patents granted to residents (per million people)	2005	4
Recipients of royalties and licence fees (USD per person)	2005	16.1
Research and development (R&D) expenditures (% of GDP)	2005	1.1
Researchers in R&D (per million people)	2005	1296
Economic performance		
GDP (USD billions)	2005	38.5
GDP (PPP USD billions)	2005	57.9
GDP per capita (USD)	2005	8666
GDP per capita (PPP USD)[k]	2005	13,042
GDP per capita, annual growth rate (%)	1975-2005[h]	2.6
GDP per capita, annual growth rate (%)	1990-2005	2.6
Average annual change in consumer price index (%)	1990-2005	40.6
Average annual change in consumer price index (%)	2004-2005	3.3
Structure of trade		
Imports of goods and services (% of GDP)	1990[i]	86
Imports of goods and services (% of GDP)	2005	56
Exports of goods and services (% of GDP)	1990[i]	78
Exports of goods and services (% of GDP)	2005	47
Primary exports (% of merchandise exports)	1990[i]	32
Primary exports (% of merchandise exports)	2005	32
Manufactured exports (% of merchandise exports)	1990[i]	68
Manufactured exports (% of merchandise exports)	2005	68
High-technology exports (% of merchandise exports)	1990[i]	5.3
High-technology exports (% of merchandise exports)	2005	11.5

Aid, private capital and debt		
Official development assistance (ODA) received (net disbursements), total (USD millions)	2005	125.4
ODA received (net disbursements), per capita (USD)	2005	28.2
ODA received (net disbursements) (as % of GDP)	2005	0.3
Net foreign direct investment inflows (% of GDP)	2005	4.6
Other private flows (% of GDP)	2005	4.6
Total debt service (as % of GDP)	2005	12.8
Total debt service (as % of exports of goods, services and net income from abroad)	2005	23.9
Unemployment		
Unemployed people (thousands)[3]	2007	264
Unemployment rate, total (% of labour force)[3]	2007	14.8
ILO unemployment rate (%)[3]	2007	9.6
Employment by economic activity, total (thousands)	2005	1573
Employment by economic activity, agriculture (%)	2005	17
Employment by economic activity, industry (%)	2005	29
Employment by economic activity, services (%)	2005	54
Refugees		
Internally displaced people (thousands)	2006	4-7
Refugees by county of asylum (thousands)	2006	2
Refugees by country of origin (thousands)	2006	94
Armaments		
Military expenditure (% of GDP)	1990j	7.6
Military expenditure (% of GDP)	2005	1.6
Conventional arms transfers (1990 prices) – Imports (USD millions)	1996	14
Conventional arms transfers (1990 prices) – Imports (USD millions)	2006	0
Conventional arms transfers (1990 prices) – Exports (USD millions)	2006	0
Conventional arms transfers (1990 prices) – Exports, share (%)	2002-2006	(.)
Total armed forces (thousands)	2007	21
Crime and justice		
Intentional homicides (per 100,000 people)	2000-2004l	1.8
Total prison population	2007	3594
Prison population (per 100,000 people)	2007	81
Female prison population (% of total)	2007	5
Year of the abolition of the death penalty	1990	
Gender related development index[2]		
Gender related development index (GDI) rank	2006	45 of 179
Gender related development index (GDI) value	2006	0.859
Life expectancy at birth, female (years)	2006	78.9
Life expectancy at birth, male (years)	2006	72.0
Adult literacy rate, female (% aged 15 and above)	1999-2006[a]	97.5[b]
Adult literacy rate, male (% aged 15 and above)	1999-2006[a]	99.0[b]
Combined gross enrolment ratio in education, female (%)	2006	79.4
Combined gross enrolment ratio in education, male (%)	2006	75.2

Estimated earned income, female (PPP USD)[k]	2006	11,753
Estimated earned income, male (PPP USD)[k]	2006	17,025
Gender empowerment measure[2]		
Gender empowerment measure (GEM) rank	2006	38 of 179
Gender empowerment measure (GEM) value	2006	0.622
Seats in Parliament held by women (% of total)	2007	20.9
Female legislators, senior officials and managers (% of total)	2006	26
Female professional and technical workers (% of total)	2006	51
Ratio of estimated female to male earned income	2006	0.69
Gender inequality in education		
Adult literacy, female rate (% aged 15 and older)	1995-2005[f]	97.1
Adult literacy rate, ratio of female rate to male rate	1995-2005[f]	0.98
Youth literacy, female rate (% aged 15-24)	1995-2005[f]	99.7
Youth literacy, ratio of female rate to male rate	1995-2005[f]	1.00
Gender inequality in economic activity		
Female economic activity rate (% aged 15 and older)	2005	44.7
Female economic activity index (1990=100, aged 15 and older)	2005	96
Female economic activity as % of male rate (aged 15 and older)	2005	74
Female employment in agriculture (%)	2005	19
Male employment in agriculture (%)	2005	16
Female employment in industry (%)	2005	18
Male employment in industry (%)	2005	37
Female employment in services (%)	2005	63
Male employment in services (%)	2005	47
Women contributing family workers (%)	2005	73
Men contributing family workers (%)	2005	27

NOTES

a. Data refer to national literacy estimates from censuses or surveys conducted between 1999 and 2006.
b. UNESCO Institute for Statistics estimates which are based on its Global Age-specific Literacy Projections model – April 2008.
c. Data refer to estimates for the period specified.
d. National or UNESCO Institute for Statistics estimate.
e. Data refer to national literacy estimates from censuses or surveys conducted between 1985 and 1994.
f. Data refer to national literacy estimates from censuses or surveys conducted between 1995 and 2005.
g. Data refer to an earlier year than that specified.
h. Data refer to a period shorter than that specified.
i. Data refer to the closest available year between 1988 and 1992.
j. Data refer to the closest available year between 1991 and 1992.
k. PPP (purchasing power parity) is a rate of exchange that accounts for price differences across countries, allowing international comparison of real output and incomes. At the PPP USD rate PPP, 1 USD has the same purchasing power in the domestic economy as 1 USD in the United States. GDP per capita (PPP USD) is GDP (in purchasing power parity terms in USD) divided by the midyear population (UNDP 2007: 366, 369).
l. Data were collected during one of the years specified.
(.) Greater (or less) than zero but small enough to be rounded to zero at the displayed number of decimal points.

