Natural Resources Management Centre &
Field Crops Research and Development Institute
Department of Agriculture

Climate-Smart Agriculture Technologies and Practices in Sri Lanka

Consortium for Scaling-up Climate Smart Agriculture in South Asia (C-SUCSeS) Project

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SAARC Agriculture Centre

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Inventory of Climate-Smart Agriculture (CSA) Technologies and Practices in Sri Lanka was conducted as one of the activities under the project Consortium for Scaling up Climate-Smart Agriculture in South Asia (C-SUCSeS) of SAARC Agriculture Centre in 2022.

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This book 'Climate-Smart Agriculture Technologies and Practices in Sri Lanka' contains the climate-smart agriculture (CSA) technologies and practices of Sri Lanka produced as an output of the inventory of CSA technologies conducted by the National Focal Point of C-SUCSeS project of Sri Lanka and the associates working under the Natural Resources Management Centre & Field Crops Research & Development Institute, Department of Agriculture, Sri Lanka. The CSA technologies and practices in this publication are those of the authors gathered from various sources and do not imply any opinion whatsoever on the part of SAC.

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Foreword

Climate change impacts are no longer isolated events but often occur simultaneously, creating a complex web of risks. The increasing frequency of extreme weather events, such as intense rainfall and prolonged droughts, underscores the unpredictability of climate patterns. This unpredictability makes it essential to develop adaptable farming practices and improved land management strategies. This complexity requires a multifaceted approach to climate resilience that considers multiple hazards and their interactions.

With the ever-increasing pressures related to climate change, the need for climate action has become a global and national priority, and adaptation efforts are crucial to building resilience in the face of these challenges. As we encounter prolonged droughts during specific periods and face floods and heavy rains in others, often with significant variations in their magnitude, spatial distribution, and temporal dimensions, it becomes evident that a deeper understanding of existing climate-smart agriculture (CSA) technologies is imperative for crafting more effective solutions.

CSA technologies provide an essential set of tools to mitigate and adapt to climate change while ensuring food security and environmental sustainability. A better understanding of CSA technologies is needed to address climate risks in meaningful ways. An inventory of CSA technologies with details of their targeted climate risks, spatial suitability, farmer acceptability ratings, and targeted farming systems is of paramount importance for making informed decisions on sustainability and resilience in management of agriculture landscapes.

Therefore, this CSA Inventory Book will serve as a comprehensive source of CSA technologies and practices, offering valuable insights and guidance to policymakers, researchers, farmers, extensionists, and all those engaged in the agriculture sector. By centralizing and categorizing this valuable information, it simplifies decision-making processes and facilitates the effective implementation of CSA strategies.

P. Malathy
Director General of Agriculture
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Preface

Climate change stands as a paramount global challenge in our era, with profound implications for agriculture. Sri Lanka, distinguished by its abundant agricultural heritage and biodiversity, is not exempt from the repercussions of this evolving climate with escalating temperatures, increasingly erratic weather patterns, and a surge of extreme events, the imperative for sustainable and climate-resilient agricultural practices has reached unprecedented level of urgency.

'The Sri Lanka Climate Smart Agriculture (CSA) Inventory' represents a groundbreaking initiative within the framework of the 'Consortium for Scaling Up Climate Smart Agriculture in South Asia (C-SUCSeS)' project. Its primary purpose is to gather and disseminate vital information on the CSA technologies and practices that are actively influencing sustainable agriculture in Sri Lanka. This compilation aims to serve as a beacon of knowledge and innovation for all stakeholders involved in the country's agriculture sector, spanning from policymakers and researchers to farmers and service providers to simplify decision-making processes and supports effective implementation of CSA technologies and practices enhance resilience to climate change and contribute to both adaptation and mitigation strategies within the agricultural sector.

This inventory is not a static document; rather, it is a living resource that evolves with the ever-changing landscape of CSA. It is regularly updated with the latest developments and emerging technologies from various agencies, ensuring that stakeholders have access to the most up-to-date and relevant information. Furthermore, it encourages knowledge sharing and collaboration among diverse groups, fostering a sense of unity among those working towards a sustainable and climate-resilient agriculture sector in Sri Lanka.

Beyond its borders, 'The Inventory' serves as a model for other nations facing similar challenges. It showcases how a nation can systematically catalog its CSA efforts, offering a blueprint for the creation of similar resources in countries with comparable environmental conditions and agricultural landscapes.

In conclusion, this inventory is a vital resource that reflects the collective commitment of Sri Lanka's agriculture sector to address the challenges posed by climate change. It is a testament to the power of collaboration, innovation and knowledge sharing in building a more sustainable and resilient agricultural future. May it inspire and guide all those who seek to make a positive impact on agriculture in the face of a changing climate.

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Acknowledgment

'The Sri Lanka Climate Smart Agriculture (CSA) Inventory' has become a reality through the unwavering dedication, guidance, and collaboration of numerous individuals and institutions. We extend our heartfelt gratitude to those who have played a pivotal role in this endeavor.

First and foremost, we express our sincere appreciation to Dr. Md. Baktear Hossain, Director of the SAARC Agriculture Centre (SAC), for his invaluable guidance and support. Dr. Hossain's insights have been instrumental in shaping the vision and direction of this Inventory.

We would also like to extend our gratitude to Mr. Kinzang Gyeltshen, Regional Programme Coordinator for the C-SUCSeS project, for his continuous support and contributions that have significantly enriched this Inventory.

Ms. P. Malathy, Director General of Agriculture - Sri Lanka, deserves special recognition for her visionary leadership and unwavering commitment to sustainable agriculture. Her guidance has been a driving force behind the success of this project.

Dr. Jayantha Senanayake, Additional Director General of Agriculture (Research) and Mr. Herath, Additional Director General of Agriculture (Development) have provided invaluable support and direction throughout the development of this Inventory. Their expertise and dedication have been instrumental in steering this project toward success.

We extend our thanks to the dedicated staff of the Natural Resources Management Centre and the Field Crops Research and Development Institute, whose tireless efforts and expertise have been pivotal in compiling and organizing the extensive information within this Inventory.

The researchers of the Department of Agriculture, officers of the Extension and Training Division of the Department of Agriculture, and the Provincial Department of Agriculture have been essential collaborators in this journey. Their contributions and commitment to advancing climate-smart agriculture are deeply appreciated.

The academia of the Faculty of Agriculture of the Universities, as well as researchers and extension officers from other agriculture-related departments, institutes, and centers, have enriched this Inventory with their knowledge and expertise.

We also acknowledge the generous support provided by the International Fund for Agricultural Development (IFAD), whose funding has been instrumental in bringing this activity to fruition. Their commitment to promoting agricultural development and sustainability has been a cornerstone of our success.

Last but not least, we extend our heartfelt thanks to the farming communities of Sri Lanka. Their resilience, innovation, and willingness to embrace climate-smart agricultural practices inspire us all and reinforce the importance of our collective efforts in building a sustainable and climate-resilient agriculture sector.

This Inventory is a testament to what can be achieved when individuals, institutions, and communities come together with a shared vision. Your contributions have made it possible, and for that, we are profoundly grateful.

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Acronyms

CEA	Central Environmental Authority
DSD	Divisional Secretariat Division
DWLC	Department of Wild Life Conservation
ESAs	Environmentally Sensitive Areas
ESCAMP	Ecosystem Conservation and Management Project
FD	Forest Department
FR	Forest Reserve
GND	Garama Niladari Division
GoSL	Government of Sri Lanka
MoMDE	Ministry of Mahaweli Development and Environment
MoSDW	Ministry of Sustainable Development and Wildlife
NBRO	National Building Research Organization
NR	National Park
PA	Protected Area
PMU	Protected Management Unit
SLMP	Strategic Landscape Management Plans
VTCS	Village Tank Cascade System

1. Introduction

1.1 Overview of the agricultural scenario in Sri Lanka

Sri Lanka, situated in the Indian Ocean at the southern tip of the Indian subcontinent, covers a total area of 65,610 km^2, which includes 2,905 km^2 of inland water bodies. The island measures 240 km in width from east to west and 435 km in length from north to south. Sri Lanka is positioned within the coordinates of 5°55’–9°50’N and 79°42’–81°53’E and features a diverse range of topographical characteristics, including central highlands, plains, and a coastal belt. The Central Highlands span approximately 65 km in a north-south direction, with a peak elevation of 2,524 m. This region serves as the hydrological heart of the country, nourishing the upper catchment of major perennial rivers that radiate from the highlands toward the coast. Most of the island's surface consists of plains ranging from 30 to 200 m above sea level. In the southwest, ridges and valleys gradually rise to merge with the Central Highlands, creating a dissected appearance in the plain (see *Fig. 1*). Along the coast, there is a scenic coastal belt featuring sandy beaches indented by bays and lagoons (Marambe et al., 2014). Four significant geographical and topographical factors notably influence the island's rainfall patterns.

***Fig. 1** General topography of Sri Lanka*

Firstly, Sri Lanka is an island located in the warm tropical Indian Ocean, which is associated with warm and humid air masses. Secondly, its proximity to the equator means that solar radiation is rarely a limiting factor for crop growth, given typical weather conditions. Thirdly, the presence of a substantial hill mass in the central part of the island, running perpendicular to the paths of two moisture-laden monsoon wind streams (southwest monsoon in the middle of the year and northeast monsoon toward the year's end), plays a crucial role in weather patterns. Lastly, the vast landmass of the Indian subcontinent to the north and northwest of Sri Lanka has a significant impact on driving the monsoon. These four features directly or indirectly influence the island's rainfall patterns. The rainfall in Sri Lanka originates from multiple sources, including monsoonal, convectional, and weather systems formed in the Bay of Bengal, which collectively contribute significantly to the annual rainfall (Punyawardena, 2020). The Sri Lankan rainfall calendar recognizes four distinct rainfall seasons, primarily based on the monsoons (Chandrapala, 2007).

Sri Lanka exhibits highly diverse climate conditions, determined by its geographical settings, divided into three climatic zones: Dry, Intermediate, and Wet zones. Additionally, the country is divided into three elevation zones: Low, Mid, and Upcountry. These zones collectively contribute to the identification of seven agro-ecological zones within the country. Taking into account the diversity in soil and landform conditions, these seven agro-climatic zones are further subdivided into 46 Agro-Ecological Regions (see *Fig. 2*).

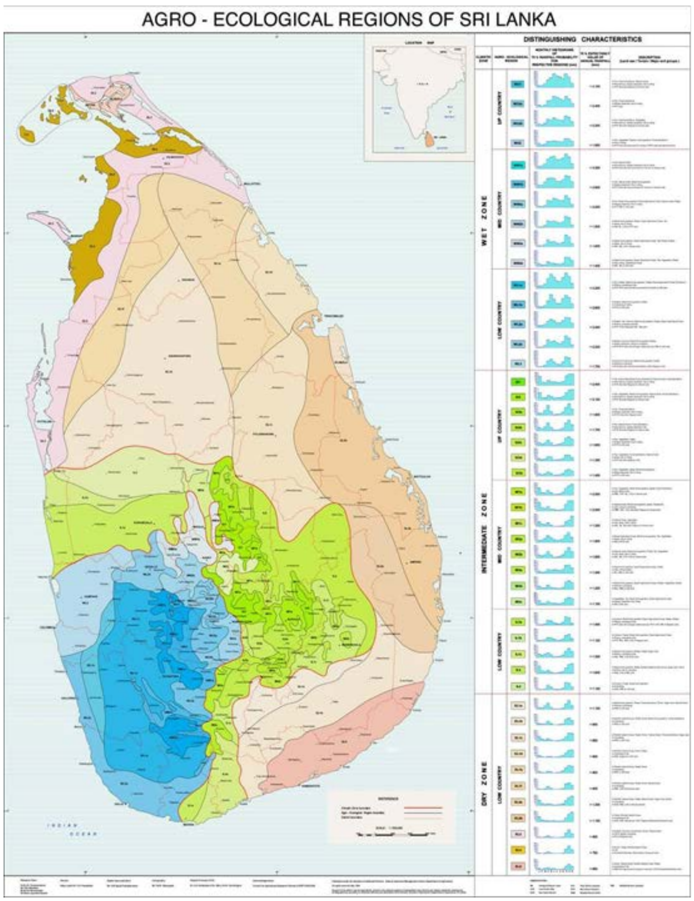


***Fig. 2** Agro-ecological Regions of Sri Lanka*

Sri Lanka relies heavily on agriculture, which is the cornerstone of its economy. Agriculture encompasses plantations, paddy and food crop cultivation, home gardening, agroforestry, floriculture, and horticulture. Until the early 1960s, the contribution of the agriculture sector to the economy was as high as 32% of the Gross Domestic Product (GDP) and 53% toward livelihoods or employment (Thorbecke and Svenjnar, 1987). Approximately 27% of the total land area is used for cultivation, with paddy cultivation accounting for 54% of this agricultural land. The majority of the country's population (about 85%) resides in rural areas, and agriculture is a vital sector of the economy, employing 28.5% of the population. Recent GDP estimates indicate that the agriculture sector contributes 7-8% to GDP, while industry contributes 27%, and the service sector contributes 8% (Central Bank, 2022). Field-level seasonal crop cultivation programs are currently operating separately based on water supply sources, including major irrigation schemes, village tank cascade systems, anicut/stream systems, and rainfed lands (*Fig. 3*).

Sri Lanka boasts 103 river basins, with the Mahaweli river basin being the largest, extending from the central highlands through the north-central region to the eastern coast and covering roughly one-sixth (10,448 km^2) of the island's land area (Shelton and Lin,

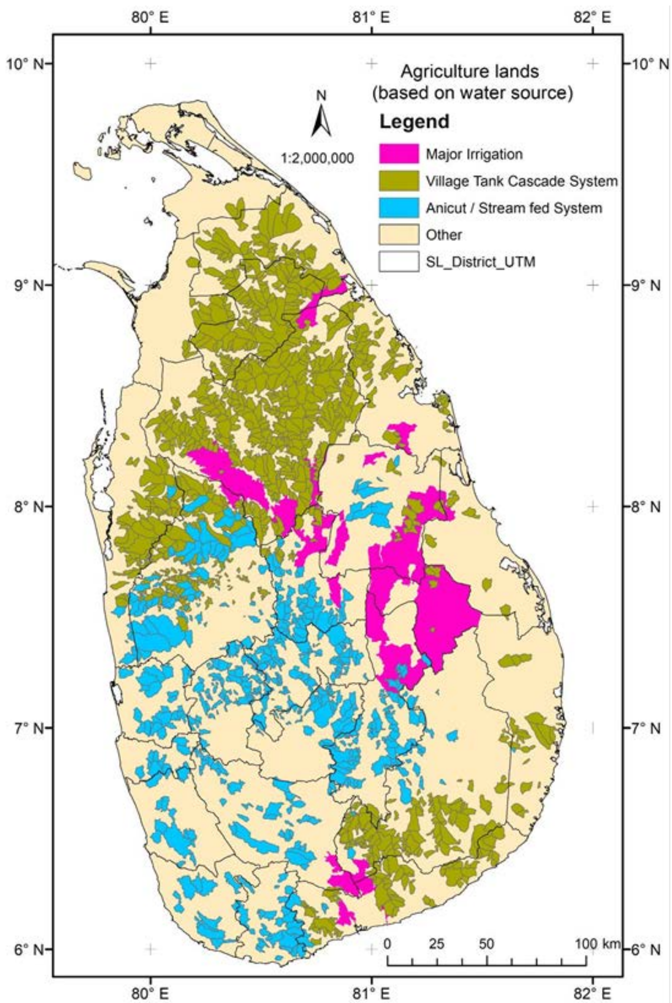


***Fig. 3** Lands under seasonal crops (classified based on water source)*

2019). The remaining river basins are connected to the central landmass and are spread across the wet zone (in the western and south-western regions), north-central, eastern, and parts of north-western and western regions. In these river basins, ancient and sustainable production agro-ecosystems, known as village tank cascade systems (VTCS), can be found. Interestingly, these VTCS are located in river basins not hydrologically connected to the central landmass (Ratnayake et al., 2021).

1.2 Climate change in Sri Lanka

The National Adaptation Plan for Climate Change in Sri Lanka has identified agriculture as one of the most vulnerable sectors to the adverse effects of climate change. The recently released National Environmental Action Plan (NEAP) for the years 2022-2030 emphasizes the urgent need for climate action to ensure sustainability (MoE, 2022). Sri Lanka's geographical location as an island in the Indian Ocean has made it significantly vulnerable to climate change, resulting in several notable impacts. These impacts include rising temperatures, changes in precipitation patterns, sea level rise, and an increased occurrence of extreme weather events. According to Eriyagama et al. (2010), there has been a significant increase in the intensity and frequency of extreme weather events in the country, leading to a surge in natural disasters. In the context of Sri Lanka, major disasters attributable to climate change include floods, landslides, prolonged droughts, coastal erosion, and hazardous heatwaves. Consequently, the country was ranked as the fourth most climate change-affected nation in 2016, according to the Global Climate Risk Index (2018).

Temperature: Analysis of historical data suggests that atmospheric temperatures are gradually increasing throughout the country (Chandrapala, 2007). Different rates of temperature increase have been reported from various locations, with recent years showing a faster warming trend (Chandrapala, 2007; De Costa, 2008). Significant increasing trends in annual mean air temperature anomalies have been observed at all monitoring stations in recent decades. Data indicates that both mean daytime maximum and mean nighttime minimum air temperatures have risen (Zubair et al., 2005). Interestingly, an increase in nighttime minimum air temperature appears to contribute more to the overall annual temperature rise than daytime maximum air temperature (Basnayake, 2007).

