Initiatives for Regenerative Agriculture and Income Creation

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Sustainable intensification (SI) is an approach to increase agricultural yields without adversely affecting the environment and social equity. Sustainable intensification (SI) represents a pivotal approach in modern agriculture, aiming to increase food production from existing farmland while minimizing pressure on the environment.

Sustainable intensification through Conservation Agriculture (CA)

SI in CA is not just about environmental sustainability; it also encompasses economic and social aspects. Farmers are encouraged to adopt new technologies and practices that are cost-effective and improve their livelihoods. This includes precision agriculture technologies that allow for more accurate application of inputs, reducing waste and costs. Additionally, SI practices contribute to the social dimension by promoting fair labour practices and contributing to rural development.

SI and CA have common goals, including improving resource-use efficiency, maintaining soil health, and increasing farm productivity. CA principles include minimal soil disturbance, maintaining soil cover, and crop rotation, which can lead to improved soil quality and water retention, reduced erosion, and increased biodiversity. Challenges in adopting CA for SI include the need for a shift in farmer perceptions, training in new agricultural practices, and the development of supportive policies and incentives. The success of SI through CA depends on a collaborative approach involving farmers, researchers, policymakers, and other stakeholders to ensure that the practices are economically viable, environmentally sound, and socially acceptable.

Sustainable intensification through Integrated Agriculture/Integrated Farming Systems

Integrated farming systems (IFS) is considered as climate resilient technology due to exploring natural mechanisms of a farming systems. It enhances the system productivity and profitability by more than 2 times. For this NITI Ayog, Govt. of India has considered IFS as powerful tool for efficient resource management at the farm level and doubling the farmers income. It is considered as a master plan for the socio-economic development of the small and marginal farmers of India through recycling resources at the farm level. This helps to enhance income generation activities for small holders while fostering environment sustainability, one of the important objectives of the project. IFS is considered as the best approach for regenerative agriculture and circular economy as it enhances the soil health, family nutrition and farm income. Giving examples, in 1 ha area if we integrate crop and livestock (3 units of cross-bred cows). The cows generate around 20.0 tonnes of manures which is recycled in the farm land as regenerative practices and reduces the dependence on chemical agriculture.

One health concept

The One Health concept is a multifaceted approach that underscores the interconnection between plant, human, animal, and environmental health. The One Health concept is a collaborative, multi-sectoral, and transdisciplinary approach—with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment. The World Health Organization (WHO), along with other international bodies like the Food and Agriculture Organization (FAO), the United Nations Environment Programme (UNEP), and the World Organization for Animal Health (WOAH), actively promotes the One Health approach to address global health challenges. In-order to Provide healthy society with good nutrition to crop-soil-animal-human, the project has to consider its efforts in the direction of one-health approach.

Climate Resilient Agriculture

Climate Resilient Agriculture (CRA) is a forward-thinking approach that aims to transform agricultural systems to be more sustainable and productive in the face of climate variability and change. It encompasses a variety of practices and technologies designed to increase the resilience of food production systems, ensuring long-term food security and reducing poverty. CRA involves the sustainable use of natural resources through improved crop and livestock production systems, which can lead to higher productivity and farm incomes. This approach is crucial for countries like India, where a significant portion of the population depends on agriculture for their livelihoods. Strategies such as the cultivation of drought-tolerant crops, efficient water and nutrient management, and conservation agricultural practices are integral to CRA. These methods not only help in adapting to climate stress but also contribute to mitigation by building soil organic carbon and creating a more conducive environment for plant growth. Moreover, Climate-Smart Agriculture (CSA) is closely related to CRA, offering an integrated approach to managing landscapes—cropland, livestock, forests, and fisheries—that addresses the interlinked challenges of food security and climate change. By adopting climate-resilient crop varieties, conservation agriculture techniques, agroforestry, precision farming, and improved livestock management, CSA aims to achieve a 'triple win' of increased productivity, enhanced resilience, and reduced greenhouse gas emissions. The transformation of agriculture into a climate-resilient system is not just about food production; it also considers the social, economic, and environmental aspects of agricultural production, ensuring a holistic approach to sustainability and resilience.

Organic Farming and Natural Farming

Organic farming, a practice that dates back to the early 20th century, is a sustainable agricultural system that emphasizes the use of organic fertilizers like compost manure, green manure, and bone meal, and incorporates techniques such as crop rotation and companion planting. Government of India is focusing on maintaining ecological balance, organic farming employs natural pest control methods and promotes the recycling of animal wastes, contributing to a reduction in soil erosion and water contamination. The principles of organic farming are deeply rooted in fostering a harmonious relationship with nature, aiming for sustainability and self-sufficiency while providing health benefits and ensuring food safety. As the world grapples with climate change and a growing population, the future of organic farming lies in its ability to maintain its environmental benefits while striving to increase yields and make organic products more accessible to consumers worldwide. Organic farming represents not just a method of cultivation but a philosophy that respects the intricate connections within ecosystems, seeking to work alongside nature rather than dominating it. It's a testament to the resilience and adaptability of agricultural practices that prioritize long-term ecological health over short-term gains.