SOURCES

Main source:

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Other sources:

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4. CBS. 2007. Statistical Yearbook 2007. Zagreb, Croatia [http://www.dzs.hr/]. 9/2008.

Energy and environment

Energy	1990		2006	
Total primary energy supply (PJ)	381.0[a]		410.6[b]	
Total primary energy supply per capita (GJ)	79.7		92.5	
Gross electricity consumption per capita (kWh)	3297[c]		4066[d]	
Final electricity demand per capita (kWh)	2766[e]		3384[f]	
Average electricity selling price, VAT excluded (EUR/kWh)	--		0.073[g]	
Average annual personal consumption of electricity, gas and other fuels per household (EUR and % of total household consumption costs)	--		825.1[h]	8.7%
Average annual personal consumption of electricity, gas and other fuels per household member (EUR and % of total personal consumption costs)	--		281.4[i]	8.7%
GDP per unit of energy use (2000 PPP USD per GJ)	--		133.3[j]	
GDP per unit of energy use (% change 1990-2004)	12[k]			
Total primary energy supply (%):[l]	**1990**		**2005**	
Coal	9.0		7.5	
Oil	53.4		50.7	
Natural Gas	24.2		26.7	
Hydro, Solar, Wind and Geothermal	3.6		6.1	
Biomass and Waste	3.4		4.0	
Electricity production by fuel type (Electricity generation capacity, MW):[m]	**1990**		**2006**	
Coal	--		290.00	
Fuel oil	--		783.50	
Natural gas	--		399.18	
Fuel oil and Natural gas combined	--		270.00	
Other fuel combinations	--		56.50	
Generation capacity from fossil fuels total	*1486*		*1799.18*	
Hydro	2061		2060.34	
of that small hydro (< 10 MW)	33		32.76	
Solar	0		0.05	
Wind	0		17.15	
Geothermal	0		0	
Biomass and Waste	0		2.00	
Generation capacity from renewable sources total	*2061*		*2079.54*	
Total in the Republic of Croatia	*3547*		*3878.72*	
Nuclear (50 % ownership of Nuclear Power Plant Krško with Slovenia)	348		348.00	
Total	*3895*		*4226.72*	
Energy dependency	**1990**		**2006**	
Net imports of energy (PJ) (% of total primary energy supply)	75.4[n]	19.8%	203.7[o]	49.6%
Net imports of electricity (GWh) (% of total electricity supply)	7062[p]	44.8%	5622[q]	31.1%
GHG (Carbon dioxide equivalent) emissions[r]	**1990**		**2006**	
Total GHG emissions (excluding net CO_2e from LULUCF) (Mt)	32.5		30.8	
Total GHG emissions (including LULUCF) (Mt)	28.3		23.3	
GHG emissions per capita excluding LULUFC (t CO_2e)	6.8		6.9	
GHG emissions per capita including LULUFC (t CO_2e)	5.9		5.2	

1990 baseline GHG emission levels negotiated under the Kyoto Protocol[s] (Mt)	36.0			
Change in CO_2e emissions excluding LULUFC (%) (1990-2006)	-5.2			
Change in CO_2e emissions including LULUFC (%) (1990-2006)	-17.7			
Change in CO_2e emissions excluding LULUFC (%) (1990 official baseline -2006)	-14.4			
Change in CO_2e emissions including LULUFC (%) (1990 official baseline -2006)	-35.3			
Carbon equivalent intensity of growth (CO_2e emissions excluding LULUFC per unit of GDP – kt of CO_2e per million 2000 PPP USD)	--		0.56	
Carbon equivalent intensity of energy (CO_2e emissions excluding LULUCF per unit of energy use - kg of CO_2e per GJ)	85.3		75.0	
Carbon equivalent intensity of growth (CO_2e emissions including LULUFC per unit of GDP - kt of CO_2e per million 2000 PPP USD)	--		0.43	
Carbon equivalent intensity of energy (CO_2e emissions including LULUCF per unit of energy use - kg of CO_2e per GJ)	74.3		56,7	
Carbon dioxide emissions[t]	**1990**		**2006**	
Total Carbon dioxide emissions (Mt CO_2)	24.1		23.7	
Carbon dioxide emissions per capita (t CO_2)	5.0		5.3	
Change in CO_2 emissions (%) (1990-2006)	-1.7			
Share of world total of CO_2 emissions (%)[u]	0.1[v]		0.1[w]	
Carbon intensity of growth (CO_2 emissions per unit of GDP - kt of CO_2 per million 2000 PPP USD)	0.52[ll, v]		0.43	
Carbon intensity of energy (CO_2 emissions per unit of energy use - kg of CO_2 per GJ)	63.3		57.7	
Carbon dioxide emissions from forest biomass (Mt CO_2/year) (1990-2005)[x]	-10.8			
Carbon stocks in forest biomass (Mt Carbon) (2005)[y]	192.4			
Forest area[z]				
% of total land area (2005)	38.2			
Total (thousand square km) (2005)	21.4			
Total change (thousand square km) (1990-2005)	0.2			
Average annual change (1990-2005)	0.1			
Transport sector	**1990**		**2006**	
Registered passenger cars	852,585[aa]		1,435,781[bb]	
Number of cars (per 1000 people)	178.4		323.4	
Motor gasoline consumption per capita (kg)	131.0[cc]		160.2[dd]	
Diesel fuel consumption per capita (kg)	--		321.4[ee]	
Final energy demand in transport (PJ)[ff]	42.5[w]		84.9	
Of that – final energy demand in road transport (PJ and % of (total) final energy demand in transport)[gg]	36.5[w]	85.9%	77.0	90.7%
Carbon dioxide equivalent emissions from the transport sector (Mt)[hh]	4.27		6.23	
Of that – CO_2e emissions from road transport (Mt CO_2e and % of (total) CO_2e emissions from the transport sector)[ii]	3.64	85.2%	5.84	93.7%
Status of major international environmental treaties[jj]			**year of ratification**	
Cartagena Protocol on Biosafety (2000)			2002	
Framework Convention on Climate Change (1992)			1996	
Kyoto Protocol to the Framework Convention on Climate Change (1997)			2007[kk]	
Convention on Biological Diversity (1992)			1996	
Vienna Convention for the Protection of the Ozone Layer (1988)			1992	
Montreal Protocol on Substances that deplete the Ozone Layer (1989)			1992	