Precipitation: In contrast to temperature, there is no clear pattern or trend observed in precipitation. Some researchers, comparing mean annual precipitation in recent and earlier periods, suggest a decreasing trend in average rainfall (Basnayake, 2007; Chandrapala, 2007; De Costa, 2008). However, there is no consensus on this matter among researchers, and opposing trends are observed in different locations. Punyawardena et al. (2013) noted that heavy rainfall events have become more frequent in the central highlands during the recent period. Nonetheless, many researchers seem to agree that rainfall variability has increased over time, especially during the Yala season (Chandrapala, 2007; Eriyagama et al., 2010; Punyawardena et al., 2013). Furthermore, the number of consecutive dry days has increased, while the duration of consecutive wet periods has decreased (Premalal, 2009; Ratnayake and Herath, 2005). Studies also indicate changes in the spatial distribution of rainfall, although a distinct pattern has not yet emerged (Basnayake, 2007; Marambe et al., 2013; Nissanka et al., 2011; Sathischandra et al., 2014). Some studies suggest that changes in distribution can potentially lead to shifts in agroecological boundaries (Eriyagama et al., 2010; Mutuwatte and Liyanage, 2013).

Extreme events: The intensity and frequency of extreme events, such as floods and droughts, have increased significantly during certain periods (Imbulana et al., 2006; Ratnayake and Herath, 2005). There is a strong correlation between areas of high rainfall intensity and the occurrence of landslides (Ratnayake and Herath, 2005).

2. Purpose of CSA Inventory

The Climate Smart Agriculture (CSA) Inventory is a comprehensive resource that compiles essential information on CSA technologies and practices implemented across the agriculture sector in Sri Lanka. Its primary purpose is to gather, categorize, and present comprehensive data on a wide range of CSA technologies and practices being utilized throughout the country. This inventory serves as a valuable information hub for a variety of stakeholders, including policymakers, regulatory authorities, researchers, extension workers, academics, service providers, agricultural practitioners, and others involved in the agriculture sector.

The Department of Agriculture is the key technical focal point in Sri Lanka's Agriculture Sector, playing a significant role in generating, introducing, and disseminating CSA technologies and practices, particularly in the food crop sector. By consolidating scattered information into a centralized and easily accessible platform, the inventory streamlines the decision-making and implementation processes related to CSA technologies and practices. It aims to bring together fragmented knowledge and information about CSA technologies, emphasizing innovative solutions that enhance agricultural productivity and increase resilience to climate change, thereby contributing to both adaptation and mitigation strategies within the agriculture sector.

The inventory functions as a dynamic document that receives regular updates, incorporating new and emerging CSA technologies and practices. It keeps track of the latest technologies released by different agencies, ensuring that stakeholders have easy access to the most current and relevant information. The inventory also fosters knowledge sharing and collaboration among various stakeholders involved in Sri Lanka's agriculture sector. Furthermore, it can serve as a valuable source of information on CSA technologies and practices available in the country, which may be equally effective when adopted in other countries with similar conditions or environments.

3. Methodology of CSA Inventory

The CSA Inventory is prepared with the primary objective of identifying CSA technologies and facilitating the scaling-up of viable technologies through national policies and programs in Sri Lanka. The C-SUCSeS team has undertaken a comprehensive approach, collecting information from various publications and sources, as well as activities carried out under different programs and projects related to the adoption of CSA technologies and practices within the country.

To ensure the accuracy and relevance of the inventory, several meetings and workshops have been conducted with key stakeholders. These include local communities, representatives from government agencies spanning various sectors, agricultural researchers, extension workers, non-governmental organizations, and academia. These stakeholders have been actively involved in the processes of data collection, compilation, categorization, evaluation, validation, and formulation of the CSA inventory.

The CSA Inventory provides detailed information on each technology, including its basic features, focus, benefits, drawbacks, and suitability within the local context of Sri Lanka. It also assesses the adaptability rate of each technology, taking into account both overall acceptability and the acceptance of farmers. Additionally, the inventory focuses on evaluating the impact and suitability of each technology for smallholder farmers and women.

Furthermore, the CSA Inventory discusses the enabling factors that contribute to the uptake of these technologies and highlights the challenges associated with scaling them up. This comprehensive approach ensures that policymakers, researchers, and stakeholders have access to valuable insights and information needed to promote the adoption of CSA technologies in Sri Lanka's agriculture sector.

4. Concept and Pillars of CSA

4.1 Concept of CSA

The concept of Climate Smart Agriculture (CSA) is grounded in addressing the challenges of climate change while promoting sustainable agricultural practices. This approach, as defined by the Food and Agriculture Organization (FAO, 2010), encompasses several key elements: sustainably increases productivity, enhances the resilience of livelihoods and ecosystems, reduces and/or removes greenhouse gases (GHGs), and enhances the achievement of national food security and development goals. The CSA is an integrated approach to managing cropland, livestock, forests, and fisheries that addresses the interlinked challenges of food security and accelerating climate change.

4.2 Pillars of CSA

Climate Smart Agriculture (CSA) is built up with the combination of three pillars to achieve their objectives (Fig. 4). CSA aims to simultaneously achieve three outcomes:

Sustainable Productivity Increase: CSA seeks to enhance agricultural productivity in a sustainable manner. This involves producing more and better-quality food to improve nutrition security and increase incomes, especially for the majority of the world's poor living in rural areas who rely on agriculture for their livelihoods.

Enhanced Resilience: CSA aims to improve the resilience of agricultural systems and livelihoods. It involves reducing vulnerability to climate-related risks such as droughts, pests, diseases, and other shocks. CSA also helps build the capacity to adapt and thrive in the face of longer-term stresses like changing weather patterns and seasons.

Greenhouse Gas Emission Reduction: CSA actively works toward reducing or removing greenhouse gas emissions associated with agricultural practices. It also focuses on avoiding deforestation caused by agriculture and explores methods to absorb carbon from the atmosphere.

Fig. 4 *Three pillars of CSA (Source: FAO, Climate-Smart Agriculture)*

The three pillars of CSA—increased productivity, enhanced resilience, and reduced emissions—are interconnected and aim to achieve multiple outcomes simultaneously. This approach builds upon existing knowledge, technologies, and principles of sustainable agriculture. However, it stands out in its explicit focus on addressing climate change. CSA systematically considers the synergies and trade-offs that exist between increasing productivity, enhancing adaptation, and mitigating greenhouse gas emissions.

By integrating these three pillars, CSA represents a comprehensive strategy for transforming agriculture to meet the challenges of a changing climate while ensuring food security and sustainable development.

5. Brief Description of Individual Technology

Sri Lanka has embraced various Climate Smart Agriculture (CSA) technologies to address the challenges posed by climate change in the agriculture sector. CSA technologies are characterized by their ability to maintain or increase agricultural productivity while contributing to at least one of the CSA pillars, namely adaptation and mitigation. The country's approach to climate adaptation encompasses both traditional and modern strategies.

For instance, in response to climate variability, ancient rulers in Sri Lanka developed village tank cascade systems (VTCS) to collect and store rainwater for irrigation, as well as for human and animal consumption during dry seasons. These traditional systems coexist with recently introduced CSA practices, including:

1. **Conservation of Genetic Diversity:** Efforts to preserve the genetic diversity of crops and animals.
2. **Improved Crop Varieties:** Production of quality, genetically improved crop varieties.

3. **Adapted Planting Times:** Timing planting to better align with changing weather patterns.
4. **Water and Soil Conservation Techniques:** Practices to conserve water and soil resources.
5. **Intercropping and Agroforestry:** Cultivating multiple crops in the same area and incorporating trees into farming systems.
6. **Shade Management:** Strategies for managing shade in agricultural systems.
7. **Mulching:** Covering the soil with organic or synthetic materials to retain moisture and control weeds.
8. **Manure Production and Organic Fertilization:** Using organic materials to improve soil fertility.
9. **Crop Diversification:** Growing a variety of crops to enhance food security.
10. **Home Gardening:** Cultivating gardens at the household level to increase food self-sufficiency.

One notable traditional sustainable agricultural production system in Sri Lanka is the Kandyan Home Garden. It features a multi-strata vegetation structure and fosters ecological interactions that help conserve soil moisture, prevent erosion, and enhance pest control. This system contributes to household livelihoods (Pushpakumara et al. 2016) and is primarily found in regions within the historic Kandyan Kingdom, including Kandy, Kegalle, Kurunegala, Matale, Nuwara Eliya, Badulla, and Ratnapura. As of 1995, Kandyan Home Gardens covered approximately 858,100 hectares.

While Sri Lanka has adopted several CSA technologies, comprehensive descriptive information on these technologies can be challenging to find in a compiled document. This report aims to fill that gap by compiling details of CSA technologies, with a focus on enhancing adaptation in different agriculture zones. The report provides key relevant information in one document, including a summary of key CSA technologies across seven categories: Crop Management, Soil Management, Water Management, Agroforestry, Energy Systems, Climate Forecasting, and Information Management (as presented in Table 1).

Table 1: Summary of key CSA technologies

ID		Name of CSA technology	Expected benefits			Targeted geographic area	Targeted cropping pattern	Targeted agro-ecosystem
			Adaptation	Mitigation	Productivity			
1	Crop Management	Crop diversification with short-age legume types cultivation	Increase nutrient availability in soil by maintaining a balance of nutrient circles	Increase carbon sequestration and storage, reduce N fertilizer use thus reducing the GHG emissions	Increase production and income of crops per unit area per unit time	All regions of the country	Short-aged legumes (mungbean, cowpea, etc.)	Shifting cultivation
2		Crop rotation	Maintaining nutrient balance as different plants have different nutrient requirements, proper nutrient translocation due to varied root board depth and pest control	Reduce the use of N fertilizers thus reducing GHG emission	Increase production and income of crops per unit area per unit time	Aperiodic the country	Cereal, legume, root and vegetable crops	Shifting cultivation
3		"Parachute" method of paddy seedling broadcasting	Increase crop establishment in the field	Reduce GHG emissions caused by fuel as no machinery is used for planting	Increase production and reduce labor cost	All paddy growing areas (dry zone mainly)	Rice	Rice systems
4		Alternative wetting and drying (AWD)	Increase possibility of paddy cultivation under water-scarce situations	Reduce GHG emissions caused by standing water in paddy fields	Increase water productivity	All Paddy growing areas (dry zone mainly)	Rice	Rice systems
5		Protected agriculture for high-value crops	Increase system resilience to climate shocks		Increase product quality, quantity and income	All regions	Capsicum, cucumber, tomato, bell pepper	Protected agriculture
6		Cultivation of stress-tolerant crop varieties	The newly introduced crop varieties are tolerant to heat, drought, and salinity thus reducing the climate risks	Reduce GHG emissions by avoiding energy use	Increase product quality, quantity and income	All regions	Rice, vegetables, legumes	Genetically modified crop varieties

ID	Name of CSA technology		Expected benefits			Targeted geographic area	Targeted cropping pattern	Targeted agro-ecosystem
			Adaptation	Mitigation	Productivity			
7		Cultivation under controlled environments	Increase system resilience to climate shocks		Increase product quality, quantity and income	All regions	Vegetables, Leafy vegetables, and Floricultural plants	Protected agriculture
8		Sorjan cultivation	Increase system resilience to climate shocks					Sojan cultivation
9		Home gardening	Increase system resilience to climate shocks through crop diversification		Increase production and income of crops per unit area per unit time	Mid country - Wet and intermediate zone	All types of crops -annuals and perennials (trees, food crops, N_2 fixing trees, woody plants, fruit plants)	Home garden
10		Seasonal-adapted planting times	Efficient use and management of rainwater harvested in village tanks	Reduce GHG emissions. Supplementary irrigation is required to ensure water availability.	Increase productivity and income.	All regions	Rice (46% of the total harvested area)	Cropping systems
11		Dry sowing	Minimizes water use and conserves soil moisture, when combined with minimum or zero tillage.	Promotes carbon storage in soil. Water retention increases, which in turn reduces energy needs for irrigation, and reduces inundation, thus reducing GHG emissions.	Productivity may be maintained/reduced depending on rainfall availability.	All regions in the country	Rice (Paddy rice: 46% of the total harvested area)	Cropping systems
12		Planting with onset of rains	Adjusting the crop calendar with onset of rains reduces losses due to changing water patterns	Rainwater supply can reduce energy needs for irrigation.	Increase land and crop productivity per unit of water	All regions	Maize (2.5% of the total harvested area)	Cropping systems

ID	Name of CSA technology		Expected benefits			Targeted geographic area	Targeted cropping pattern	Targeted agro-ecosystem
			Adaptation	Mitigation	Productivity			
13		Cover crops	Leguminous cover crops reduce the requirement for N fertilizer and enrich soil fertility.	Plough down the cover crops to promote carbon storage in soil.	Increase productivity per unit of nutrients supplied	All regions	Coconut (17.5% of the total harvested area)	Cover crops
14		Organic fertilizers	Enhance soil health, water retention and soil functions; increase system potential to overcome climate shocks	Reduce N fertilizer use, thus reducing nitrous oxide emissions	Enhance product quality and income	All regions	Tea (9.7% of the total harvested area)	Organic farming
15		Mulching	Conserve soil moisture retention; control soil erosion; control weed	Reduce fertilizer use and GHG emissions; increase carbon storage in soils	Increase productivity per unit of water consumed	All regions	Tea (9.7% of the total harvested area)	Cropping systems and soil conservation
16	**Livestock and Poultry Farming**	Rearing and conservation of indigenous cattle	Local breeds can show greater resistance to diseases and heat stress	Reduce GHG emissions and energy when integrating techniques related to feeding and manure management.	Reduce production costs by reducing external inputs	All regions	Cattle	Livestock
17	**Livestock and Poultry Farming**	Composting and biogas production from cattle manure	Increases system resilience to climate shocks	Reduces N fertilizer use, thus N_2O emissions.	Increased land productivity, product quality, and income	All regions	Cattle	Livestock
18	**Livestock and Poultry Farming**	Compost production from poultry waste	Improve organic matter usage in crop production and minimize fertilizer use	Reduce N fertilizer use, thus reducing N_2O emissions.	Increase land productivity, product quality and income.	All regions	Chicken	Livestock
19	**Livestock and Poultry Farming**	Rearing adaptive breeds	Increase system resilience to climate shocks	Reduce GHG emissions and energy when integrated with techniques related to feeding and manure management.	Increase stability in productivity.	All regions	Chicken	Livestock

ID	Name of CSA technology		Expected benefits			Targeted geographic area	Targeted cropping pattern	Targeted agro-ecosystem
			Adaptation	Mitigation	Productivity			
20	**Soil Management**	Multi-purpose soil conservation bunds and terraces	Minimize soil erosion through surface runoff of water	Reduce energy required to restore the land in case of soil erosion	Increase land productivity	All regions	All types of upland crops	Soil conservation
21		Biochar	Increase system potential to overcome climate shocks by influencing soil chemical, physical, and biological properties	Increase biological activity and improve nutrient use efficiency, which reduces N_2O emissions and increases carbon sequestration	Increase product quality and income	All regions	All types of crops (annuals and perennials)	Soil nutrient management and Soil conservation
22		Conservation Agriculture	Minimize soil erosion	Reduce energy requirement to restore the land in case of soil erosion	Increase land and crop productivity	All regions	Upland annuals	Soil conservation
23		Contour planting	Minimize soil erosion	Reduce energy requirement to restore the land in case of soil erosion	Upcountry	All regions	Upland annuals	Soil conservation
24	**Water Management**	Drip and sprinkler irrigation systems	Ensure water availability, and maintain crop micro-climate Field Capacity conditions), which can be established even in sloppy agricultural lands with high wind conditions (Drip)	Use of efficient fuel pumps may be required to avoid an increase in energy consumption	Increase land and crop productivity per unit volume of water	All regions	All types of crops (annuals and perennials)	Micro irrigation
25		Recharging of groundwater through percolation pits	Create a high groundwater level by recharging rainwater to the groundwater table	No significant benefits	Increase land and crop productivity, reduced dependence on rainwater	All regions	All types of crops (annuals and perennials)	Ground water table

ID	Name of CSA technology		Expected benefits			Targeted geographic area	Targeted cropping pattern	Targeted agro-ecosystem
			Adaptation	Mitigation	Productivity			
26		Rainwater harvest	Efficient use and management of rainwater	Reduce GHG emissions by reducing supplementary irrigation methods with higher energy consumption	Increase production and income of crops	All regions	All types of crops (annuals and perennials)	Rainwater harvesting systems
27		Cascade system in the dry zone	Efficient use of stream water	Mitigate the effects of drought on crops	Sustain crop production and farmer's income	Dry zone	Rice, Vegetables	Cascade systems
28	**Agroforestry**	Agroforestry (agriculture-forest integration)	Inclusion of tree crops for shade reduces the heat stress of soil.	Increase carbon sequestration and storage	Crop diversification can improve yields, with potential benefits for food and nutrition security and farmer's income	All regions	Forest trees, all types of food crops (annuals and perennials), grasses for animals	Agroforestry
29		Agroforestry (crop-livestock integration)	Improve organic matter use through integrated crop-animal systems, minimize fertilizer use, and improve energy use efficiency	Reduce burning of fossil fuel, contributing to minimizing GHG emissions	Increase land productivity and farmer's income.	All regions	Forest trees, all types of food crops (annuals and perennials), grasses for animals	Agroforestry (crop-livestock integration)
30		Boundary trees and hedgerows	Inclusion of trees reduces heat stress on soil and controls atmospheric temperature	Increase carbon sequestration and storage	Improve product quantity, quality, and income	All regions	Forest trees, all types of food crops (annuals and perennials), grasses for animals	Agroforestry
31		Fruit orchards	Increase nutrient availability in soil by maintaining a balance of nutrient circles	Increase carbon sequestration and storage, reduce N fertilizer use thus	Increase crop productivity and income	All regions	Legumes	Agroforestry

ID		Name of CSA technology	Expected benefits			Targeted geographic area	Targeted cropping pattern	Targeted agro-ecosystem
			Adaptation	Mitigation	Productivity			
				reducing the GHG emission				
32	**Energy Systems**	Cultivation of nitrogen-fixing plants	Ensure water availability	Reduce GHG emissions by reducing energy-consumptive water pumping systems (electricity, fuel)	Increase land productivity per unit volume of water	All regions in the country	All types of crops (annuals and perennials)	Renewable energy systems
33		Photovoltaic lights for agro-farms, protected houses, and storage houses	Ensure light availability	Reduce energy consumption and GHG emissions		Sufficient light areas	Agro-farms, protected houses, and storage & processing houses.	Renewable energy systems
34		Solar-powered water pump	Increase system resilience to climate shocks	Reduce GHG emissions by reducing electricity usage	Increase crop productivity and income	All regions	All types of crops (annuals and perennials)	Renewable energy systems
35		Biogas technology	Increase system resilience to climate shocks	Can use as a supplementary energy source; reduce GHG emission	Increase land productivity, product quality and income	All regions	All types of crops (annuals and perennials)	Renewable energy systems
36	**Weather**	Agro-Met Advisory & alerts	Increase system resilience to climate shocks, minimize the threats of climate risks	Crop scheduling according to weather forecast, therefore minimizes unnecessary energy consumption as well as GHG emission	Increase productivity and income by minimizing the threats of climate risks	All regions	All types of crops (annuals and perennials)	Weather forecasting

5.1 Crop diversification with short-age legume types cultivation

The technology involves the introduction of short-age legume types into crop rotation to enhance soil quality and crop yield. Short-age legumes, with their quick growth and harvest cycle, contribute to soil improvement and increase the resilience of farming systems.