Organic farming is a revolutionary approach to agriculture that prioritizes the health of our planet and its inhabitants. By ditching synthetic pesticides and fertilizers, organic farming methods like crop rotation, composting, and agroforestry promote soil fertility, biodiversity, and efficient water use. This eco-friendly approach not only produces nutritious food that's rich in antioxidants and essential micronutrients but also supports local economies, mitigates climate change, and conserves natural resources for future generations. As the world shifts towards sustainable living, organic farming is emerging as a vital component of a healthier, more sustainable food system that benefits both people and the planet. By embracing organic farming practices, we can reduce pollution, protect ecosystems, and ensure a healthier future for all.

Resource Conservation Technology (ZT, BP, DSR, LL, INM, Mulching etc.)

The rising global demand for food has placed significant pressure on the use of water in agriculture, posing a potential threat to the sustainability of agricultural production and, consequently, food security. To address these challenges, there is a growing adoption of resource-conservation technologies such as Conservation Agriculture (CA), Zero Tillage, Bed Planting, Crop Residue Management, Direct Sowing of Rice, Laser Land Levelling etc. Although these approaches offer advantages like reduced labour expenses, stabilized or enhanced crop yields, increased water efficiency, and improved soil health on a local farm level, their broader effects on hydrology outcomes on larger time and geographical scales remain uncertain. Resource Conservation Technologies (RCT) can have a significant impact on water use and water productivity in agriculture (Fig.1). These technologies are designed to optimize water management practices, reduce waste, and enhance the efficiency of water utilization. Conservation agriculture is one way to save the land from degrading while also saving water and energy.

Government policies and incentives that promote resource-conservation technologies can play a crucial role in reducing groundwater depletion and carbon emissions in agriculture. Subsidies, tax incentives, and regulations can encourage farmers to adopt these practices. In conclusion, resource-conservation technologies in agriculture offer a range of strategies to reduce groundwater depletion and carbon emissions. By optimizing water use, improving soil health, and adopting energy-efficient practices, farmers can contribute to more sustainable and environmentally friendly agricultural systems. Government support and incentives can accelerate the adoption of these technologies, leading to more significant reductions in groundwater use and carbon emissions within the agricultural sector.

Biochar Application

Biochar, a sustainable solid substance produced via the pyrolysis of carbon-rich biomass, has emerged as a viable approach for the sequestration of carbon in soil. This exhaustive review scrutinizes the existing body of knowledge pertaining to the application of biochar within this framework. It aims to investigate the characteristics and production methodologies of biochar while emphasizing its potential as a stable carbon reservoir. The influence of various feedstock materials and pyrolysis parameters on the diverse physicochemical attributes of biochar, along with its capacity for soil carbon sequestration, is thoroughly examined. The mechanisms through which biochar enhances soil carbon sequestration are elaborated upon, encompassing its function as a physical barrier to carbon loss and its capability to foster stable soil aggregates and modulate soil microbial communities. Challenges and constraints, including the variability in biochar characteristics and the determination of optimal application rates, are addressed, alongside strategies to enhance biochar efficacy through conversion processes. The review culminates by underscoring the significance of long-term field investigations, standardized protocols, and economic assessments to facilitate the widespread implementation of biochar for soil carbon sequestration and its potential role in climate change mitigation.

INM practice on carbon sequestration

Among the various agronomic practices to increase carbon sequestration in a cropping system, INM practice (combined application of inorganic fertilizer and organic fertilizer) seems to be a viable option to increase yield while improving soil carbon. accrual basis Effect of different INM practices on soil carbon fractions. The decrease in production quantities is due to the depletion of soil carbon reserves. Fertilization initiatives induce carbon sequestration pools and dynamics. The results showed that application of organic fertilizer with NPK fertilizers significantly improved TOC and other carbon fractions, while application of NPK fertilizers alone had little effect on TOC. Long-term experiments have shown that optimal use of inorganic fertilizers either increased or maintained SOC over time in soil containing only NPK, there is no significant effect on TOC. Due to the addition of plant litter, the total organic carbon level in the soil increased. The highest TOC values were found in the RS + NPK plots, which means that the use of rice.