Stockholm Convention on Persistent Organic Pollutants (2001)	2007
Convention of the Law of the Sea (1982)	1995
Convention to Combat Desertification (1994)	2000

NOTES ON METHODOLOGY AND SOURCES

a. UNDP 2007: 306 (9.1 Mt of oil equivalent converted into PJ)
b. MELE 2007: 84
c. Eurostat 2008 (Total electricity supply – 15,755 GWh – divided by population)
d. Eurostat 2008 (Total electricity supply – 18,052 GWh – divided by population)
e. Eurostat 2008 (Final electricity consumption – 13,218 GWh – divided by population)
f. Eurostat 2008 (Final electricity consumption – 15,023 GWh – divided by population)
g. MELE 2007: 160 (0.5302 HRK/kWh were converted into EUR/kWh)
h. CBS 2007: 195 – Costs of electricity, gas and other fuels per household (6023 HRK) divided by total personal consumption costs per household (69,457 HRK) to obtain %.
i. CBS 2007: 195 – Costs of electricity, gas and other fuels per household member (2054 HRK) divided by total personal consumption costs per household member (23,682 HRK).
j. GDP (USD 2000 constant prices PPP in 2006) divided by 410.6 PJ (MELE 2007: 84).
k. UNDP 2007: 302
l. UNDP 2007: 306
m. Eurostat 2008 (1990 data – except for nuclear energy where the data is from MELE 2007: 149); MELE 2007: 149-53, 184 (2006 data) – (This includes all electricity production facilities of HEP (Croatian Power Company) in the Republic of Croatia, all industrial power plants in the Republic of Croatia, other power plants in the Republic of Croatia (not under HEP Group ownership) and total installed electrical power capacity of renewable energy sources).
n. Eurostat 2008 – 1.8 Mt of oil equivalent of net imports of energy (converted into the PJ=75.4 PJ) divided by 9.1 Mt of oil equivalent (UNDP 2007: 306) to obtain %.
o. CBS 2008: 56 – Total energy imports (324.86 PJ) subtracted by total energy exports (121.15 PJ) = 203.7 PJ; to get % of total primary energy supply, 203.7 PJ is divided by 410.6 PJ (MELE 2007: 84).
p. Eurostat 2008: Net imports of electricity – 7062 GWh divided by total electricity supply (15,755 GWh) to obtain %.
q. Eurostat 2008: net imports of electricity – 5622 GWh divided by total electricity supply (18,052 GWh) to obtain %.
r. MEPPPC 2008: xii,xiv unless otherwise noted
s. The Republic of Croatia ratified the Kyoto Protocol after the baseline GHG emissions for the year 1990 were increased (by 3.5 Mt). The initial number was too low because until 1991 only a small amount of electricity was produced in Croatia and 49% was imported (of that, 22% was from thermal power plants from other Yugoslav Republics, 15% from the Krško nuclear power plant, and 11% from abroad). In 1990 only 27% of electricity was produced in Croatian thermal power plants (MEPPPC 2007: 18). Thus, Croatian GHG emissions were relatively low at the time and the initial baseline was set too low considering future economic development.
t. MEPPPC 2008: xiv unless otherwise noted
u. UNDP 2007: 310
v. In cases where data for 1990 are not available, data for the closest year between 1991 and 1992 have been used.
w. 2005 year data
x. UNDP 2007: 310
y. UNDP 2007: 310
z. UNDP 2007: 302
aa. Ekonerg 2006: 28
bb. CBS 2007: 353
cc. Eurostat 2008 – (Final energy demand of motor gasoline – 591 thousand tonnes – divided by the population in 1991 (4.513 million, source: CBS 2007: 92) since the Eurostat 2008 data is from 1991.
dd. MELE 2007: 122 – (Final energy demand of motor gasoline – 711.3 thousand metric tonnes – divided by population).
ee. MELE 2007: 125 – (Final energy demand of motor gasoline – 1426.9 thousand metric tonnes – divided by population).
ff. Eurostat 2008 – 1016 thousand tonnes of oil equivalent in 1991 (2028 in 2006) converted into the PJ.
gg. Eurostat 2008 – 872 thousand tonnes of oil equivalent in 1991 (1838 in 2006) converted into the PJ. Shares were calculated by dividing final energy demand in road transport by final energy demand in transport.
hh. MEPPPC 2008: 28
ii. MEPPPC 2008: 28 – Shares were calculated by dividing CO_2e emissions from the road transport sector by the transport sector
jj. UNDP 2007: 314 unless otherwise noted
kk. MEPPPC 2008: vii
ll. UNDP 2007: 310