Technology Developed/Introduced by: The technology is a result of agricultural research and development efforts by various institutions, including agricultural universities, research organizations, and government agencies.

Basic Features of the Technology:

- Incorporation of short-age legume crops into crop rotation.
- Quick growth and harvest compared to traditional legumes.
- Nitrogen fixation to enrich soil fertility.
- Improved soil structure and water retention.
- Reduced pest and disease pressure through crop diversification.

***Fig. 5** Harvesting of mung bean bean (green gram) (A), Mung bean field at Uyirtharasankulam village in Mathoddam (B)*

CSA Category: This technology aligns with several Climate-Smart Agriculture (CSA) categories:

- Carbon Smart: Potential for carbon sequestration in the soil.
- Nutrient Smart: Reduces reliance on chemical fertilizers through nitrogen fixation.
- Knowledge Smart: Equips farmers with knowledge of legume crop types and management.

Benefits of the Technology:

- Increased soil fertility and crop productivity.
- Enhanced soil structure and water management.
- Reduced pest and disease risks.
- Crop diversification for stable food supply.
- Improved farm income through diverse crops.
- Environmental sustainability by reducing erosion and pollution.

Drawbacks/Limitations:

- Limited access to suitable seed varieties.
- Lack of technical implementation support.
- Inadequate infrastructure and resources.

Suitability of the Technology:

- Geographical Area: Suitable for regions with varying climate and soil conditions.
- Cropping Pattern/Season: Adaptable to different cropping patterns and seasons.
- Agro-Ecosystem: Suitable for various agro-ecosystems, including smallholder and commercial farms.

Adaptability Rate: The adaptability of the technology depends on local farming systems and conditions. It can positively impact smallholder farmers and women by diversifying income sources and enhancing resilience.

Impact and Suitability to Smallholder Farmers and Women: The technology has the potential to empower smallholder farmers, especially women, by increasing income and farming system resilience.

Success Story: In a case study, the introduction of short-age legume types in crop rotation increased overall farm yield by 15% over two years. This resulted in a 10% reduction in chemical fertilizer use, saving farmers $500 annually.

Enabling Factors for Uptake and Challenges in Scaling Up:

Enabling Factors:

- Availability of suitable legume varieties.
- Knowledge dissemination and training.
- Government support for infrastructure development.

Challenges:

- Limited access to quality seeds.
- Need for ongoing technical support.
- Investment in infrastructure and resources.

Incorporating short-age legume types into crop rotation is a promising agricultural practice with multiple benefits, including improved soil quality, increased yield, and sustainability. While challenges exist, the technology's potential to empower smallholders and enhance farming resilience makes it a valuable addition to modern agriculture. Scaling up requires addressing seed availability and providing adequate support to farmers.

5.2 Crop rotation

Crop rotation is a farming practice involving the sequential planting of different crops on the same land to manage soil fertility, pests, diseases, and enhance crop yield. It is adaptable for both small and large plots, promoting diversified agriculture.

Technology Developed/Introduced by: Crop rotation is a traditional agricultural practice adopted and refined by farmers over generations. Its principles have been integrated into modern farming techniques.

Basic Features of the Technology:

- Sequential planting of diverse crops.
- Management of soil nutrients and reduction of pest and disease pressure.
- Improved crop yields and soil health.

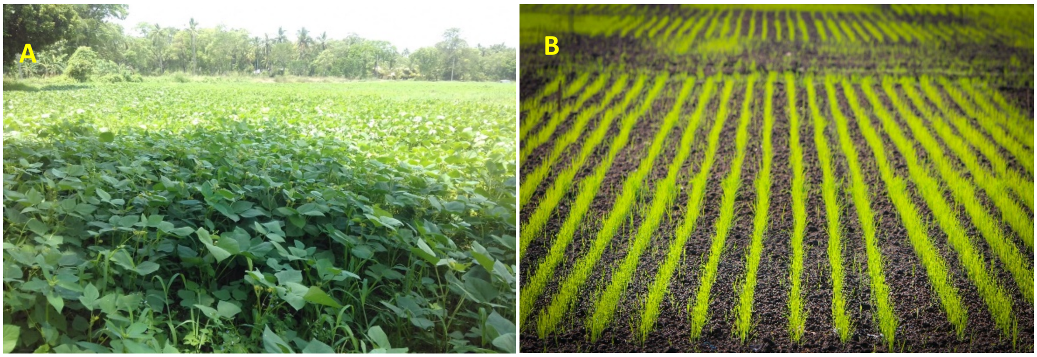


***Fig. 6** Cowpea in Yala Season (A), and Rice in Maha Season (B); Rice-based crop rotation*

CSA Category: Crop rotation falls under the 'Nutrient Smart' category of Climate-Smart Agriculture (CSA). It optimizes soil nutrient utilization and reduces reliance on chemical fertilizers, thereby minimizing environmental impacts.

Benefits of the Technology:

- **Improved Soil Fertility:** Varied nutrient requirements of different crops enhance soil health and nutrient cycling.
- **Pest and Disease Management:** Diverse crops reduce the buildup of specific pests and diseases.
- **Improved Crop Yield:** Enhanced soil fertility and pest management contribute to increased crop yields.

Drawbacks/Limitations:

- **Extra Planning and Labor:** Crop rotation demands meticulous planning and labor resources.
- **Local Suitability:** Applicability varies depending on local conditions such as soil type and climate.

Suitability of the Technology:

- *Geographical Area:* Suitable for a wide range of geographical areas.
- *Cropping Pattern/Season:* Adaptable to various cropping patterns and seasons.
- *Agro-Ecosystem:* Beneficial where access to chemical inputs is available.

Adaptability Rate: The adoption of crop rotation depends on the specific farming context. Some farmers may resist change, while others may readily embrace this sustainable practice. Smallholder farmers and women can benefit from crop rotation by enhancing livelihoods and food security.

Impact and Suitability for Smallholder Farmers and Women: Crop rotation can significantly benefit smallholder farmers and women by increasing yields, reducing input costs, and improving food security.

Success Story: In Sri Lanka, crop rotation practices led to a 20% increase in overall farm yield over two years, resulting in a 15% reduction in chemical fertilizer use and increased income for farmers.

Enabling Factors for Uptake and Challenges in Scaling Up:

Enabling Factors:

- Availability of extension services.
- Access to financing and markets.
- Supportive policies and regulations.

Challenges:

- Initial investments in infrastructure and equipment.
- Ongoing support and training for efficient implementation.

Crop rotation is a sustainable agricultural practice that optimizes soil health, minimizes pest and disease pressures, and enhances crop yields. Its adaptability to various farming contexts makes it a valuable tool for smallholder farmers and women, promoting food security and reducing environmental impacts. While challenges exist, enabling factors such as support services and policies can facilitate its widespread adoption and scalability.

5.3 Parachute method of paddy seedling broadcasting

The "Parachute" method of paddy seedling broadcasting is an innovative technique developed in China, later introduced to Sri Lanka by the Rice Research Institute (RRI) at Batalagoda. It involves projecting rice seedlings, uprooted from soil-containing trays, into puddled fields. This technology is known for its small size, ease of use, and uniform seedling distribution.

Technology Developed/Introduced by: The "Parachute" method was developed in China and introduced to Sri Lanka by the Rice Research Institute (RRI) at Batalagoda.

Basic Features of the Technology:

- Projecting rice seedlings into puddled fields.
- Small and portable equipment.
- Uniform seedling distribution.
- Efficient planting technique.

Fig. 7 Rice nursery (A), Seedlings uprooted from nursery (B) and Crop establishment (C)

CSA Category: The "Parachute" method can be categorized as "Knowledge Smart" and "Energy Smart" under Climate-Smart Agriculture (CSA). It offers an efficient planting approach that conserves energy and knowledge transferability to other farmers.

Benefits of the Technology:

- **Time and Labor Savings:** Reduces planting time and labor requirements.
- **Increased Rice Yields:** Ensures uniform seed distribution, leading to higher yields.
- **Accessibility:** Allows planting in challenging areas, such as hilly or flooded fields.
- **Reduced Herbicide Use:** Dense planting can suppress weeds, potentially reducing herbicide reliance.

Drawbacks/Limitations:

- **Less Precision:** May be less precise compared to other planting methods, potentially affecting adoption rates.

Suitability of the Technology:

- *Geographical Area:* Suitable for regions where rice is a major crop.
- *Ecosystem:* Applicable to both highland and wetland ecosystems.
- *Farmers:* Particularly beneficial for smallholder farmers lacking extensive labor or costly planting equipment.

Farmer Reception: The "Parachute" method has been well-received by farmers and has proven successful in increasing rice yields and improving the livelihoods of smallholder farmers, particularly women.

Enabling Factors for Uptake:

- Availability of necessary equipment.
- Training and knowledge transfer on its usage.

Challenges in Scaling Up:

- Additional resources and support required for widespread adoption.

The "Parachute" method of paddy seedling broadcasting is an innovative agricultural technology that enhances rice planting efficiency. Its benefits, including time and labor savings, increased yields, and adaptability to challenging terrains, have made it a valuable addition to rice farming practices. While some challenges in scaling up exist, the positive reception among farmers highlights its potential for broader adoption and the improvement of smallholder livelihoods, especially for women in the rice-growing regions.

5.4 Alternative Wetting and Drying (AWD)

Alternate Wetting and Drying (AWD) is a water management technique employed in irrigated lowland rice cultivation. It deviates from the traditional practice of continuously maintaining standing water in rice fields by using controlled and intermittent irrigation.

CSA Category: AWD falls under the "Water Smart" category of Climate-Smart Agriculture (CSA) due to its reduced water usage compared to flood irrigation. Additionally, it can be considered "Carbon Smart" because it minimizes methane emissions from paddy fields.

Basic Features of the Technology:

- Controlled and intermittent irrigation for rice cultivation.
- Focuses on optimizing soil moisture to conserve water.
- Reduced methane emissions due to minimized standing water.

Main Focus of the Technology: The primary goal of AWD is to maintain the ideal soil moisture level in paddy fields, promoting water conservation in rice cultivation.

Benefits of the Technology:

- **Water Conservation:** AWD significantly reduces water consumption in rice farming.
- **Methane Emission Reduction:** It lowers methane emissions from paddy fields.

Drawbacks/Limitations:

- **Complexity for Individual Farmers:** Requires coordinated water control, which can be challenging for individual farmers.
- **Weed Management:** Weed emergence can be a common issue in this technique.

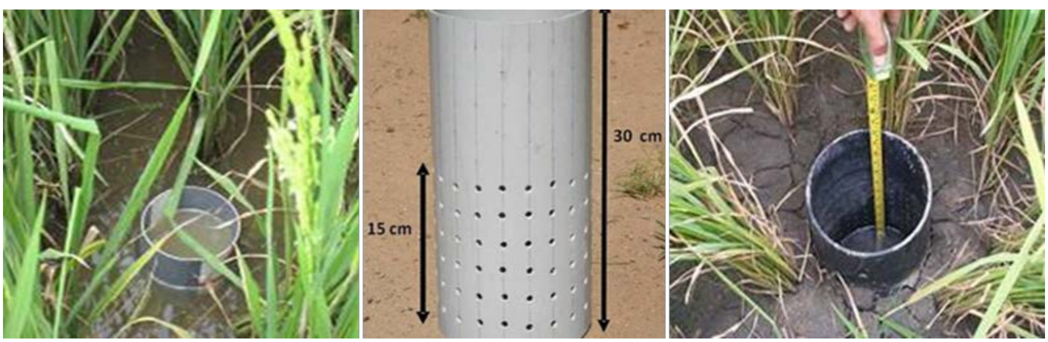


Fig. 8 *AWD technique in paddy cultivation*

Suitability of the Technology:

- *Geographical Area:* More suitable for paddy lands under minor irrigation systems with greater control over water.

Reasons for Low Adaptability and Acceptability:

- **Weed Control:** Difficulty in managing weeds.
- **Water Management:** Challenges in water control at the individual farmer level.
- **Lack of Awareness:** Limited awareness about the technique and its benefits.

Scaling Up Strategy: Increasing awareness and promoting judicious water management are key factors for scaling up the AWD technology. Providing training and support to farmers in weed control and efficient water use can enhance its acceptance and adoption.

Alternate Wetting and Drying (AWD) is a water-saving technique for rice cultivation with potential benefits in water conservation and reduced methane emissions. However, its adaptability and acceptability are hindered by challenges related to weed control, water management, and awareness. Scaling up this technology requires concerted efforts to address these challenges and educate farmers about its advantages, ultimately promoting more sustainable rice cultivation practices.

5.5 Protected agriculture for high-value crops

Protected agriculture for high-value crops is a technology that involves cultivating high-value crops, such as vegetables and flowers, within controlled environments like greenhouses or polytunnels. It aims to optimize plant growth by regulating factors like temperature, humidity, and light. This technology was developed in the 20th century to extend growing seasons and protect crops from extreme weather conditions.

CSA Category: Protected agriculture for high-value crops falls under the "Weather Smart" category of Climate-Smart Agriculture (CSA) technologies, focusing on enhancing agricultural efficiency and resilience.

Basic Features of the Technology:

- Utilizes greenhouses or polytunnels to create controlled environments.
- Employs irrigation, fertilization, and pest control methods for optimal crop growth.

Fig. 9 *Protected house (A), Cucumber grown in protected houses (B)*

Main Focus of the Technology: The primary focus is to safeguard plants from abiotic stresses (temperature, water levels) and biotic factors (pests and diseases).

Benefits of the Technology:

- **High-Value Crops:** Ideal for growing high-value crops like cucumbers, bitter gourds, and tomatoes.

- **Increased Crop Yields:** Enhances yields due to controlled conditions.
- **Resource Efficiency:** Reduces water and fertilizer usage.
- **Improved Food Security:** Contributes to enhanced food and nutrition security.

Fig. 10 *Chilli grown in plant houses*

Limitations:

- **High Initial Cost:** Setting up greenhouses or polytunnels can be expensive.
- **Skilled Labor:** Requires skilled labor to manage the system effectively.

Suitability of the Technology:

- *Geographical Area:* Suitable for a wide range of regions, especially those with extreme weather or short growing seasons.
- *Cropping Patterns/Agro-Ecosystems:* Adaptable to various cropping patterns and agro-ecosystems, catering to different high-value crops.

Adaptability Rate: Protected agriculture for high-value crops generally enjoys a high adaptability rate, as it allows for extended growing seasons and protection against adverse weather conditions. It is particularly suitable for smallholder farmers and women, contributing to increased yields and food security.

Enabling Factors for Uptake:

- Government Support: Policies and incentives can encourage adoption.
- Access to Financing: Financial support can assist in initial setup costs.
- Technical Assistance: Training and technical guidance are essential for effective implementation.

Challenges in Scaling Up:

- High Initial Costs: The substantial investment required to establish greenhouses or polytunnels can be a barrier.
- Skilled Labor: The need for skilled workers to manage the system poses challenges.

Protected agriculture for high-value crops is a technology that enhances crop cultivation by controlling environmental factors. It offers numerous benefits, including increased yields, resource efficiency, and improved food security. While initial costs and labor requirements pose challenges, government support, access to financing, and technical assistance can facilitate wider adoption. This technology is adaptable to various regions and cropping systems, making it a valuable tool for modern agriculture.

5.6 Cultivation of stress-tolerant crop varieties

Stress-tolerant crop varieties are a technology aimed at enhancing crop resilience against stress conditions like drought, submergence, and salinity. This technology involves selecting or genetically engineering crop varieties with traits such as resistance to biotic stresses and tolerance to abiotic stresses. These varieties help mitigate the negative impacts of climate change on crop production.

CSA Category: Stress-tolerant crop varieties fall under both the "Weather Smart" and "Water Smart" categories of Climate-Smart Agriculture (CSA). They focus on improving crop resilience, reducing climate-related risks, and optimizing water use.