Carbon sequestration and crop yield under different INM practices

According to the results, treatments using only inorganic fertilizers or a combination of inorganic fertilizers and organic fertilizer can promote C sequestration in the soil. However, the type of carbon fraction retained (passive or labile) and thus the rate of soil sequestration will probably depend on the type and quality of organic fertilizer used. Therefore, in organic fertilizer blocks containing more resistant compounds such as rice straw, both TOC and PPC fractions increase, while the use of vermicompost and FYM with chemical fertilizers accumulates labile carbon fractions due to the higher proportion of resistant organic substances in these compounds. This is a "win-win" method that can increase rice production while improving labile carbon fractions, which are important indicators of soil quality. Moreover, combination of FYM with inorganic fertilizers can be used for high yield in near future. In the short term, rice straw + NPK yields 3-4 t ha-1 and at the same time improves soil TOC content and passive carbon stocks. The presence of easily degradable organic molecules in VC and FYM caused the rapid release of C and various forms of labile nutrients, which increased yield.

Precision agriculture: It refers to the use of advanced technologies and data analytics to optimize farming practices and inputs on a site-specific basis. Although the main goal of precision agriculture is to increase productivity and efficiency, precision agriculture can also play a role in promoting carbon sequestration in several ways.

Optimized food management: precision agriculture technologies such as soil sensors, remote sensing and geographic information systems. (GIS), allows farmers to apply fertilizers more precisely according to the needs of crops and soil conditions. This reduces nitrogen loss and minimizes emissions of nitrogen oxide (N2O), a powerful greenhouse gas.

Reduced tillage and soil health: Precision planting and seeding equipment allows for more precise and controlled operations that can facilitate tillage or no-till practices. It helps maintain soil organic matter and structure by increasing soil carbon sequestration.

Cover cropping and crop rotation: Precision farming tools help plan and execute cover cropping and versatile cropping more efficiently. It promotes soil health, improves nutrient cycling and increases the supply of organic matter, all of which support carbon sequestration.

Carbon accounting and monitoring: Precision agriculture technologies can also help track and assess changes in soil carbon over time. This information can inform carbon accounting activities and support the verification of carbon tracking practices for carbon markets or incentives.

Mulching: It is the application of organic or synthetic materials to the soil surface around plants to conserve soil moisture, control weeds, moderate soil temperatures and improve general soil health. Although mulching is primarily focused on improving soil fertility and moisture retention rather than direct carbon sequestration, it can contribute to carbon sequestration in a number of indirect ways: Add organic matter: Mulch materials such as straw, hay, wood chips or compost gradually to break over time adding organic matter to the soil. During decomposition, this organic matter participates in soil carbon fixation, and part of the carbon is stabilized in the pool of soil organic matter.

Reduced soil erosion: By protecting the soil surface from rain and wind erosion, mulch helps maintain soil structure and prevent loss of organic carbon-rich soil. This conservation of soil organic matter supports long-term carbon sequestration in agricultural lands.

Sustainable Farming Support: Mulching can complement reduced tillage or no-irrigation practices, further minimizing soil disturbance and loss of organic matter. Together, these practices help conserve soil carbon stocks and promote soil health, which is essential for sustainable carbon sequestration.

Better water use efficiency: Mulch reduces evaporation from the soil surface and improves water use in plant growth. This can indirectly support carbon sequestration by promoting healthier plants with increased biomass production and more efficient carbon uptake through photosynthesis.

Long-term impact: Although the cover itself can degrade relatively quickly depending on the material used, its indirect effects on soil health and structure can lead to permanent improvements in carbon sequestration potential over time. This includes better soil aggregation and stability, which helps retain organic carbon in the soil profile.

Crop Diversification: Crop rotation and diversification are agricultural practices where different crops are grown in succession on the same piece of land. These practices provide multiple benefits for soil health, nutrient cycling, pest and disease control, and water use efficiency. Importantly, they also promote carbon sequestration in agricultural land. Here's how crop rotation and diversification contribute to carbon sequestration. Remunerative crops (flowers, vegetables, spices etc.) and inclusion of millets (climate resilient nutri-cereal crops) can well fit to the farming systems with more farm returns, more environmental benefits. In places practising rice-wheat can be replaced with rice-wheat-green gram, which is regenerative, more profit giving and climate resilient practice/crop rotation. Resilience to climate change: diverse crop rotation can improve resilience to climate change, including drought and pests. Climate-resilient agricultural systems maintain higher biomass production and soil carbon storage. They reduce carbon losses caused by extreme weather events and support long-term carbon sequestration in agricultural land.

Conclusion

Sustainable intensification of agricultural practices is very important. The project gives emphasis on fertilizer management, cover cropping, zero-tillage, improved irrigation, crop rotation and agroforestry practices. In this project, I have tried to aid few aspects such as Sustainable Intensification through CA and IFS, resource conservation technologies (RCTs), organic-farming and natural farming, one health concept and climate resilient agriculture (CRA). These additional aspects may be considered and can contribute in mitigation of GHG emission, natural resource degradation and promote carbon sequestration.

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