- Per capita – respective values were divided by population (1990=4.778 million; 2006=4.440 million, source: CBS 2007: 92).
- Changes in CO_2/CO_2e emissions were calculated using existing values in the table.
- Carbon (equivalent) intensity of growth was calculated by dividing respective CO_2/CO_2e emissions by GDP (USD 2000 constant prices PPP). It is the ratio of emitted CO_2/CO_2e to GDP in PPP terms. Carbon intensity of growth (also known as the carbon intensity of economy) refers to the amount of carbon dioxide generated by every US dollar of growth in the world economy (UNDP 2007: 364).
- Carbon (equivalent) intensity of energy was calculated by dividing respective CO_2/CO_2e emissions by total energy used (total primary energy supply). It is the ratio of emitted CO_2/CO_2e to energy use. Carbon intensity of energy refers to the amount of carbon dioxide generated for every unit of energy used (UNDP 2007: 364).
- All calculations were made by the UNDP Croatia staff.

CONVERSION FACTORS:

- 1 kilogramme of oil equivalent = 41,868,000 Joules (MELE 2007: 247)
- 1 Million tonnes of oil equivalent = 41,868 x 1012 PJ
- 1EUR = 7.3 HRK
- P = peta = 1015
- T = tera = 1012
- G = giga = 109
- GDP (USD 2000 constant prices PPP) in 2006: 54,736 million (MELE 2007: 22)

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Poverty indicators

	2007	
	With income in kind	Without income in kind
At-risk-of-poverty rate (%)	17.4	19.0
At-risk-of-poverty threshold for one-person households (HRK)	23,969.31	22,311.00
At-risk-of-poverty threshold for households consisting of two adults and two children (HRK)	50,335.55	46,853.10
At-risk-of-poverty rate by age and sex (%)		
Men	15.9	17.7
Women	18.7	20.3
0-15 years	15.4	16.3
Men	14.9	15.7
Women	16.0	17.0
16-24 years	15.0	16.0
Men	14.2	16.1
Women	15.9	15.9
25-49 years	11.7	12.5
Men	11.5	12.8
Women	11.9	12.3
50-64 years	16.9	18.2
Men	16.8	18.5
Women	17.0	18.0
65 years and over	29.0	33.2
Men	25.2	28.9
Women	31.4	36.0
At-risk-of-poverty rate, by most frequent activity status (%)		
Employed	4.1	4.2
Men	5.0	5.2
Women	(3.1)	(3.0)
Self-employed	17.9	24.1
Men	18.6	25.5
Women	16.9	22.2
Unemployed	34.5	35.8
Men	42.8	43.7
Women	27.0	28.6
Retired	22.8	24.8
Men	22.3	24.5
Women	23.1	25.1
Other economically inactive	28.2	30.7
Men	19.7	22.4
Women	32.4	34.9

At-risk-of-poverty rate, by household type and age (%)		
One-person household	36.5	41.3
Men	27.9	33.6
Women	39.8	44.3
One-person household, 30-64 years	28.2	30.8
One-person household, 65 years and over	41.5	47.5
Two adults, no dependent children, both adults under 65 years	17.7	18.8
Two adults, no dependent children, at least one adult 65 years or over	28.7	31.9
Other households with no dependent children	8.9	10.6
Single parent household, one or more dependent children	(26.0)	(23.6)
Two adults, one dependent child	11.2	12.6
Two adults, two dependent children	10.1	10.3
Two adults, three or more dependent children	25.9	27.7
Other households with dependent children	12.3	13.3
At-risk-of-poverty rate by tenure status (%)		
Tenant	21.4	18.2
Owner or rent free	17.2	19.1
Inequality of income distribution – quintile share ratio (S80/S20)	4.3	4.9
Gini coefficient	0.28	0.30
Relative at-risk-of-poverty gap (%)	21.9	24.9
Dispersion around the at-risk-of-poverty threshold		
40% cut off	5.2	7.2
50% cut off	10.5	12.6
70% cut off	24.0	26.3
At-risk-of-poverty threshold before social transfers (%)		
Social transfers excluded from income	24.3	26.3
Pensions and social transfers excluded from income	41.6	43.4

NOTE

( ) Insufficiently reliable estimate

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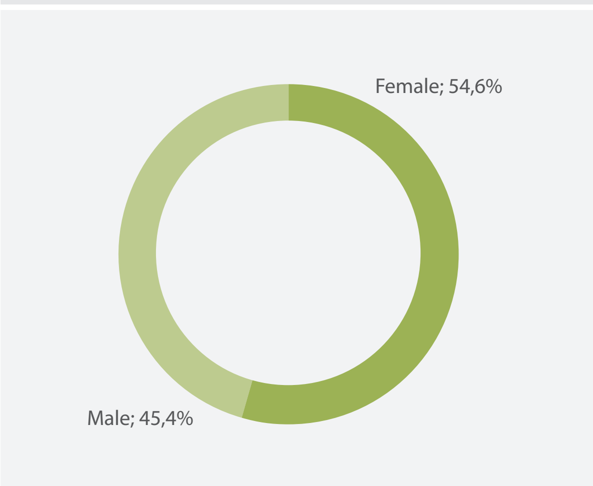
Annex 2