Basic Features of the Technology:

- Identification and selection of stress-tolerant crop varieties.
- Traits include deep root systems, improved water use efficiency, and resistance to various stresses.
- Utilizes traditional breeding or genetic engineering methods.

Main Focus of the Technology: The primary focus is to enhance crop resilience, increase yields, and reduce climate change-related risks.

Benefits of the Technology:

- **Climate Resilience:** Stress-tolerant varieties withstand unpredictable and extreme weather conditions.
- **Stable Food Supply:** Ensures a reliable food supply despite climate-related challenges.
- **Resource Efficiency:** Requires fewer inputs like irrigation and pesticides, promoting sustainability.

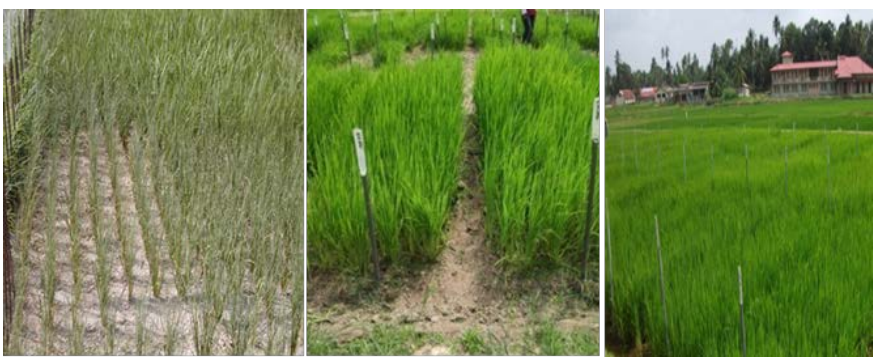


Fig. 11 *Screening of rice lines for drought resistance*

Limitations:

- **Regional Suitability:** This may not be suitable for all regions and may require specialized knowledge.

- **Supply Challenges:** Availability of quality stress-tolerant varieties can be limited.
- **GM Concerns:** Concerns exist regarding the environmental and health impacts of genetically modified (GM) varieties.

Suitability of the Technology:

- *Geographical Area:* Most suitable for regions prone to drought or environmental stress.
- *Crops/Cropping Patterns:* Adaptable to a wide range of crops and cropping patterns.

Adaptability Rate: The technology generally enjoys a positive adaptability rate, with farmers reporting increased yields and reduced climate-related risks. However, the availability of suitable stress-resistant varieties can be a limiting factor.

Impact on Smallholder Farmers and Women: Stress-tolerant crop varieties are suitable for smallholder farmers and women, as they help reduce climate risks and enhance food security in vulnerable environments.

Enabling Factors for Uptake:

- Training and Extension Services: Providing knowledge and technical support.
- Financing and Investment: Access to financial resources.
- Supportive Policies: Policies that encourage the adoption of stress-tolerant varieties.

Challenges in Scaling Up:

- Research and Development: Ongoing research is needed to develop and refine stress-tolerant varieties.
- Availability of Suitable Varieties: Ensuring a consistent supply of quality stress-resistant seeds.
- Infrastructure and Support: Necessary infrastructure and support systems for implementation.

Stress-tolerant crop varieties are a critical technology for enhancing crop resilience to climate change. They offer numerous benefits, including climate resilience, stable food supply, and resource efficiency. While challenges like regional suitability and GM concerns exist, enabling factors such as training, financing, and supportive policies can facilitate broader adoption. This technology is adaptable to various crops and cropping systems, making it an important tool for ensuring food security in the face of climate change.

5.7 Cultivation under controlled environments

Cultivation of crops under controlled environments, such as net houses and rain shelters, is a technology that involves using structures to protect crops from adverse weather conditions, pests, and diseases. These controlled environments extend the growing season and enhance crop productivity, addressing challenges posed by extreme weather like drought, heat, and frost.

Types of Structures:

- **Rain Shelter:** A unit with a rain-impervious roof and typically no or open sidewalls, lacking mechanical ventilation or heating systems.
- **Net-House:** Resembles a greenhouse, covered with insect-proof netting but accessible to rain. It may provide some shading but usually lacks mechanical ventilation or heating.

***Fig. 12** Net / Shade houses*

CSA Category: Cultivation under net houses and rain shelters falls under the "Weather Smart" category of Climate-Smart Agriculture (CSA). It focuses on mitigating the impact of extreme weather conditions on crop production.

Basic Features of the Technology:

- Use of structures made from materials like plastic, glass, or metal.
- Allows sunlight and air circulation while protecting crops from rain and insects.

Benefits of the Technology:

- **Increased Crop Productivity:** Provides a controlled environment that boosts yields.
- **Extended Growing Period:** Allows for year-round or extended-season cultivation.
- **Reduced Crop Loss:** Shields crops from adverse weather conditions, minimizing losses.

Limitations:

- **Cost:** Construction and maintenance of structures can be expensive.
- **Resource Inputs:** May require additional resources such as water and fertilizers.

Suitability of the Technology:

- *Geographical Area:* Most suitable for areas with extreme weather conditions like heat or frost.
- *Cropping Patterns:* Effective for high-value crops like vegetables and flowers.

Fig. 13 *Rain shelters for onion seed production*

Adaptability Rate: The adaptability rate varies by region and resource availability. Generally, farmers accept this technology well due to its positive impact on crop yield and resilience to adverse weather conditions.

Impact on Smallholder Farmers and Women: Cultivation under net houses and rain shelters is suitable for smallholder farmers and women as it enhances crop productivity and income. However, the initial cost of construction and maintenance may pose a barrier for some.

Enabling Factors for Uptake:

- Training and Extension Services: Knowledge and technical support for implementation.
- Financial Support: Access to funds for constructing and maintaining structures.
- Supportive Policies: Policies promoting the adoption of protective structures.

Challenges in Scaling Up:

- **Initial Cost:** High construction and maintenance costs can hinder widespread adoption.
- **Resource Availability:** Adequate water and fertilizers may be required.
- **Awareness:** Limited awareness about the benefits of these structures can be a challenge.

Cultivation of crops under net-houses and rain shelters is a technology that offers enhanced crop resilience and productivity. While it provides several benefits, including increased yields and extended growing seasons, challenges such as high costs and resource inputs exist. Enabling factors like training, financing, and supportive policies can facilitate broader adoption. This technology is well-suited for smallholder farmers and women, empowering them to increase crop yields and income while mitigating the impact of adverse weather conditions.

5.8 Sorjan cultivation

Sorjan farming is an integrated system that combines crop and fish cultivation in parallel raised beds and sunken beds (trojans). Developed by the International Rice Research Institute (IRRI), it is widely adopted in South Asia. Raised beds are used for crops like rice, while sunken beds are used for fish cultivation. This system aims to improve water and nutrient management and fits into the "Water Smart" and "Nutrient Smart" categories of Climate-Smart Agriculture (CSA).

Basic Features of the Technology:

- Parallel arrangement of raised beds for crops and sunken beds for fish.
- Utilizes the soils from ditches to construct raised beds.
- Integrated cultivation of lowland crops and fish.

Fig. 14 *Sorjan farming in Colombo district*

Suitable Geographical Area: Sorjan farming is suitable for southwest coastal low-lying areas in Sri Lanka with complex hydrologic conditions, including flooding, drought, and poor drainage.

Benefits of the Technology:

- **Increased Productivity:** Enhances crop and fish production.
- **Improved Water and Nutrient Management:** Efficient use of resources.
- **Income Generation:** Provides additional cash income.
- **Diverse Diet:** Produces a variety of crops and fish for better nutrition.

Limitations:

- **Water Supply:** Requires a consistent and reliable water supply.
- **Disease Vulnerability:** Susceptible to diseases affecting both crops and fish.

Adaptability Rate: Sorjan farming is generally well-accepted due to increased productivity and income potential. However, its success depends on proper management and resource availability.

Impact on Smallholder Farmers and Women: Beneficial for smallholder farmers and women, providing income from crop and fish production and improving food security.

Government Initiative: A program initiated in 2021 by the Colombo District Secretariat in Sri Lanka aims to use the Sorjan method to develop paddy fields unsuitable for rice cultivation.

Enabling Factors for Uptake:

- Training and Extension Services: Knowledge and technical support.
- Access to Inputs: Availability of seeds and fingerlings.

- Infrastructure and Equipment: Initial investments for setup.
- Proper Management: Maintenance of the system for long-term success.

Challenges in Scaling Up:

- **Infrastructure Investment:** Initial investments required for construction.
- **Resource Management:** Proper management and maintenance are essential.
- **Disease Control:** Addressing potential diseases affecting crops and fish.

Sorjan farming is an integrated system combining crop and fish cultivation to enhance productivity and income. While it offers multiple benefits, including improved resource management and diversified nutrition, challenges like water supply and disease management exist. Enabling factors such as training, access to inputs, and supportive government initiatives can promote adoption. This technology is particularly suitable for coastal low-lying areas with complex hydrological conditions. Careful management and investment are crucial for its success and scalability.

5.9 Home gardening

Home gardening is a form of farming that involves cultivating a variety of plants and vegetables, including annual, biennial, and perennial crops, typically in small plots near the home. These gardens often employ multi-species and multi-storied cropping systems, integrating plants with different canopy depths. Home gardening promotes organic farming and food safety, allowing individuals to efficiently and sustainably grow their crops, regardless of location-specific challenges or land availability.

Basic Features of Home Gardening:

- Use of raised beds or containers for plant cultivation.
- Incorporation of organic matter to improve soil fertility.
- Implementation of sustainable irrigation and pest management practices.
- Inclusion of decorative plants, flowers, herbs, and spices.

Fig. 15 *Home gardening*

CSA Category: Home gardening aligns with the "Knowledge Smart" category of Climate-Smart Agriculture (CSA), emphasizing education and understanding for successful gardening practices. Its primary focus is to enable individuals to grow food in an environmentally and financially sustainable manner.

Main Focus of the Technology:

- Improving human fitness and health.

- Enhancing food and dietary security.
- Promoting social value and gender balance.
- Increasing income and environmental diversity.

Benefits of Home Gardening:

- **Diverse Crop Range:** Allows the cultivation of various crops, supporting food nutrition and income.
- **Improved Food Security:** Diversified crops contribute to balanced diets.
- **Sustainable Practices:** Supports organic and sustainable farming, benefiting soil health and reducing chemical inputs.

Limitations:

- **Limited Yield:** Smaller yields compared to larger-scale agriculture due to limited space.
- **Profitability:** May be less profitable compared to other forms of agriculture due to smaller output.

Suitability of Home Gardening:

- Suitable for various geographical regions and agro-ecosystems.
- Particularly well-suited for smallholder farmers and women due to minimal land requirements and ease of management.

Adaptability Rate: Home gardening is highly adaptable, as it can be practiced in diverse climates and soil types. It is generally well-accepted by farmers due to minimal investment and its potential to provide food and income. However, its suitability may vary depending on individual needs and resources.

Enabling Factors for Uptake:

- Education and Training: Access to programs promoting gardening knowledge.
- Land Resources: Availability of suitable land and resources.
- Supportive Policies: Policies and regulations encouraging home gardening.

Challenges in Scaling Up:

- **Awareness:** Limited understanding of the benefits of home gardening.
- **Alternative Food Sources:** Availability of other food sources.
- **Cost:** Initial and maintenance costs of home gardens.

Home gardening is a versatile farming approach that empowers individuals to grow a diverse range of crops near their homes. It promotes food security, nutrition, and sustainable practices while addressing environmental concerns. Although limited by space and potential profitability, home gardening is adaptable to various regions and is particularly beneficial for smallholder farmers and women. Widespread adoption depends on raising awareness, providing access to resources, and supportive policies.

5.10 Seasonal-adapted planting times

Planting crops at specific times based on local climate and weather patterns is a traditional farming practice used by farmers worldwide for optimizing crop yields and reducing the risk of crop failure. In Sri Lanka, there are two main cultivation seasons - Maha and Yala - corresponding to the two monsoons.

Fig. 16 *Brinjal cultivation commenced with the onset of rainfall*

CSA Category: This technology aligns with the "Weather Smart" category of Climate-Smart Agriculture (CSA), focusing on improving crop resilience to weather extremes like droughts, floods, and extreme temperatures by planting at optimal times.

Main Focus of the Technology: The primary objective is to synchronize crop planting with local rainy periods, ensuring optimal conditions for growth and development.

Benefits of Seasonal Planting Times:

- Increased crop yields
- Reduced crop losses
- Lower production costs

Limitations:

- Need for accurate weather forecasting
- Potential vulnerability to pests and diseases during planting periods

Suitability of Seasonal Planting Times:

- Suitable for diverse geographical areas with varying climates
- Particularly effective in regions with distinct wet and dry seasons
- Applicable to various cropping patterns and agroecosystems

Adaptability Rate: High adaptability, as it is a well-established traditional practice with widespread acceptance among farmers, contributing to improved crop yields and reduced risk of crop failure.

Impact on Smallholder Farmers and Women: Beneficial for smallholder farmers and women by increasing crop yields and reducing the risk of crop failure, positively impacting their livelihoods.

Enabling Factors for Uptake:

- Availability of accurate weather forecasting data

- Extension services offering guidance on optimal planting times

Challenges in Scaling Up:

- Infrastructure investment needs, such as irrigation systems
- Educational efforts to enhance farmers' understanding of the technology's importance

Seasonal planting based on local weather patterns is a traditional yet effective farming practice. It aligns with the "Weather Smart" category of CSA and focuses on optimizing crop growth by synchronizing planting with rainy periods. Benefits include increased yields and reduced losses, making it suitable for diverse climates and cropping systems. Farmers have widely embraced this practice, particularly benefiting smallholders and women, though challenges include infrastructure and educational needs.

5.11 Dry sowing

Dry sowing, also known as direct seeding or direct planting, involves planting seeds directly into dry soil without pre-moistening. It is a crop establishment technique designed to reduce water use in agriculture.

CSA Category: This technique falls under the "Water Smart" category of Climate-Smart Agriculture (CSA), aiming to minimize water consumption in crop production. It may also align with the "Energy Smart" category by reducing the need for energy-intensive irrigation.

Fig. 17 *Dry Sowing (rice)-Jaffna, Sri Lanka*

Main Focus of the Technology: The primary focus of dry sowing is water conservation in crop establishment, particularly in areas with limited access to irrigation.

Benefits of Dry Sowing:

- Time and labor savings compared to wet sowing or transplanting
- Timely planting without waiting for soil moisture or irrigation setup
- Potential economic benefits of reducing irrigation water costs
- Reduced risk of soil erosion during planting

Limitations:

- Risk of poor germination or crop failure in cases of inadequate soil moisture
- Vulnerability to seed predation by birds and other animals
- Unsuitability for certain crops that require specific germination conditions

Suitability of Dry Sowing:

- Suitable for a variety of crops, especially drought-tolerant ones
- Applicable in arid and semi-arid regions
- Compatibility with different agro-ecosystems

Adaptability Rate: Adaptability varies depending on location and crop type. Some farmers may be hesitant due to the risk of crop failure without sufficient soil moisture. However, combining dry sowing with other CSA practices can enhance its success rate.

Impact on Smallholder Farmers and Women: Dry sowing can benefit smallholder farmers and women by reducing irrigation-related labor and costs and improving crop yields in water-scarce areas.

Enabling Factors for Uptake:

- Availability of dry sowing equipment
- Adoption of complementary CSA practices
- Education and training on dry sowing

Challenges in Scaling Up:

- The need for research to identify suitable crops, varieties, and agro-ecosystems for dry sowing
- Educational efforts to increase awareness and knowledge about the technique

Dry sowing is a water-smart technique aimed at conserving water during crop establishment. It offers time and labor savings and can be economically beneficial. However, its success depends on factors like soil moisture and crop type. It is adaptable to various regions and can be particularly advantageous for smallholders and women, but education and research are essential for scaling up its adoption.

5.12 Planting with onset of rains

Planting crops with the onset of rain is a technique that involves sowing seeds or seedlings at the start of the rainy season to utilize natural moisture for crop growth, especially in areas without irrigation infrastructure.

CSA Category: This technique falls under the "Weather Smart" category of Climate-Smart Agriculture (CSA) as it optimizes crop growth based on weather patterns and conditions. It also aligns with "Water Smart" practices by conserving water resources through rain-dependent cultivation.

Main Focus of the Technology: The primary focus is to leverage rainfall as a water source for crop cultivation and to maximize yields, especially in regions without access to irrigation.

Fig. 18 *Land preparation with the onset of rains for upcoming crop cultivation*

Benefits of Planting Crops with the Onset of Rain:

- Increased crop yields due to timely planting with rainfall
- Reduced reliance on irrigation, conserving water resources
- Lower production costs associated with irrigation

Limitations:

- Requires accurate timing and planning based on weather forecasts
- Vulnerable to crop failure if the rainy season is delayed or insufficient
- Weather patterns can be unpredictable, posing challenges in timing planting

Suitability of the Technology:

- Suitable for regions with sufficient rainfall during specific seasons
- Applicable to various geographical areas and cropping patterns

Adaptability Rate: Adaptability varies based on factors like seed availability, labor resources, and local market demand for crops. Generally well-accepted, particularly in areas without irrigation options.

Impact on Smallholder Farmers and Women: The technique can significantly benefit smallholder farmers and women by providing an alternative means of crop cultivation not reliant on irrigation infrastructure.

Enabling Factors for Uptake:

- Access to quality seeds suitable for rain-dependent planting
- Training and extension services on timing and planning
- Support from local governments and NGOs for implementation

Challenges in Scaling Up:

- Need for additional infrastructure and resources in some cases
- Difficulties in accurately forecasting the onset of the rainy season

Planting crops with the onset of rain is a weather-smart technique that optimizes crop growth using natural rainfall. While it offers benefits like increased yields and reduced water usage, its success depends on accurate timing and planning. This technique can be widely adapted, particularly in regions without irrigation, and is valuable for smallholder farmers and women. To scale up its adoption, infrastructure support and improved weather forecasting may be necessary.