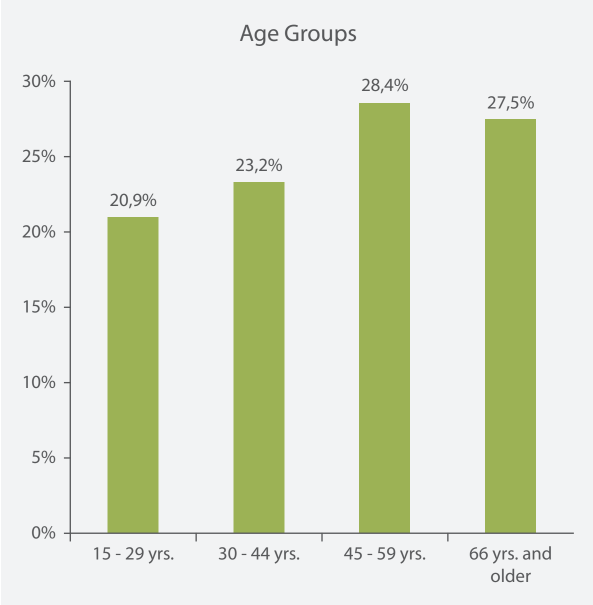
General Socio-Economic Questions and Answers from the Public Opinion Survey

Note: The following socio-demographic information was collected for all respondents to the public survey on attitudes towards climate change. The research was conducted by phone survey (CATI - computer assisted telephone interviewing) from a central location on a sample of 1000 randomly selected respondents older than 14. The sample was stratified according to the Croatian administrative territorial divisions (20 counties and the city of Zagreb) - in other words the percentages of respondents from different counties corresponded to the percentages from the 2001 Census. Due to the different response rates, higher educated citizens were overrepresented, but this bias was corrected by means of a statistical weighting of the data. The households participating in the research were chosen with a random-number generator. Individuals within the households were also randomly selected. The data were gathered between 30th June and 10th July 2008. Not all socio-economic indicators from the survey are presented below. To obtain all the data available, please contact UNDP Croatia directly.

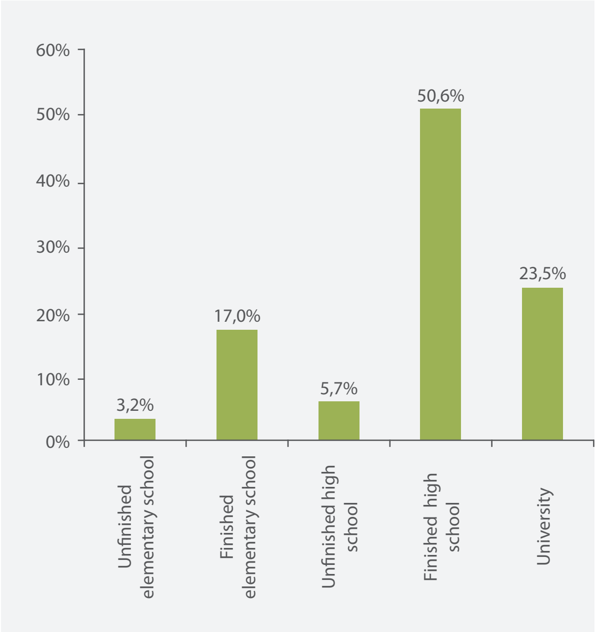
1. Gender:



2. Age:

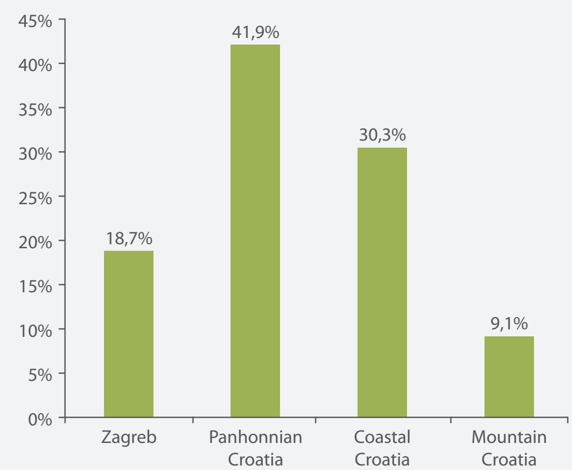


3. Education Level:

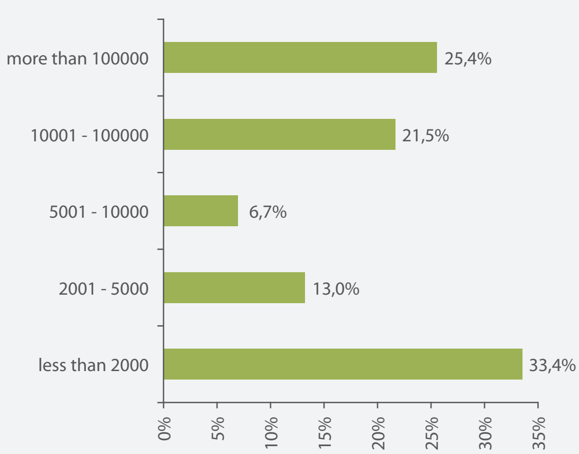


4. Location – town or municipality or name of village or nearest large town.

5. Region:



6.How many people live in this town / city / community?



7.What is your occupation?

Self Employed:

I. Farmer,

II. Fisherman,

III. Professional (lawyer, medical practitioner, accountant, architect, etc.),

IV. Owner of a shop, craftsmen, other self-employed person,

V. Business proprietors - owner (full or partner) of a company

Employed:

I. Employed professional (employed doctor, lawyer, accountant, architect),

II. General management, director or top management (managing directors, director general, other director),

III. Middle management, other management (department head, junior manager, teacher, technician),

IV. Employed position, working mainly at a desk,

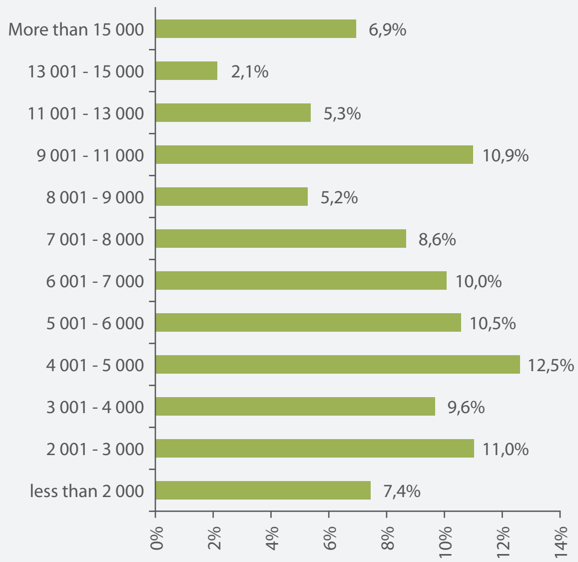
V. Employed position, not at a desk, but in a service job (hospital, restaurant, police, fireman, etc.),

VI. Supervisor,

VII. Skilled manual worker,

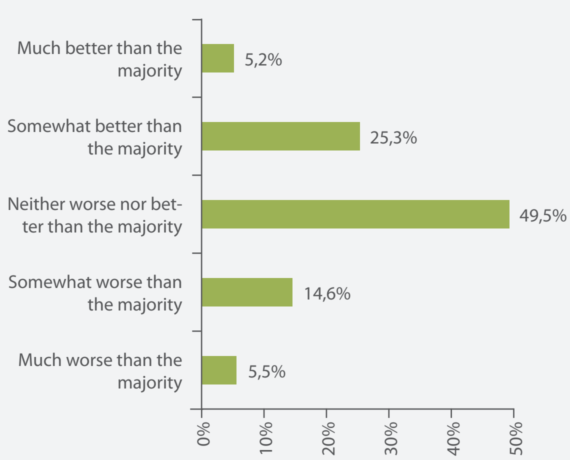
VIII. Other (unskilled) manual worker, servant.

8. What is the average net (after tax) income of your household per month including wages, rents received, interest from investments, and transfers from the Government?

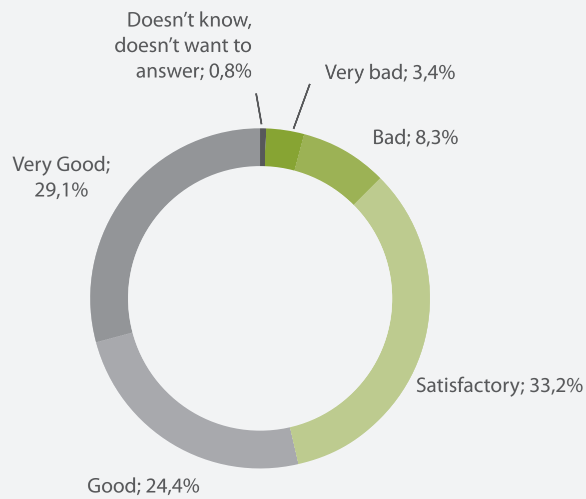


9. What would, in your opinion, be the lowest income amount your household would have to have in order to live without difficulties?

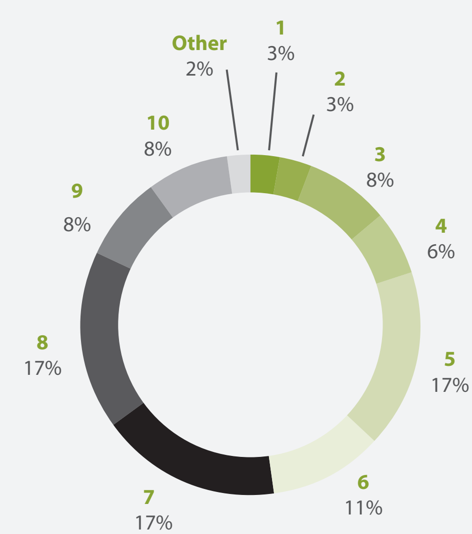
10. Could you please evaluate your financial situation (i.e. financial situation of your family)?



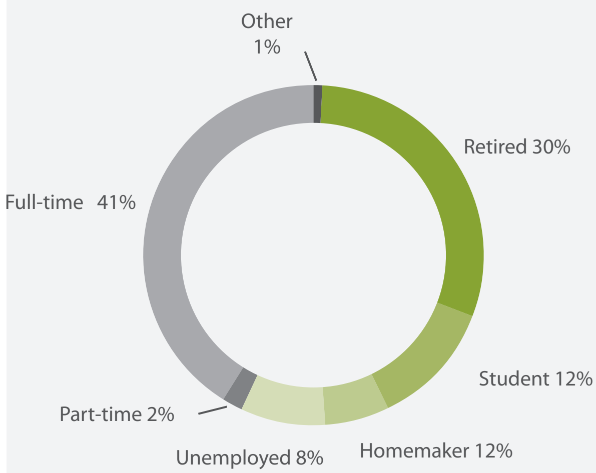
11. How would you describe your general state of health?