5.13 Cover crops

Cover crops, also known as live mulches, are plants grown between main crops to benefit soil health and crop growth. They offer various advantages such as soil improvement, erosion control, water conservation, and enhanced nutrient availability. Cover crops can be annual or perennial and are suitable for diverse climates and cropping systems.

CSA Categories: Cover crops align with several CSA categories:

- "Water Smart" by reducing soil erosion and enhancing water infiltration and retention.
- "Nutrient Smart" by fixing nitrogen from the air and adding organic matter to the soil.
- "Carbon Smart" by sequestering carbon in the soil and reducing greenhouse gas emissions.

Main Focus of the Technology: The primary focus is on enhancing soil health, productivity, and overall sustainability while providing additional benefits such as erosion control and water conservation.

Fig. 19 *Cover crops under coconut cultivation*

Benefits of Cover Crops:

- Improved soil structure and fertility
- Reduced erosion and runoff
- Increased water infiltration and retention
- Enhanced biodiversity on farms
- Potential use as forage for livestock and natural pest management

Limitations:

- Cost and labor involved in establishment and maintenance
- Competition with cash crops for resources (light, water, nutrients)

Suitability of the Technology: Cover crops can thrive in diverse climates, cropping systems, and regions. They can be integrated between main crops or grown independently. Suitable for both annual and perennial cropping systems.

Adaptability Rate: Cover crops have been widely adopted by farmers, showing high levels of acceptance and adaptability.

Impact on Smallholder Farmers and Women: Cover crops are particularly beneficial for smallholder farmers as they can enhance soil health and productivity with relatively low inputs. Additionally, they offer erosion control and water conservation benefits, which are crucial for smallholders. Women farmers can also benefit, as cover crops can provide extra income and food security.

Enabling Factors for Uptake:

- Availability of appropriate cover crop seed varieties
- Access to training and extension services
- Access to markets for cover crop products

Challenges in Scaling Up:

- Requires additional management practices
- Potential competition with main crops for resources

Cover crops are a versatile CSA technology with numerous benefits for soil health and crop production. While challenges like cost and resource competition exist, proper management and support can minimize these issues. Cover crops are well-suited for smallholder farmers and women, contributing to sustainable and resilient agriculture.

5.14 Organic fertilizers

Organic fertilizers, derived from organic sources like compost, manure, and sewage, offer a natural and sustainable alternative to synthetic chemical fertilizers. They provide essential nutrients to plants, improve soil health, and reduce environmental impacts.

CSA Categories: Organic fertilizers align with multiple CSA categories:

- "Carbon Smart" by returning carbon to the soil during decomposition.
- "Nutrient Smart" as they supply various essential nutrients.
- "Energy Smart" by acting as an energy source for soil microbes.

Main Focus of the Technology: The primary focus is on enhancing soil health, nutrient cycling, and sustainable crop production while minimizing environmental harm.

Benefits of Organic Fertilizers:

- Improved soil health and structure
- Enhanced water retention
- Increased nutrient cycling
- Reduced environmental impacts
- Lower greenhouse gas emissions

Limitations:

- May not provide immediate and consistent nutrient supply
- Requires more frequent and precise application
- May need more labor and management

Fig. 20 *Compost preparation*

Suitability of the Technology: Organic fertilizers are suitable for various geographical areas and cropping patterns, especially in organic farming systems.

Adaptability Rate: Organic fertilizers have high adaptability and are generally accepted by farmers, making them suitable for smallholder farmers and women.

Impact on Smallholder Farmers and Women: Organic fertilizers are beneficial for smallholders, providing affordable and accessible alternatives to synthetic fertilizers. They contribute to sustainable and environmentally friendly farming practices.

Enabling Factors for Uptake:

- Education and training programs
- Supportive government policies
- Reliable supply chains

Challenges in Scaling Up:

- Need for further research and development
- Ensuring consistent nutrient supply
- Longer production times compared to synthetic fertilizers
- Higher input requirements, potentially increasing production costs

Organic fertilizers offer numerous advantages, including improved soil health and reduced environmental impacts. While they have some limitations, proper education, supportive policies, and supply chain development can promote their adoption and contribute to sustainable agriculture.

5.15 Mulching

Mulching is a soil management technique involving the application of organic or inorganic materials to the soil surface. It helps conserve moisture, control weeds, regulate soil temperature, and improve soil health, ultimately enhancing crop production.

CSA Categories: Mulching falls under multiple CSA categories:

- "Water Smart" by conserving soil moisture.
- "Carbon Smart" through increased carbon storage in decomposing organic mulch.
- "Energy Smart" as it reduces the need for irrigation and weed control.

***Fig. 21** Mulching with organic materials*

Main Focus of the Technology: The primary focus is on conserving soil moisture, suppressing weeds, and regulating soil temperature to enhance crop yields.

Benefits of Mulching:

- Improved soil moisture retention
- Weed suppression
- Soil temperature regulation
- Enhanced soil structure and health
- Increased carbon storage in soil

Limitations:

- Costs and labor associated with mulch application
- Environmental impacts if mulch materials are harmful or improperly disposed of

Suitability of the Technology: Mulching is suitable for various cropping systems, including both annual and perennial crops. It is particularly effective in dryland cropping systems.

Adaptability Rate: Mulching is well-accepted by farmers, with a high adaptability rate. It is a simple and cost-effective technique that is suitable for smallholder farmers and women.

Impact on Smallholder Farmers and Women: Mulching benefits smallholders by conserving moisture and reducing the need for costly irrigation and weed control. It is a technique that can be easily implemented by women farmers.

Enabling Factors for Uptake:

- Availability of mulching materials
- Technical assistance and training
- Government support and policies promoting mulching

Challenges in Scaling Up:

- Initial costs of mulch materials
- Labor requirements for mulch application
- Availability of machinery for distributing mulch
- Ensuring proper disposal of mulch materials

Mulching is an effective practice for improving soil health and crop productivity. While there are costs and labor associated with its application, it offers substantial benefits, especially in dryland cropping systems. Proper training, availability of materials, and government support can facilitate its widespread adoption, particularly among smallholder farmers and women.

5.16 Rearing and conservation of indigenous cattle

Indigenous cattle breeds are adapted to local environments and are valuable for draught power, milk, meat, and cultural significance. Conservation and rearing of these breeds preserve genetic diversity and local traditions.

CSA Categories: This technology aligns with the "carbon smart" category by promoting livestock breeds that are adapted to local conditions, reducing the need for energy-intensive practices. It also falls under the "knowledge smart" category by preserving local knowledge and traditions related to indigenous breeds.

Fig. 22 *Dairy farming*

Main Focus of the Technology: The primary focus is on conserving and rearing indigenous cattle breeds that are well-suited to local environments and farming systems.

Benefits of Indigenous Cattle:

- Well-adapted to local conditions, resistant to diseases and parasites
- Thrive on locally available feed, which is cost-effective for farmers
- Unique genetic traits for specific types of farming (e.g., dairy, meat, draft work)
- Cultural significance and economic value to local communities

Limitations:

- Lower productivity compared to high-yield commercial breeds
- Expensive conservation and breeding efforts
- Requires specialized knowledge and expertise

Suitability of the Technology: Suitable for regions where indigenous cattle breeds are well-adapted and culturally significant. Appropriate for farmers valuing the contributions of indigenous breeds.

Adaptability Rate: Adoption rates may vary by context but may be higher among farmers already using indigenous breeds.

Impact on Smallholder Farmers and Women: Indigenous cattle are vital for smallholders and women, providing draught power, milk, and livelihood support.

Enabling Factors for Uptake:

- Availability of indigenous breeds
- Local demand for indigenous cattle products
- Recognition of their economic and cultural value

Challenges in Scaling Up:

- Awareness and understanding of indigenous breed value
- Limited resources and infrastructure for conservation and rearing

Conserving and rearing indigenous cattle breeds is vital for preserving genetic diversity, local traditions, and the livelihoods of smallholder farmers and women. This technology aligns with CSA principles by promoting climate-smart livestock that requires fewer energy-intensive practices and by preserving local knowledge and traditions. However, challenges such as lower productivity and the need for specialized knowledge and resources may hinder widespread adoption.

5.17 Composting and biogas production from cattle waste

Composting and biogas production from cattle waste is a technology that converts cow manure into valuable resources, addressing environmental concerns and providing bioenergy and compost.

CSA Categories: This technology aligns with the "carbon smart" category of CSA technologies, as it helps reduce methane emissions from cow manure.

Fig. 23 *Livestock farming and biogas production*

Main Focus of the Technology: The primary focus is to reduce environmental impacts from cow manure while providing valuable resources, including nutrient-rich compost and biogas for energy.

Benefits:

- Reduces methane emissions, mitigating global warming
- Produces nutrient-rich compost, reducing synthetic fertilizer use
- Generates biogas as a clean and renewable energy source
- Offers potential income generation from compost and biogas sales
- Improves soil health and fertility, leading to higher crop yields

Limitations:

- Requires management and maintenance
- Can produce unpleasant odors
- Requires specialized equipment and infrastructure

- Generates liquid and solid by-products that need proper management

Suitability of the Technology: Applicable in various geographical areas and agro-ecosystems where cows are raised for dairy or meat production.

Impact on Smallholder Farmers and Women: Advantages for smallholders and women include cost reduction through decreased synthetic fertilizer use, potential income from compost and biogas, and improved soil fertility leading to higher crop yields.

Enabling Factors for Uptake:

- Access to financing and technical support
- Availability of equipment and infrastructure

Challenges in Scaling Up:

- Farmer education on benefits and proper implementation
- Infrastructure and equipment investment

Composting and biogas production from cattle waste offer environmentally sustainable solutions to manage cow manure. This technology reduces methane emissions, produces valuable compost, and generates clean energy. Smallholders and women can benefit from cost savings and potential income. However, challenges include the need for education and investment in infrastructure.

5.18 Compost production from poultry waste

Compost production from poultry waste is an environmentally friendly waste management technique that converts poultry manure and bedding into nutrient-rich compost for agricultural use. It involves collecting and decomposing waste materials through the action of microorganisms.

***Fig. 24** Compost production from poultry wastes*

CSA Categories: This technology falls under the "Nutrient Smart" and "Carbon Smart" categories of CSA technologies, as it focuses on recycling nutrients, reducing greenhouse gas emissions, and enhancing soil health.

Main Focus of the Technology: The primary focus is to recycle nutrients from poultry waste and reduce greenhouse gas emissions while providing a valuable soil amendment. It also helps reduce waste sent to landfills.

Benefits:

- Reduces waste sent to landfills, mitigating greenhouse gas emissions
- Provides a valuable source of organic matter for agriculture
- Generates income for poultry farmers through compost sales
- Reduces the need for synthetic fertilizers in agriculture
- Improves soil health and crop yields
- Mitigates odor and fly issues with proper management

Limitations:

- Potential for odor and fly issues during composting
- Concerns about pathogens or contaminants in the compost
- Availability of sufficient quantities of feedstock may be a challenge
- Need to build or expand composting infrastructure
- Education of potential customers about the benefits of poultry waste compost

Suitability of the Technology: Applicable in areas with intensive poultry production, especially in regions with large commercial chicken or turkey operations. Can be implemented year-round in various farming patterns.

Impact on Smallholder Farmers and Women: Benefits smallholders and women by providing an income source through compost sales. Also improves soil fertility and crop yields, enhancing food security and income.

Enabling Factors for Uptake:

- Funding and support for composting infrastructure development
- Regulatory incentives and policies encouraging composting
- Availability of training and technical assistance
- Education of potential customers about compost benefits

Challenges in Scaling Up:

- Ensuring a sufficient supply of feedstock
- Building or expanding composting infrastructure
- Finding markets for compost and educating potential customers
- Managing odor and fly issues during composting

Compost production from poultry waste offers an environmentally sustainable solution for managing poultry waste, reducing greenhouse gas emissions, and enhancing soil health. It generates income for farmers, reduces reliance on synthetic fertilizers, and contributes to a more sustainable poultry industry. Challenges include feedstock availability and market development, but the technology holds great potential.

5.19 Rearing adaptive breeds

The technology of selecting and raising adaptive poultry breeds suited to specific agroecological conditions is a means to improve the sustainability and productivity of poultry farming in Sri Lanka. It involves selecting chicken breeds adapted to local conditions and implementing management practices to optimize poultry health and productivity.

CSA Categories: This technology falls under the "Knowledge Smart" category of CSA technologies, as it relies on knowledge of local agroecological conditions to select and rear appropriate poultry breeds.

Main Focus of the Technology: The primary focus is on enhancing the sustainability and productivity of poultry production in different regions of Sri Lanka.

Benefits:

- Resistance to local diseases and pests, reducing veterinary treatment costs
- Improved feed conversion ratios, lowering production costs
- Resilience to extreme weather conditions, such as floods or droughts
- Enhanced animal welfare through breed adaptation

Fig. 25 *Free-range poultry farming (A) and Commercial breeder farm (B)*

Limitations:

- Initial costs for acquiring poultry and setting up breeding programs
- Need for knowledge and expertise in rearing adaptive breeds
- Challenges in finding markets for less common poultry breeds

Suitability of the Technology: Suitability depends on geographical area and local context. Farmer acceptance and adaptability may vary based on specific circumstances.

Impact on Smallholder Farmers and Women: The technology can positively impact smallholder farmers and women by improving poultry productivity and sustainability, contributing to food security and income generation.

Enabling Factors for Uptake:

- Availability of quality breeding stock and hatcheries
- Supportive government policies, grants, or subsidies
- Extension services and training programs on adaptive breed management

Challenges in Scaling Up:

- Need for infrastructure development (feed mills, processing plants)
- Resistance to change among farmers accustomed to existing practices
- Education, training, and outreach efforts required to promote adaptive breed adoption

Selecting and rearing adaptive poultry breeds can enhance poultry farming sustainability and productivity in Sri Lanka. While challenges exist, such as initial costs and resistance to change, supportive policies and capacity-building efforts can facilitate technology adoption.

5.20 Multi-purpose soil conservation bunds and terraces

Multi-purpose soil conservation bunds and terraces are sustainable agricultural practices designed to reduce erosion, increase water retention, and improve overall land productivity. They involve constructing bunds and terraces within fields and cultivating selected perennial crops or plant species on the bunds to enhance sustainability and provide additional income for farmers.

Basic Features of the Technology:

- Construction of small embankments (bunds) and terraces within agricultural fields.
- Bunds and terraces are typically built along contour lines, perpendicular to the slope of the land.
- Soil bunds can vary in size and shape based on local conditions.
- Use of a covered container to contain decomposing materials for enhanced sustainability.
- Addition of water and oxygen to facilitate decomposition processes.
- Monitoring of temperature and pH levels to ensure optimal conditions for microorganisms.

Fig. 26 *Multi-purpose soil conservation bunds (A) and Terraces (B)*

CSA Categories: This technology falls into the "Water Smart" and "Knowledge Smart" categories of CSA technologies, primarily focusing on reducing erosion and increasing water retention, guided by local knowledge.

Main Focus of the Technology: The primary focus is on mitigating soil erosion, preserving moisture, and improving crop yields through the use of bunds and terraces.

Benefits:

- Retention of water in soil, vital for plant growth.
- Prevention of soil erosion, reducing the risk of landslides and soil degradation.
- Versatility in growing a wide range of crops and additional purposes.
- Sustainability through cultivation of tree or plant species on bunds, providing additional income.

Additional Income from Tree/Plant Species: Cultivating species like Gliricidia, Sesbania, drumsticks, pomegranate, lime, and lemongrass on bunds can:

- Generate extra income for farmers.
- Maximize land productivity.
- Make the bunds sustainable.
- Provide various benefits such as green manure, fuelwood, and animal feed.

Limitations:

- High construction and maintenance costs.
- Labor-intensive and regular maintenance required.
- Vulnerability to damage by heavy rainfall or natural disasters.

Suitability of the Technology: Suitability depends on local soil and water conditions. Ideal for areas with high erosion rates or limited irrigation access.

Impact on Smallholder Farmers and Women: Positively impacts smallholder farmers and women by improving land productivity and providing additional income. Suitable for those with limited access to other conservation technologies.

Enabling Factors for Uptake:

- Supportive government policies and programs.
- Access to credit and financing options.
- Availability of technical assistance and guidance.
- Community and regional organization support.

Challenges in Scaling Up:

- Lack of awareness and understanding among farmers.
- Limited infrastructure, hindering material and equipment transportation in remote areas.

Multi-purpose soil conservation bunds and terraces offer effective solutions to soil erosion, water retention, and land productivity improvement. While challenges exist, such as construction costs and awareness gaps, government support, technical assistance, and community involvement can facilitate their adoption and scaling up.

5.21 Biochar: A Soil Amendment Technology for Sustainable Agriculture

Biochar is a transformative technology that involves the application of charred organic matter to soil, known as pyrolysis, to enhance soil health and agricultural productivity. It has gained prominence due to its ability to sequester carbon in soil, improve soil fertility, and promote sustainable farming practices.

Basic Features of the Technology:

- Biochar is produced through pyrolysis, which is the thermal decomposition of organic matter under controlled conditions.
- It possesses a high surface area and porous structure, enabling it to retain moisture and nutrients in the soil.
- Biochar can be created from various feedstocks like wood, straw, and manure.
- It serves as a habitat for beneficial soil microbes.