12. On a scale of 1 to 10 where 10 means perfectly satisfied and 1 means completely dissatisfied, how would you rate your satisfaction with your life over the last 12 months?



13. Are you working?



14. What is the size of your house / flat in square metres?

15. How many people are there in your household?

16. What is your marital/ family status?

a. Single.

b. Married, with no children.

c. Married with one or more children - how many?

d. Not married with one or more children – how many?

e. Married with children and grandchildren – how many?

f. Unmarried with children and grandchildren – how many?

Annex 3
Basic Information about Climate Models

Numerous factors can influence the Earth's climate. When discussing climate change and human causes, the most important factor presenting a new variable is the increase of greenhouse gases (GHGs) – most importantly CO_2. Through the use of advanced computing technology, a number of "Climate Models" have been developed. These models attempt to imitate the Earth's climate with changes in greenhouse gas levels along with many other variables such as sea ice, the carbon cycle, evaporation rates, etc. Climate models attempt to imitate the development of natural conditions using a number of climate related variables and to simulate the possible development of those variables in the future – such as rain, temperature, cloud cover, etc. In general, climate models have been categorised into Regional Climate Models (RCMs) – which cover a smaller area in more detail – and Global Climate Models (GCM) – also called General Climate Models – which cover the entire globe in less detail.

While Global Climate Models give a good representation of the entire planet, they are not as helpful for looking in detail at smaller areas – such as the different regions of Croatia that have very different landscapes and climates. For example, the latest Hadley Centre[I] model, HadGEM1,[II] uses 135 km grid boxes. This means that the climate model does not estimate variations within an area 135 km by 135 km. For Croatia, this could mean that the climate in Karlovac could be estimated as the same as the climate in Rijeka. That is why Regional Climate Models (RCM) have been developed with more detailed resolution, usually 50 x 50 km or higher. The RCM models are obtained by downscaling GCMs.[1] Downscaling methodologies use two broad and markedly different approaches to resolve climate parameters at substantially finer (higher) resolutions than global-scale GCMs provide. The first category is *dynamic downscaling*, sometimes called *mesoscale simulation*, which uses a high-resolution grid (e.g. a 10 km by 10 km grid) and is performed within a GCM but over a chosen local area. A substantial advantage of dynamic downscaling is that the wide range of parameters, available within a GCM (e.g. temperature, precipitation, soil moisture, wind direction and strength, etc.), are also available within the finer-scale grid. However, dynamic downscaling requires supercomputer systems to run the simulations. As supercomputer capabilities increase in resolution capabilities and availability, dynamic downscaling will become more available. The second category, called *statistical* or *empirical downscaling*, has become more fully developed and more widely used. Statistical downscaling relies on the availability of a multi-decade data set (e.g. 25-30 years) of past climate change parameters (e.g. weather station data from a number of stations across the region), and the GCM data sets for the same parameters for the same past time period. To project climatic conditions into the future, the GCM data for the desired future time period is combined with an existing statistical relationship for each of the weather station locations for that region. Statistically downscaled RCMs usually require less computational power and can be run on Personal Computers.[2]

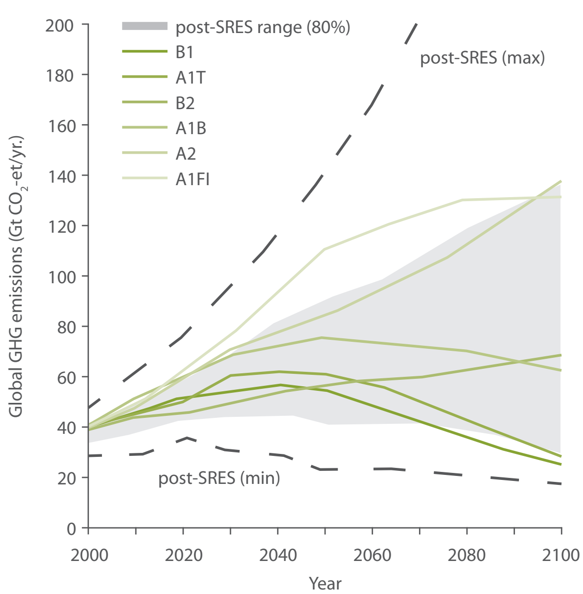
[I] The Met Office Hadley Centre is the UK's official centre for climate change research and one of the world's leading centres for climate change research.

[II] The HadGEM1 model is the Met Office Hadley centre global environment model. This version of the model includes a detailed representation of the atmosphere, land surface, ocean, and cryosphere.

Overview of IPCC Climate Change Emissions Scenarios (IPCC 2007a)

In addition to various climatic data and other variables, climate models require some type of prediction of how global society will develop in terms of energy use (the type of energy used and the quantity), population growth and economic growth. All of these are important for predicting GHGs, which directly influence climate change. The different projections are usually called *emissions scenarios*. The most well-known (and the most common) emissions scenarios are those developed by the Intergovernmental Panel on Climate Change (IPPC). However, other scenarios developed by other projects also exist, such as scenarios from the EU-funded project ADAM.[III] When models are run with the same climate data for various emissions scenarios, they produce various climate change projections. It is also possible to run different models with the same emissions scenario, which will yield somewhat different results for the future climate.