Fig. 27 *Biochar production*

CSA Categories: Biochar falls under the "Carbon Smart" category of CSA technologies, as it aids in carbon sequestration, mitigating greenhouse gas emissions.

Main Focus of the Technology: The primary focus of biochar technology is to enhance soil quality, fertility, and resilience while promoting carbon sequestration and reducing greenhouse gas emissions.

Benefits:

1. **Improved Soil Structure and Fertility:** Biochar enhances soil structure, particularly in areas with poor soil quality, by retaining moisture and nutrients.
2. **Reduced Nutrient Leaching:** It reduces the loss of nutrients through leaching, promoting efficient nutrient use by plants.
3. **Greenhouse Gas Mitigation:** Biochar sequesters carbon in the soil, offsetting emissions generated during pyrolysis.
4. **Enhanced Crop Yields:** It can lead to increased crop yields, especially in regions with low organic matter content in the soil.

Drawbacks:

1. **High Production Costs:** Large-scale biochar production can be expensive due to the need for specialized equipment.
2. **Limited Long-Term Research:** There is a lack of comprehensive research on the long-term effects of biochar on soil health and crop yields.
3. **Variable Adaptability:** Success with biochar application varies among farmers and regions, depending on local conditions.

Suitability of the Technology: Biochar is most effective in soils with low organic matter content and erosion-prone characteristics. It has shown promise in drought-tolerant crop systems.

Impact on Smallholder Farmers and Women: Smallholder farmers and women may benefit from biochar, as it can improve soil health and crop yields in resource-constrained areas.

Enabling Factors for Uptake:

- **Government Policies:** Supportive policies and incentives can offset production costs and encourage adoption.
- **Technical Assistance:** Training and technical guidance help farmers understand the benefits and proper application of biochar.

Challenges in Scaling Up:

- **Infrastructure and Supply Chains:** Limited infrastructure and supply chains can hinder access to biochar.
- **Awareness and Understanding:** Lack of awareness and understanding among farmers and policymakers can limit adoption.

Conclusion: Biochar technology holds the potential to revolutionize agriculture by improving soil health, increasing crop yields, and mitigating climate change. Addressing challenges and promoting policies that support biochar adoption is essential to harness its full potential in agriculture.

5.22 Conservation Agriculture (CA): Sustainable Farming for the Future

Conservation Agriculture (CA) is a farming practice designed to conserve natural resources, enhance soil health, and mitigate the adverse effects of traditional tillage practices. By minimizing soil disturbance through zero tillage (ZT) or minimum tillage (MT) and employing herbicides for weed control, CA promotes sustainable and environmentally friendly agriculture.

Basic Features of the Technology:

- CA involves a reduction in tillage equipment usage, with primary tillage avoided and secondary tillage limited to planting bed preparation.
- Herbicides are employed for weed control and land preparation.
- CA often includes the use of cover crops, particularly legumes, in crop rotation.

Fig. 28 *Third season mung bean cultivation with zero tillage*

CSA Categories: CA aligns with several CSA categories, including "Carbon Smart" (carbon sequestration), "Water Smart" (improved water use efficiency), and "Nutrient Smart" (maintaining soil nutrient levels).

Main Focus of the Technology: The primary focus of CA is to enhance soil health, reduce carbon emissions, and improve water and nutrient management in agriculture.

Benefits:

1. **Reduced Fossil Fuel Usage:** CA significantly reduces energy-intensive tillage, leading to cost savings for farmers and a reduced carbon footprint.
2. **Enhanced Soil Health:** Reduced soil disturbance preserves soil structure, reducing erosion and promoting a healthier soil ecosystem.
3. **Improved Water Retention:** CA practices increase water retention in soil, aiding crop growth and resilience.
4. **Higher Crop Yields:** Improved nutrient cycling and reduced weed pressure can lead to higher crop yields.
5. **Cost Savings:** By cutting down on inputs like fuel and labor, CA can result in economic benefits for farmers.

Drawbacks:

1. **Herbicide Reliance:** CA may lead to increased reliance on herbicides due to reduced tillage, which can raise environmental and health concerns.
2. **Initial Costs:** Transitioning to CA may require investments in specialized machinery and training, which could deter some farmers.
3. **Learning Curve:** Farmers may need time to adapt to CA practices and optimize their benefits.

Suitability of the Technology: CA is suitable for diverse geographical areas, cropping patterns, and agro-ecosystems. However, transitioning from traditional tillage practices may require additional investments in equipment and farmer training.

Impact on Smallholder Farmers and Women: Smallholder farmers and women can particularly benefit from CA due to its potential to improve soil health, reduce labor requirements, and enhance crop yields. Access to appropriate training and technology is key to realizing these benefits.

Enabling Factors for Uptake:

- **Education and Training:** Farmer education and training are crucial for understanding CA benefits and techniques.
- **Incentives:** Government incentives, such as subsidies and credit access, can offset initial implementation costs and promote CA adoption.

Challenges in Scaling Up:

- **Initial Investment:** The upfront costs of transitioning to CA may be a barrier for some farmers.
- **Learning Curve:** Farmers need time to adapt to CA practices and optimize their results.
- **Herbicide Concerns:** Increased herbicide use can raise environmental and health concerns.

Conservation Agriculture (CA) offers numerous benefits, including enhanced soil health, improved water conservation, and increased crop yields. Addressing challenges and promoting enabling factors like education and incentives can facilitate widespread CA adoption, realizing its potential for sustainable and productive agriculture.

5.23 Contour Planting: Sustaining Agriculture through Land Conservation

Contour planting is a sustainable farming technique that involves planting crops along the natural contours of the land. Developed in the early 20th century, it was designed to combat soil erosion on hilly or sloping farmland. This method offers numerous benefits, including reduced soil erosion, preserved soil fertility, increased crop yields, and improved water resource management.

Basic Features of the Technology:

- Crops are planted in rows perpendicular to the slope of the land, creating a series of terraces.
- Contour planting slows water runoff, allowing the soil to absorb more water and reducing erosion.
- This technique can be used in areas with steep slopes or heavy rainfall.

Fig. 29 *Contour planting in the uplands*

CSA Categories: Contour planting aligns with multiple CSA categories, including "Weather Smart" (adapting to changing weather patterns) and "Water Smart" (conserving water resources and improving irrigation efficiency).

Main Focus of the Technology: The primary focus of contour planting is to combat soil erosion, preserve soil fertility, conserve water, and increase crop yields.

Benefits:

1. **Soil Erosion Prevention:** Contour planting significantly reduces soil erosion, protecting against degradation.
2. **Water Conservation:** By intercepting and absorbing water, contour planting reduces the need for irrigation, conserving water resources.
3. **Increased Crop Yields:** Preserving soil fertility and structure results in higher crop yields.
4. **Weather Adaptation:** The technique is adaptable to regions with heavy rainfall and changing weather patterns.
5. **Resource Efficiency:** Contour planting requires fewer inputs than traditional row planting.

Drawbacks:

1. **Labor-Intensive:** Contour planting can be more labor-intensive, requiring precise land preparation and potentially specialized equipment.
2. **Space Utilization:** It may not be as space-efficient as traditional row planting, as crops are not closely spaced.

Suitability of the Technology: Contour planting is suitable for a wide range of crops and sloping or hilly terrains. It is particularly effective in regions with heavy rainfall.

Impact on Smallholder Farmers and Women: Contour planting can enhance food security, increase income, and reduce risks related to soil erosion and water scarcity for smallholder farmers and women. However, it may present challenges if additional resources or skills are required.

Enabling Factors for Uptake:

- **Training and Extension Services:** Providing education and training is essential to promote contour planting.
- **Financial Support and Inputs:** Access to financial support and necessary inputs can facilitate adoption.
- **Supportive Policies and Regulations:** Favorable policies can encourage the uptake of this technology.

Challenges in Scaling Up:

- **Infrastructure:** Lack of infrastructure can hinder widespread adoption.
- **Access to Markets and Information:** Limited access to markets and information can impede scaling up.
- **Cultural Barriers:** Overcoming cultural barriers may be necessary in some regions.

Contour planting is a valuable sustainable agriculture technique that helps combat soil erosion, preserve soil fertility, conserve water, and increase crop yields. Addressing challenges and promoting enabling factors like education and incentives can facilitate its widespread adoption, realizing its potential for sustainable and productive agriculture in various landscapes.

5.24 Efficient Irrigation Techniques: Drip and Sprinkler Irrigation

Drip irrigation, pioneered by Israeli engineer Simcha Blass in the 1950s, and sprinkler irrigation, dating back to Charles Skinner's "Skinner System" in 1894, are modern irrigation methods used in Sri Lanka. Both techniques offer water-efficient, energy-efficient, and nutrient-efficient solutions for various crops, making them valuable "Water Smart," "Energy Smart," and "Nutrient Smart" technologies.

Basic Features of the Technology:

1. **Drip Irrigation:**
   - Precisely delivers water to plant roots through tubes or emitters.
   - Ideal for a range of crops, particularly suited for arid regions.
   - Can be coupled with fertigation for efficient fertilizer use.
2. **Sprinkler Irrigation:**
   - Distributes water over a wide area using sprinklers or spray nozzles.
   - Versatile and adaptable for different soil types, slopes, and tall crops.

Fig. 30 *Sprinkler (A) and Drip (B) irrigation systems*

Benefits:

1. **Water Efficiency:** Both techniques reduce water wastage through targeted delivery, crucial in water-scarce regions and during droughts.
2. **Increased Crop Yields:** Consistent and controlled water supply leads to healthier and more productive crops.
3. **Labor Savings:** Reduces manual labor required for irrigation, allowing farmers to focus on other tasks.
4. **Energy Efficiency:** Minimizes the energy required for pumping, benefiting both water and energy conservation.

Constraints:

1. **Upfront Costs:** The initial investment in equipment can be a barrier for smallholder farmers.
2. **Learning Curve:** Effective use of these systems may require training and adaptation.

Suitability of the Technology: Micro irrigation techniques can be adopted in various terrains, including undulating, hilly, and shallow soil areas, where traditional flooding methods are less effective.

Impact on Smallholder Farmers and Women: The adaptability rate among smallholder farmers varies based on factors such as financing, technical support, and education. While challenges exist, the benefits make these techniques appealing, potentially improving food security and income for smallholders, including women.

Enabling Factors for Uptake:

1. **Access to Financing:** Providing financial support can help overcome upfront costs.
2. **Training and Education:** Effective training programs are essential for farmers to utilize these systems optimally.
3. **Technical Support:** Availability of maintenance services and technical assistance aids adoption.

Challenges in Scaling Up:

1. **Local Adaptation:** Systems must be adapted to suit local conditions.
2. **Financing and Support:** Availability of financing and technical support is crucial for widespread adoption.
3. **Cultural Barriers:** Some farmers may be resistant to change or unfamiliar with these techniques.

Drip and sprinkler irrigation are efficient, sustainable, and adaptable technologies that enhance water, energy, and nutrient use efficiency in agriculture. While challenges exist, addressing these issues and promoting enabling factors can facilitate their adoption and contribute to more sustainable and productive farming practices in Sri Lanka and similar regions.

5.25 Groundwater Recharge through Percolation Pits: A Sustainable Water Solution

Groundwater recharge through percolation pits is a technology designed to replenish aquifers and enhance water availability for both agricultural and domestic purposes. It involves the construction of pits or trenches, filled with water, allowing it to slowly percolate into the soil and recharge groundwater. This method, developed in the 1970s, is particularly well-suited for areas with low annual rainfall and has found widespread adoption in regions with limited access to clean water.

Basic Features of the Technology:

- **Pit Construction:** Circular or rectangular pits, typically 1-2 meters deep, lined with permeable materials like gravel, facilitate water seepage into the soil.
- **Water Source:** Water is sourced from surface water bodies such as rivers or reservoirs.

Fig. 31 *Percolation pits (A) and Silt trap (B)*

Benefits:

1. **Increased Water Availability:** Recharging groundwater ensures a more consistent and available water supply, crucial for irrigation and domestic use.
2. **Agricultural Benefits:** Improved water availability can lead to increased crop yields and better soil health.
3. **Erosion Prevention:** Percolation pits help prevent soil erosion, contributing to long-term soil health and land productivity.

Constraints:

1. **Infrastructure Costs:** The initial cost of constructing and maintaining percolation pits may be prohibitive for smallholder farmers.
2. **Geological Suitability:** Effectiveness is influenced by local geology, and the method may not be suitable for all areas.

Suitability of the Technology: This technology is most suitable for regions with a high-water table, porous soils, and a dry or semi-arid climate. It is particularly beneficial in irrigated agriculture where increased water availability is critical.

Impact on Smallholder Farmers and Women: The adaptability rate depends on local conditions, funding, and community willingness. While offering numerous benefits, potential challenges and limitations must be considered.

Enabling Factors for Uptake:

1. **Suitable Geology:** Permeable soils and an adequate water table depth are necessary for practical pit construction.
2. **Water Source:** Reliable water sources, such as surface runoff or treated wastewater, are essential.

3. **Supportive Policies:** Financial incentives, technical assistance, and educational programs can promote the use of percolation pits.

Challenges in Scaling Up:

1. **Infrastructure Costs:** The upfront expense may limit widespread adoption.
2. **Environmental Concerns:** Proper construction and maintenance are essential to prevent groundwater contamination.
3. **Monitoring and Maintenance:** Ongoing upkeep and monitoring can be resource-intensive and require infrastructure development and expertise.

Groundwater recharge through percolation pits is a sustainable technology offering increased water availability for agriculture and domestic use. Its success depends on addressing challenges and leveraging enabling factors to ensure its widespread adoption and contribution to sustainable water management.

5.26 Rainwater Harvesting: A Sustainable Water Solution

Rainwater harvesting is a versatile technique that involves the collection and storage of rainwater for various purposes. It offers a solution to water scarcity and has gained prominence as an environmentally friendly and sustainable water management practice.

Basic Features:

1. **Collection:** Rainwater is meticulously collected from surfaces such as rooftops or other catchment areas.
2. **Storage:** The collected rainwater is stored in containers or underground reservoirs, safeguarding it for future use.
3. **Utilization:** The stored rainwater finds applications in various sectors, from agriculture to household needs, and even industrial processes.

Fig. 32 *Rainwater harvesting tank and ponds*

Benefits:

1. **Irrigation:** One of the paramount benefits is its role as a reliable source of irrigation water. Particularly in regions with limited access to conventional water sources, rainwater harvesting ensures that crops receive essential hydration.
2. **Reduced Demand:** Rainwater harvesting reduces the strain on municipal water supplies. By substituting harvested rainwater for potable water, it curtails costs and lessens energy-intensive water treatment processes.
3. **Flood Prevention:** During heavy rainfall, excess rainwater can be stored, mitigating the risk of flooding and preventing damage to crops and infrastructure.

Constraints:

1. **Initial Cost:** The initial setup of a rainwater harvesting system can be relatively expensive, potentially discouraging adoption, especially among small-scale farmers.
2. **Maintenance:** To ensure the system functions optimally, regular maintenance is essential. This ongoing upkeep can require additional financial resources and time.

Suitability: Rainwater harvesting is highly adaptable and suitable for a wide range of geographical areas, cropping patterns, and agro-ecosystems. Its versatility shines in regions with limited access to conventional water sources and areas with high water demand.

Impact on Smallholder Farmers and Women: The adaptability rate of rainwater harvesting varies based on the local context. Smallholder farmers stand to gain significantly from this practice due to their vulnerability to water shortages. Moreover, women, often responsible for household water management, can experience reduced workloads as reliable rainwater sources alleviate their water-related tasks.

Enabling Factors for Uptake:

1. **Financial Incentives:** Subsidies, grants, or tax incentives can play a pivotal role in encouraging adoption, offsetting the initial setup costs.
2. **Technical Assistance:** Training programs and expert support empower farmers with the knowledge and skills required to establish and maintain effective rainwater harvesting systems.

Challenges in Scaling Up:

1. **Lack of Infrastructure:** Inadequate infrastructure and limited technical expertise in certain areas can impede the widespread implementation of rainwater harvesting.
2. **Cultural Barriers:** Resistance to adopting new technologies may exist, particularly in regions where traditional irrigation practices have deep-rooted cultural significance.

Rainwater harvesting presents numerous advantages, including reliable irrigation and reduced demand for potable water. While challenges like initial costs and maintenance persist, the adaptability of this technique varies by context. With the right support mechanisms, including financial incentives and technical assistance, rainwater harvesting holds substantial potential, especially for smallholder farmers and women, as an eco-conscious and sustainable water solution.

5.27 The Cascade System: Nurturing Agriculture in Sri Lanka's Dry Zone

The Cascade system is a remarkable irrigation technology specifically designed for the arid regions of Sri Lanka. It addresses the challenge of providing water resources to agricultural fields in areas where water access is limited. This traditional system comprises a series of interconnected tanks, forming a cascade that efficiently manages water resources for farming.

Basic Features:

1. **Gravity-Driven Flow:** The core principle of the Cascade system is the use of gravity to transport water from higher-elevation reservoirs to lower-elevation fields. This eliminates the need for energy-intensive pumping.
2. **Interconnected Reservoirs:** The system is a network of reservoirs, canals, and channels. These interconnected components efficiently distribute stored water to irrigate crops.

Fig. 33 *A graphical illustration of the tank cascade system*

Alignment with Water-Smart CSA Technologies: The Cascade system exemplifies the principles of water-smart Climate-Smart Agriculture (CSA) technologies. Its primary focus is on enhancing water management practices in agriculture, making it a vital tool in combating water scarcity.

Benefits:

1. **Efficient Water Use:** A significant advantage of the Cascade system is its ability to maximize water utilization. By capturing and storing water at different elevations, the system optimizes the use of gravity for economical and efficient water distribution.
2. **Drought Resilience:** In regions with erratic rainfall patterns and water scarcity, the Cascade system acts as a buffer against droughts. It provides a reliable water source for crop irrigation even during prolonged dry spells.