Figure 1: Global GHG emissions (in Gt CO_2-eq per year): six illustrative SRES (Special Report on Emissions Scenarios) scenarios (coloured lines) and 80th percentile range of recent scenarios published since SRES (post SRES) (grey area). Dashed lines show the full range of post SRES scenarios. The emissions include CO_2, CH_4, N_2O and F-gases



Source: IPCC 2007a.

Figure 1 shows the range of error of GHGs emissions expressed in Giga tonnes (Gt) of CO_2 equivalent per year. Coloured lines represent different IPCCs SRES emission scenarios, and the grey area represents the 80th percentile of published research since SRES scenarios have been presented (post SRES), while the dashed line shows the full range of published studies.[3] Up to now, the IPCC SRES emission scenarios have been those most utilised by various projects and study groups.

A1: Rapid convergent growth: The A1 scenario describes a future world of very rapid economic growth and global population that peaks mid-century and declines afterwards, along with the rapid introduction of new and more efficient technologies. The major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The difference between the A1FI, A1B, A1T scenarios are mainly in the source of energy used to drive this expanding economy.

A1FI: Fossil-fuel Intensive, fossil fuels continue to dominate the energy supply for the foreseeable future.

A1B: Balance between fossil fuels and other energy sources

A1T: Emphasis on new Technology using renewable energy rather than fossil fuel.

A2: Fragmented world: The A2 emissions scenario describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in a continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change is more fragmented and slower than in other storylines.

[I] ADAM (Adaptation and Mitigation Strategies: supporting European climate policy) is an integrated research project running from 2006 to 2009 that will lead to a better understanding of the trade-offs and conflicts that exist between adaptation and mitigation policies. ADAM will support EU policy development in the next stage of development of the Kyoto Protocol and will inform the emergence of new adaptation strategies for Europe.
More information: http://www.adamproject.eu/.

B1: Convergence with global environmental emphasis: The B1 storyline and scenario family describes a convergent world with the same global population that peaks mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

B2: Local sustainability: The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

Annex 4
How this Report was Prepared

The idea of focusing on climate change as a theme for the 2008 NHDR arose from several factors. First global attention to the issue of climate change has been increasing and conceptual linkages between human development and climate change were given prominence in the 2006/2007 global Human Development Report, Fighting climate change: Human solidarity in a Divided World. Second, Croatia was selected as the pilot country within UNDP for a climate change NHDR because of its representative mix of economic sectors (fisheries, tourism, agriculture, and industry), its expected challenge in meeting its commitments under the Kyoto Protocol, and the availability of outstanding national experts in several fields related to climate change.

Broad cooperation from a variety of stakeholders was critical to shaping the Report, its messages, and its added value to existing knowledge on climate change in Croatia. An initial scoping meeting with more than 30 representatives of Government, academia, businesses, donors, and the NGO community helped to ensure that the Report could target gaps in existing knowledge and take advantage of ongoing research. In this meeting and in a series of consultations that preceded it, stakeholders identified adaptation as a key area to focus on because of the overall lack of information at the national level and the potential importance of the findings to policy-making in key economic sectors. Stakeholders also identified "critical sectors" that merited extra analysis in terms of potential socioeconomic impacts: coastal zones and water, agriculture, and tourism. Croatian contributors to the Report were selected according to these priorities, and the project hired an international consultant with expertise in the relatively new and narrow field of economic modeling of the impacts and adaptation to climate change to provide information on cutting-edge techniques to the Croatian experts. Over the course of time after the initial meeting, the team of writers worked to involve more stakeholders – especially in sectors that may be affected by climate change. The participants in the process also organised a relatively informal advisory group that has provided feedback on all sections of the Report.

The Report is truly inclusive in terms of the many organisations and individuals across Croatia who provided content and analysis for the Report. In addition, Croatian researchers were extremely helpful in identifying regional or international research findings that were potentially relevant to Croatia in cases where national data were not available. Last but not least, the Croatian public had their say in the Report, with the opinions of 1,000 Croatians forming the lead chapter in the Report and resulting in a new understanding of the awareness and opinions of the Croatian public regarding climate change.

Peer review of the Report also reflects a national and international effort. In Croatia, the Report was reviewed by members of the advisory group and several additional organisations, in the form of both desk reviews and discussions during a one-day presentation of findings for the advisory group. The final document greatly benefited from their input. Feedback and comments were also provided by three international experts and UNDP experts on climate change and human development at the regional and global level of the organizsation.

Finally, it should be noted that this Report is not seen as the concluding work on climate change in Croatia, but as a contribution in the ongoing national effort to address climate change while promoting human development. Also, this Report aims to initiate a broad national discussion with high-level decision-makers included, on the impacts and vulnerability of the Croatian economy to climate variability and climate change and on the challenges, costs and opportunities that a "climate-altered" world brings. Feedback and comments from readers are welcomed.

Annex 5
Endnotes and Bibliography

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Human Development Report - Croatia 2008

A Climate for Change:
Climate change and its impacts on society and economy in Croatia

Climate change is one of the greatest challenges facing the world today. Its impacts can already be seen across the globe. Croatia may already be facing impacts from climate change and will inevitably see those impacts in the future. The 2007/2008 Global Human Development Report demonstrated that climate change is happening and that actions must be taken to reduce its impacts and reduce the extent of that change. Impacts from climate change - caused by increasing levels of greenhouse gases (GHGs) in the atmosphere - are expected to lead to a myriad of problems that affect human development. Negative impacts may include damages from more frequent natural disasters and sea level rise, strains on food production, harm to human health, and many others. If not addressed, climate change in Croatia can restrict people's choices, slow down and undermine development gains, and have a negative impact on human development in general.

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