Constraints:

1. **Cost:** The construction and maintenance of reservoirs and associated infrastructure can be financially burdensome for farmers, particularly those with limited resources.
2. **Environmental Impact:** The system's infrastructure may disrupt natural water flows, potentially harming local ecosystems and wildlife. Over-extraction of water from rivers and other sources can exacerbate environmental issues.

Suitability: The Cascade system is particularly suited for deployment in Sri Lanka's dry zones and other regions characterized by water scarcity. It thrives in cropping patterns requiring consistent water supplies, such as rice cultivation, and in agro-ecosystems with low rainfall and limited access to conventional irrigation infrastructure.

Impact on Smallholder Farmers and Women: The Cascade system has proven to be highly adaptable and beneficial for smallholder farmers, including women. It offers a reliable water source, boosting crop yields and reducing water wastage. Moreover, it empowers women by easing their water-related responsibilities within households.

Enabling Factors for Uptake:

1. **Financial Support:** Government initiatives like subsidies or financial incentives can encourage farmers to embrace the Cascade system. Investment in reservoirs and canals further supports its expansion.
2. **Technical Assistance:** Training programs equip farmers with the skills to effectively utilize the Cascade system and optimize their irrigation efforts.

Challenges in Scaling Up:

1. **Infrastructure Costs:** The substantial financial burden associated with infrastructure construction and maintenance can hinder widespread adoption.
2. **Environmental Concerns:** Building large reservoirs and canals may raise environmental alarms, necessitating careful planning and management.
3. **Water Distribution:** Ensuring equitable water distribution and addressing potential disputes among stakeholders pose social and political challenges.

The Cascade system offers substantial benefits, including enhanced agricultural productivity and improved water management, especially in Sri Lanka's arid regions. However, its scalability and sustainability require a thorough consideration of costs, benefits, and challenges. With the right support mechanisms, the Cascade system can be a pivotal tool in achieving sustainable and equitable water management for all stakeholders.

5.28 Agroforestry (agriculture-forest integration)

Agroforestry is a sustainable land management practice that blends the cultivation of trees and woody perennial plants with crops and livestock. It is a multifaceted approach that combines the strengths of both forestry and agriculture, offering numerous benefits to smallholder farmers, particularly in developing countries. This comprehensive system encompasses various techniques, including alley cropping, silvopasture, and forest farming.

Basic Features:

1. **Integration of Trees:** Agroforestry fundamentally involves the deliberate integration of trees and shrubs within the agricultural landscape.
2. **Diverse Plant Species:** Agroforestry promotes biodiversity by employing a diverse mix of plant species.
3. **Sound Management Practices:** Successful agroforestry relies on sound management practices to ensure the harmonious coexistence of trees, crops, and livestock.

Alignment with "Smart" CSA Technologies: Agroforestry stands as a "carbon-smart" practice by sequestering carbon dioxide during tree growth, contributing to climate change mitigation. It is "nutrient-smart" through its capacity to enhance soil fertility via organic matter addition. Furthermore, agroforestry qualifies as "water-smart" by improving soil water retention, reducing erosion, and minimizing irrigation demands. Lastly, it is "knowledge-smart" due to its multifaceted nature, requiring a deep understanding of ecological, economic, and social factors for success.

Fig. 34 *Paddy-based agroforestry system*

Main Focus: Agroforestry primarily aims to enhance agricultural sustainability and productivity. It provides an array of advantages, including improved soil quality and structure, enhanced water retention and infiltration, diversified crop stability, and augmented income and food security for farmers. However, it also faces constraints, such as initial investment requirements and potential competition for water and nutrients among trees and crops.

Benefits of Agroforestry:

1. **Soil Health and Erosion Control:** Trees and shrubs help reduce soil erosion, improve soil structure, and increase water retention, preventing sediment runoff into rivers.
2. **Ecosystem Services:** Agroforestry systems deliver ecosystem services like wildlife habitat, carbon sequestration, and pollination.
3. **Diversified Income:** By cultivating non-timber forest products such as nuts, fruits, and medicinal plants, agroforestry diversifies farm income.
4. **Resource Efficiency:** Perennial tree crops are cost-effective in terms of time, seeds, fertilizer, and land compared to annual crops.
5. **Non-timber Forest Products:** Agroforestry systems supply valuable non-timber forest products, contributing to increased output of tree products and associated crop yields.

Diversification and Pest Control: Diversification within agroforestry reduces the risk of pest infestations. Proper planning ensures optimal use of tree species' space and benefits, maximizing ecological and socio-economic advantages. Perennial tree crops offer economic and ecological benefits, including food, medicinal resources, and enhanced soil fertility.

Limitations:

1. **Complex Management:** Agroforestry systems can be more intricate to manage compared to traditional monoculture systems.
2. **Initial Costs:** Setting up agroforestry systems can be financially demanding, requiring investments in tree purchasing and planting.
3. **Productivity Variability:** Productivity may fluctuate depending on tree and crop species and local environmental conditions.

Suitability: Agroforestry finds applicability in various geographic areas and agro-ecosystems, including tropical and subtropical regions, drylands, and temperate zones. Its flexibility extends to diverse cropping patterns and seasons, adapting to the specific needs and resources of individual farmers.

Impact on Smallholder Farmers and Women: Agroforestry is highly adaptable and beneficial for smallholder farmers and women. It offers a dependable income source and enhances food security. Furthermore, it empowers women by alleviating their water-related responsibilities within households.

Enabling Factors for Uptake:

1. **Education and Training:** Providing education and training empowers farmers with the knowledge to understand and manage agroforestry effectively.
2. **Research and Development:** Continuous research and development lead to improved agroforestry technologies and practices, enhancing system efficiency and productivity.
3. **Government Support:** Government policies, including subsidies and land tenure reforms, can incentivize agroforestry adoption.

Challenges in Scaling Up:

1. **Market Access:** Limited market access for non-timber forest products can hinder income generation from these resources.
2. **Infrastructure Gaps:** Inadequate infrastructure, such as processing facilities and transportation networks, may hamper product distribution.
3. **Cultural Barriers:** Cultural and social resistance may impede agroforestry adoption, stemming from a lack of awareness of its benefits.

Agroforestry offers a wide range of environmental, economic, and social benefits. However, its adoption should be approached thoughtfully, considering its limitations and challenges, as well as the enabling factors that facilitate its uptake and expansion. With proper support mechanisms, agroforestry can serve as a pivotal tool for achieving sustainable and equitable land management, benefiting both farmers and the environment.

5.29 Agroforestry (crop-livestock integration)

Crop-livestock integration, a vital facet of agroforestry, presents an innovative approach to sustainable land management. This practice involves the simultaneous cultivation of crops and the rearing of livestock on the same piece of land, fostering synergistic interactions between these two essential components of agriculture. It was developed to address the pressing need for sustainable and efficient agricultural systems, particularly relevant in the context of global food security and environmental conservation.

Forms of Crop-Livestock Integration: Crop-livestock integration takes on various forms, each offering unique advantages:

1. **Intercropping:** In this approach, crops of different types are grown alongside one another in the same field. The interplay between crops and livestock can enhance productivity through nutrient cycling and mutual support.

2. **Alley Cropping:** Alley cropping involves planting rows of trees or shrubs alongside crops, creating alleys where livestock can graze. This configuration capitalizes on the spatial arrangement to maximize resource utilization.
3. **Silvopasture:** Silvopasture integrates trees, forage, and livestock within a single management unit. Trees provide shade, forage, and timber, while livestock contribute to nutrient cycling and soil enrichment.

Fig. 35 *Crop – livestock farming*

Alignment with "Smart" CSA Technologies: Crop-livestock integration aligns with several "smart" Climate-Smart Agriculture (CSA) categories:

1. **Carbon Smart:** Trees and shrubs in this system absorb and sequester carbon dioxide, acting as a potent tool for mitigating climate change.
2. **Water Smart:** The integrated approach can enhance water retention, reduce erosion, and improve water quality, making it a valuable asset in water management.
3. **Nutrient Smart:** Through nitrogen-fixing capabilities and organic matter incorporation, trees and shrubs improve soil fertility, potentially reducing reliance on synthetic fertilizers.
4. **Knowledge Smart:** Implementing crop-livestock integration necessitates a comprehensive understanding of ecological, economic, and social factors, making it a knowledge-intensive practice.

Main Focus: The primary goal of crop-livestock integration is to bolster agricultural sustainability by optimizing resource utilization. It offers an array of benefits that transcend traditional agricultural practices.

Benefits of Crop-Livestock Integration:

1. **Enhanced Crop Productivity:** Crop-livestock integration capitalizes on the synergy between livestock and crops. Livestock provide natural fertilizer in the form of manure, enriching the soil with essential nutrients and organic matter. This results in increased crop yields and improved soil fertility.

Evidence: Numerous studies have demonstrated significant yield increases in crop-livestock integrated systems compared to monoculture systems. For instance, maize yields in intercropping systems with cattle have been reported to be up to 30% higher in certain regions.

2. **Weed Control:** Livestock play a pivotal role in weed management by selectively grazing on unwanted plants, reducing the need for herbicides.
3. **Soil Health:** The presence of livestock leads to enhanced soil health by promoting aeration, organic matter accumulation, improved water retention, and nutrient cycling.

Evidence: Research conducted in agroforestry systems with livestock integration has shown notable improvements in soil health parameters, such as increased organic carbon content, improved soil structure, and increased microbial activity.

4. **Pest and Disease Control:** Livestock's capacity to consume pests and diseases contributes to a reduction in crop losses and the need for chemical pesticides.
5. **Erosion Reduction:** Trees and vegetation in crop-livestock integration systems act as physical barriers against wind and water erosion, stabilizing soil and protecting it from degradation.

Evidence: Studies in silvopasture systems have revealed a significant reduction in soil erosion rates compared to conventional grazing systems, mitigating soil loss and maintaining soil quality.

Limitations:

1. **Complex Management:** Managing the intricate interactions between crops and livestock to maximize benefits while minimizing risks can be challenging. Overgrazing or crop damage may occur if not properly managed.
2. **Labor-Intensive:** Implementing and maintaining crop-livestock integrated systems can demand substantial labor input and a high level of expertise, potentially limiting adoption.

Suitability: Crop-livestock integration exhibits a remarkable degree of adaptability, making it suitable for a wide range of geographic regions, cropping patterns, and climatic conditions. Its flexibility allows it to align seamlessly with the specific needs and resources of diverse environments and agro-ecosystems.

Impact on Smallholder Farmers and Women: Crop-livestock integration garners widespread acceptance among farmers and is particularly advantageous for smallholder farmers and women. It offers a reliable income source diversification, contributing to improved food security. Furthermore, by reducing the reliance on external inputs, such as costly fertilizers and pesticides, it benefits both the environment and farmers' economic stability.

Enabling Factors for Uptake:

1. **Education and Training:** To maximize the benefits of crop-livestock integration, farmers need comprehensive education and training to understand the intricate management practices required for this integrated approach.

2. **Financial Support:** As the initial investments in terms of land, infrastructure, and equipment can be substantial, access to credit or financing mechanisms is vital for farmers to establish and transition to crop-livestock integration.
3. **Government Support:** Government policies and support can incentivize adoption through subsidies, land tenure reforms, and other forms of assistance.

Challenges in Scaling Up:

1. **Market Access and Price Volatility:** Smallholder farmers, who often rely on local markets, may face limited opportunities to sell their products at fair prices. Additionally, global commodity price fluctuations can hinder long-term planning.
2. **Environmental and Social Impacts:** Issues such as land degradation, deforestation, and compatibility with other land uses (e.g., conservation and urban development) must be addressed to ensure sustainable practices.
3. **Management Complexities:** The need to manage the dynamic interactions between crops and livestock presents ongoing challenges.

Crop-livestock integration offers a multitude of benefits for farmers, communities, and the environment. To ensure its long-term success, it is imperative to consider enabling factors and address challenges in its adoption. With proper support mechanisms, crop-livestock integration can emerge as a pivotal tool for achieving sustainable and profitable agriculture, benefiting both farmers and the ecosystem.

5.30 Harnessing Nature's Boundaries: Boundary Trees and Hedgerows

Boundary trees and hedgerows represent a nature-based technology designed to establish a natural barrier at the margins of farmers' fields. This innovative approach offers a range of benefits, from safeguarding fields to supporting biodiversity and mitigating climate change. Initially introduced to demarcate property boundaries and separate fields, this technology has evolved to serve various purposes, including wildlife habitat creation, erosion reduction, and windbreak formation. The fundamental premise involves planting diverse species of trees and hedgerows along field edges, often trained to grow in specific shapes or patterns.

Alignment with "Smart" CSA Technologies: Boundary trees and hedgerows align with multiple "smart" Climate-Smart Agriculture (CSA) categories:

1. **Knowledge Smart:** Effective implementation requires a deep understanding of the local ecosystem and optimal planting and maintenance techniques for the trees and hedgerows.
2. **Carbon Smart:** These living barriers have the capacity to sequester carbon dioxide from the atmosphere, contributing to climate change mitigation.
3. **Water Smart:** Boundary trees and hedgerows regulate water flow, potentially reducing flooding risks and enhancing water management.

Main Focus: The primary objective of this technology is to establish a physical barrier that separates fields and minimizes the risk of crop damage or contamination from neighboring farms.

Fig. 36 *Boundary trees at the margins of farmers' fields*

Benefits of Boundary Trees and Hedgerows:

1. **Natural Field Protection:** Boundary trees and hedgerows offer a sustainable and eco-friendly means of safeguarding fields, unlike traditional barriers such as fences. These living plants provide protection from wind and offer shade to crops, contributing to crop health and reducing the risk of physical damage.
2. **Biodiversity Enhancement:** By creating diverse habitats for wildlife, including beneficial insects, boundary trees and hedgerows promotes biodiversity on farms. This diversity can aid in natural pest control and pollination, improving overall ecosystem health.

Evidence: Research has shown that the presence of hedgerows can significantly increase beneficial insect populations, leading to reduced pest pressures and higher crop yields.

3. **Soil Health Improvement:** Boundary trees and hedgerows can contribute to soil health by reducing erosion, improving water retention, and adding organic matter through leaf litter and root systems.

Evidence: Studies conducted in agroforestry systems with hedgerows have reported decreased soil erosion rates, indicating the potential for soil conservation and enhanced soil structure.

4. **Carbon Sequestration:** These plantings act as carbon sinks, absorbing and storing atmospheric carbon dioxide. This not only mitigates climate change but also contributes to enhanced soil fertility.

Evidence: Observations and studies have documented the carbon-sequestering capacity of trees and shrubs in agroforestry systems, indicating their role in climate change mitigation.

Limitations:

1. **Time for Establishment:** It can take several years for boundary trees and hedgerows to grow and become effective protective barriers, potentially leaving fields vulnerable during this establishment period.
2. **Initial Costs:** There may be initial expenses associated with planting and maintaining trees and hedgerows, which could present a barrier to adoption for some farmers.

Suitability: Boundary trees and hedgerows are versatile and adaptable, making them suitable for various geographical regions, cropping patterns, and climates. They are particularly well-suited to agro-ecosystems where natural barriers are essential to protect crops and soil.

Impact on Smallholder Farmers and Women: This technology is highly advantageous for smallholder farmers and women, who often face resource limitations. Boundary trees and hedgerows reduce the risk of crop damage and soil erosion, offering a sustainable means of protection. Moreover, they can provide additional income and food sources through the sale of products like fruits and nuts, thereby improving livelihoods.

Enabling Factors for Uptake:

1. **Financial Support:** Access to funding and resources can help farmers overcome the initial costs associated with planting and maintaining boundary trees and hedgerows.
2. **Education and Training:** Comprehensive education and outreach programs can equip farmers with the knowledge and skills needed to successfully implement this technology. Training should cover species selection and management techniques.
3. **Availability of Suitable Species:** Access to tree and hedgerow species adapted to local climates and soil conditions is essential for successful adoption.

Challenges in Scaling Up:

1. **Initial Investment:** The time and financial resources required for planting and establishment can be a significant hurdle for farmers considering this technology.
2. **Concerns about Crop Yields:** Farmers may have reservations about the potential impacts of boundary trees and hedgerows on crop yields and field access.
3. **Cultural and Traditional Barriers:** Addressing deeply ingrained cultural or traditional practices that conflict with the adoption of this technology may pose a challenge.

Boundary trees and hedgerows, as a nature-based technology, offer a multitude of benefits for farmers and the environment. Successful adoption hinges on addressing enabling factors and overcoming challenges. With adequate support mechanisms, these living barriers can play a pivotal role in protecting fields, promoting biodiversity, and contributing to sustainable and profitable farming.

5.31 Orchard Farming: Cultivating Nature's Bounty

Orchard farming, often referred to as fruit tree planting or fruit gardening, represents the deliberate cultivation of fruit-bearing trees and shrubs. This sustainable and environmentally friendly practice can be found in diverse regions worldwide, serving as an essential source of food production. Developed independently by various civilizations throughout history, orchard farming is now a common agricultural practice, integrated into both small-scale and large-scale operations.

Key Features: Orchard farming involves the meticulous selection and planting of fruit trees and shrubs, coupled with their ongoing care and maintenance. Tasks encompass critical activities like irrigation, pruning, fertilization, and pest control. The choice of fruit species is influenced by local climate, soil conditions, and farmer preferences.

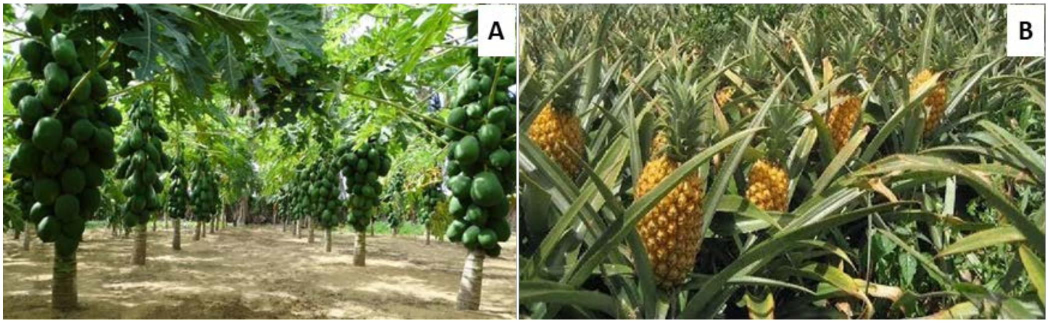


Fig. 37 *Papaya (A), and Pineapple (B) orchard*

Alignment with CSA Categories: Orchard farming harmonizes with multiple Climate-Smart Agriculture (CSA) categories:

1. **Knowledge Smart:** Successful orchard farming necessitates knowledge of fruit tree species, growth requirements, and maintenance practices for a productive harvest.
2. **Water Smart:** This practice efficiently employs irrigation systems to meet the water needs of fruit trees and ensure their growth and fruit production.
3. **Carbon Smart:** Fruit trees contribute to carbon sequestration by absorbing carbon dioxide from the atmosphere during growth, mitigating greenhouse gas emissions.

Main Focus: The central objective of orchard farming is the cultivation of a diverse array of fruits for local consumption and potential export. Additionally, this practice can yield environmental benefits, such as carbon sequestration through tree growth and providing habitat for wildlife.

Benefits of Orchard Farming:

1. **Fresh, High-Quality Fruit:** Orchards are renowned for producing fresh, high-quality fruit, meeting consumer demand for nutritious and flavorful options.

Evidence: Research has shown that orchard fruits often have superior taste and nutritional profiles compared to commercially grown alternatives.

2. **Source of Income:** Orchards can serve as a reliable source of income for farmers, offering financial stability and diversification of revenue streams.

Evidence: Economic studies have demonstrated the income-generating potential of well-managed orchards, particularly in areas with high market demand for fresh fruit.

3. **Habitat and Food for Wildlife:** Fruit trees and shrubs provide essential habitat and food for various wildlife species, contributing to biodiversity conservation.

Evidence: Observations of orchards have revealed increased wildlife activity, including birds and pollinators, which can aid in natural pest control and ecosystem health.

4. **Aesthetic Value:** Orchards hold aesthetic value, enhancing the visual appeal of landscapes while promoting eco-friendly agriculture.

Evidence: Orchards often serve as scenic attractions, offering a picturesque view and contributing to tourism opportunities.

Limitations:

1. **Planning and Management:** Orchards demand careful planning and ongoing management, including regular pruning, fertilization, and pest control.
2. **Initial Setup Costs:** The establishment of an orchard incurs upfront costs related to purchasing trees, equipment, and infrastructure, which may present a barrier to entry for some farmers.
3. **Yield Variability:** Orchards may experience fluctuating yields from year to year due to factors such as weather conditions and disease outbreaks.

Suitability: Orchard farming exhibits adaptability across various geographical regions, dependent on the specific fruit species cultivated and local climatic conditions. Different fruits, such as citrus varieties or temperate fruits like apples and pears, thrive in distinct climates and seasons. The agro-ecosystem, encompassing natural environments and agricultural practices, also influences the viability of orchard farming.

Impact on Smallholder Farmers and Women: Orchard farming offers significant advantages for smallholder farmers and women, particularly in resource-limited settings. These benefits include income generation, improved economic status, and empowerment of women involved in orchard care and management. Furthermore, orchards can enhance household food security and contribute to community well-being.

Enabling Factors for Uptake:

1. **Market Demand:** High consumer demand for fresh, locally-grown fruit incentivizes orchard farming, encouraging its adoption.
2. **Resource Availability:** Access to suitable land and water resources plays a pivotal role in successful orchard establishment.
3. **Supportive Market and Supply Chain:** The presence of a supportive market and efficient supply chain facilitates the sale and distribution of orchard fruits.
4. **Advances in Horticultural Techniques:** Technological advancements in horticulture assist farmers in efficiently growing fruit trees and managing orchards.

Challenges in Scaling Up:

1. **Initial Investment:** The significant upfront investment required for orchard establishment can hinder widespread adoption.
2. **Irrigation Consistency:** Orchards often necessitate consistent and reliable irrigation, which may be challenging in water-scarce regions.
3. **Pest and Disease Management:** The susceptibility of fruit trees to pests and diseases demands vigilance and expertise in pest control and management.

Orchard farming, celebrated for its abundance of fresh, high-quality fruit, represents a sustainable and profitable agricultural practice. While challenges exist, such as upfront costs and yield variability, orchards provide a means of income generation, biodiversity support, and empowerment for smallholder farmers and women. Orchards stand as a vital component of sustainable agriculture, contributing to food security and environmental conservation.

5.32 Planting Nitrogen-Fixing Plants: Nurturing Soil Health and Crop Prosperity

Planting nitrogen-fixing plants represents a sustainable and natural technique for enhancing soil fertility and crop yields. These remarkable plants possess the unique ability to convert atmospheric nitrogen into a plant-usable form through a process known as nitrogen fixation. This breakthrough, discovered in the early 20th century, has been instrumental in developing a method to improve soil fertility. Today, nitrogen-fixing plants are extensively employed in agriculture, particularly in regions with poor soil quality.

Key Features: The fundamental characteristics of this technology encompass its capacity to enrich soil fertility, fix atmospheric nitrogen, and promote the growth of other plants. These plants also contribute to carbon sequestration, offer habitat for wildlife, and foster beneficial organisms.

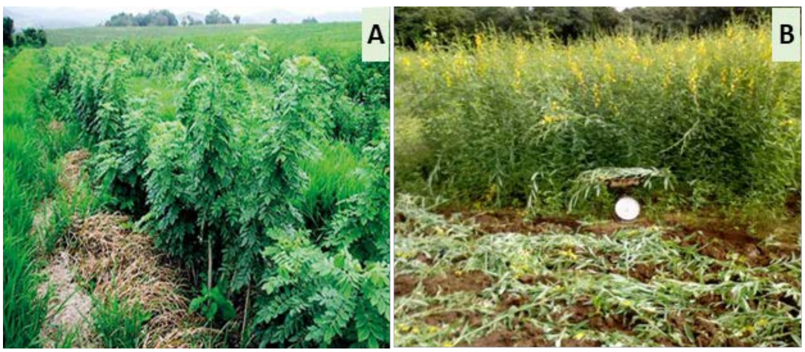


Fig. 38 *Gliricidia (A), and Sunhemp (B) cultivation*

Alignment with CSA Categories: Planting nitrogen-fixing plants falls under the "Nutrient Smart" category within Climate-Smart Agriculture (CSA). By enhancing soil nitrogen content, these plants reduce the reliance on synthetic fertilizers, thus making agriculture more sustainable. Additionally, their ability to sequester carbon and enhance soil health aligns with the "Carbon Smart" designation.

Role in Agroforestry: Nitrogen-fixing tree and plant species play a pivotal role in agroforestry systems. The symbiotic relationship between these plants and nitrogen-fixing bacteria in root nodules enhances soil fertility, contributing to sustainable agricultural practices.

Benefits of Planting Nitrogen-Fixing Plants:

1. **Enhanced Soil Fertility:** Nitrogen-fixing plants enrich the soil with essential nitrogen, alleviating one of the limiting factors for plant growth.

Evidence: Scientific studies have demonstrated substantial increases in crop yields when nitrogen-fixing plants are integrated into farming systems.

2. **Soil Health Improvement:** These plants have extensive root systems that improve soil structure, aeration, drainage, and water retention.

Evidence: Observations of soil properties in areas with nitrogen-fixing plant cover have revealed enhanced soil health and reduced erosion.

3. **Carbon Sequestration:** Nitrogen-fixing plants sequester carbon dioxide from the atmosphere during growth, mitigating greenhouse gas emissions.

Evidence: Studies have measured increased carbon sequestration in soils associated with nitrogen-fixing plant cultivation.

Drawbacks and Limitations:

1. **Slow Growth:** Nitrogen-fixing trees can have a slow growth rate, which delays their impact on soil nitrogen levels.
2. **Soil Suitability:** Not all soils are suitable for nitrogen-fixing plants, necessitating careful consideration of local soil conditions.
3. **Initial Establishment:** The time and effort required for planting and establishing these plants may discourage some farmers.

Suitability: The suitability of planting nitrogen-fixing plants spans a wide range of geographical regions, with adaptability to both tropical and temperate climates. The choice of specific plant species hinges on local climate and soil conditions. Furthermore, nitrogen-fixing plants can be integrated into diverse cropping patterns and agro-ecosystems, enhancing their adaptability.

Impact on Smallholder Farmers and Women: Planting nitrogen-fixing plants can have a significant impact on smallholder farmers and women. These plants improve soil fertility, leading to increased crop yields and, subsequently, higher income. Reduced dependency on expensive chemical fertilizers further alleviates financial burdens. The involvement of women in the cultivation and management of these plants can empower them and enhance their economic status.

Enabling Factors for Uptake:

1. **Appropriate Plant Species:** The availability of suitable nitrogen-fixing plant species that match local climate and soil conditions is crucial.
2. **Training and Support:** Farmers require training and support to effectively plant and manage nitrogen-fixing plants on their farms.

Challenges in Scaling Up:

1. **Identifying Suitable Species:** The challenge of identifying new nitrogen-fixing plant species adaptable to a variety of agro-ecological conditions requires dedicated research efforts.
2. **Farmer Capacity:** Overcoming farmers' limited capacity and potential reluctance to adopt unfamiliar practices is a significant challenge.

Planting nitrogen-fixing trees and plants on farmlands offers a promising solution for enhancing soil fertility and boosting crop yields while promoting sustainable agriculture. While challenges exist, including the need for suitable plant species and overcoming farmer reluctance, this practice has the potential to significantly improve soil health and increase agricultural productivity. Widespread adoption will require collaborative efforts to address these challenges and harness the full benefits of nitrogen-fixing plants.

5.33 Solar-Powered Water Pumping for Micro Irrigation: A Sustainable Solution for Agriculture

Solar-powered water pumping systems for micro irrigation represent an innovative and sustainable approach to agricultural irrigation. These systems harness solar energy through panels to power water pumps, offering energy efficiency and environmental friendliness as they replace fossil fuels. Developed as an eco-friendly alternative to energy-intensive and emission-contributing traditional irrigation methods, these systems find applications in diverse agricultural settings, from smallholder farms to urban gardens.

Key Features: The core features of solar-powered water pumping systems include their energy efficiency, reliance on renewable solar energy, and suitability for smallholder farmers. Shared usage of these systems can help reduce per-user costs, enhancing accessibility.

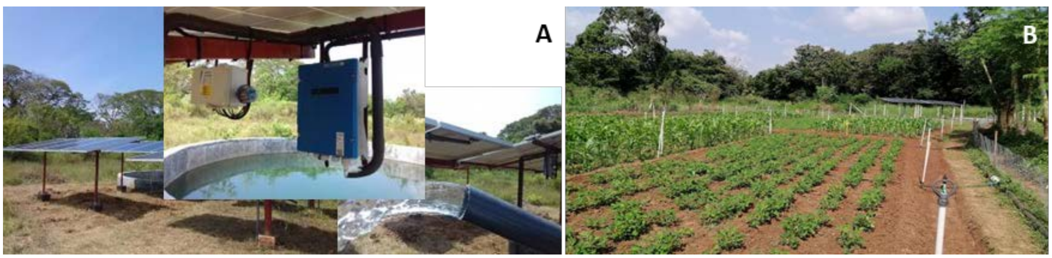


Fig. 39 *Solar-powered water pumping system (A) and solar-powered water pump irrigation (B)*

Alignment with CSA Categories: Solar-powered water pumping systems align with "Water Smart" and "Energy Smart" categories within Climate-Smart Agriculture (CSA). These systems efficiently deliver water to crops at the root zone, conserving water and energy simultaneously.

Benefits of Solar-Powered Water Pumping Systems:

1. **Energy Efficiency:** These systems reduce energy consumption by using solar power, mitigating the environmental impact of traditional fossil fuel-based irrigation.

Evidence: Studies have shown substantial energy savings and reduced greenhouse gas emissions associated with solar-powered irrigation.

2. **Water Conservation:** Precise and efficient irrigation delivered directly to the root zone of plants reduces water wastage and promotes water conservation.

Evidence: Solar-powered micro irrigation systems have demonstrated higher water use efficiency compared to conventional irrigation methods.

3. **Accessibility:** Easy installation and maintenance make these systems accessible to smallholder farmers and resource-constrained users.

Evidence: Adoption rates among smallholder farmers have increased due to the affordability and user-friendliness of solar-powered water pumping systems.

Drawbacks and Limitations:

1. **Sunlight Dependency:** Effective operation of these systems relies on adequate sunlight, making them less reliable in areas with limited sunshine.
2. **Capital Costs:** The upfront capital cost of purchasing and installing solar-powered water pumping systems may pose a barrier to smallholder farmers.

Suitability: Solar-powered water pumping systems are suitable for a wide range of geographical areas and agroecosystems, particularly those with ample sunshine. They can adapt to diverse cropping patterns and seasonal variations, offering flexibility in their applications.

Impact on Smallholder Farmers and Women: Solar-powered water pumping systems have garnered positive responses from smallholder farmers and women users. These systems significantly increase crop yields, improving livelihoods. However, the initial cost of acquiring and installing the technology may deter some potential users.

Enabling Factors for Uptake:

1. **Affordable Technology:** The availability of cost-effective and reliable solar-powered water pumping systems facilitates adoption.
2. **Supportive Policies:** Favorable policies and financing mechanisms can encourage the uptake of these systems.

Challenges in Scaling Up:

1. **Upfront Costs:** Overcoming the challenge of high initial investment costs is crucial for scaling up adoption.
2. **Sunshine Dependency:** In regions with limited sunlight, these systems may not operate effectively, necessitating alternative solutions.
3. **Access to Financing and Expertise:** Providing access to financing and technical expertise, especially for smallholder farmers and women, is essential for broader adoption.

Solar-powered water pumping systems for micro irrigation present a sustainable and eco-friendly solution for agricultural water management. While challenges exist, such as capital costs and sunlight dependency, the numerous benefits, including energy and water savings, make these systems a valuable addition to climate-smart agriculture. Widespread adoption will require concerted efforts to address challenges and promote the sustainable use of solar-powered irrigation technology.

5.34 Photovoltaic Lights: Illuminating Sustainable Agriculture

Photovoltaic lights, commonly known as solar-powered lights, are a revolutionary lighting technology that harnesses solar panels to convert sunlight into electricity. Developed in the mid-20th century, these lights have gained increasing popularity due to their eco-friendly nature and ability to provide reliable illumination without reliance on a power grid.

Fig. 40 Sri Lanka's first-ever solar power plant - Vavunathivu

Versatile Applications: Photovoltaic lights find diverse applications, including agro-farms, protected houses, storage houses, and processing houses. They offer a cost-effective and environmentally friendly alternative to conventional lighting methods in these settings.

Alignment with CSA Categories: Photovoltaic lights fall under the "Energy Smart" category within Climate-Smart Agriculture (CSA). These lights promote energy efficiency and reduce the carbon footprint of agricultural operations, contributing to overall sustainability.

Benefits of Photovoltaic Lights:

1. **Environmental Friendliness:** Photovoltaic lights produce no greenhouse gases or harmful emissions, making them an excellent choice for reducing the carbon footprint.

Evidence: Numerous studies highlight the environmental benefits of photovoltaic lights, showcasing their potential to reduce greenhouse gas emissions and reliance on fossil fuels.

2. **Low Maintenance:** These lights require minimal upkeep, as they do not consume fuel or other consumables. Solar panels have a long lifespan with proper care, making them suitable for agro-farms where constant monitoring may not be practical.

Evidence: Users have reported lower maintenance costs and effort compared to traditional lighting systems.

Drawbacks and Limitations:

1. **Sunlight Dependency:** Photovoltaic lights operate only when exposed to sunlight, potentially leading to insufficient lighting during evenings or cloudy days.
2. **Initial Capital Costs:** The upfront investment for purchasing and installing photovoltaic lighting systems can be high, particularly for larger buildings or farms.

Suitability: The suitability of photovoltaic lights is influenced by geographical factors such as sunlight availability. They perform optimally in regions with ample sunlight and may be less effective in areas with frequent cloudy conditions. Crop patterns and seasons also play a role, as these lights can extend the growing season and provide additional lighting during darker winter months. Agro-ecosystems benefit from reduced reliance on fossil fuels, leading to cost savings and lower energy consumption.

Impact on Smallholder Farmers and Women: Photovoltaic lights have a significant impact on smallholder farmers and women. They offer reliable lighting for daily tasks and enhance safety and security, particularly for women facing higher risks in poorly lit areas.

Enabling Factors for Uptake:

1. **Government Incentives:** Government incentives and funding programs can offset initial installation costs, making photovoltaic lights more accessible to agricultural businesses.
2. **Environmental Awareness:** Growing awareness of the environmental benefits of photovoltaic lights and the desire to reduce reliance on fossil fuels drive adoption.
3. **Technological Advancements:** The increasing availability and affordability of photovoltaic technology make these lights more accessible to a broader user base.

Challenges in Scaling Up:

1. **High Initial Costs:** The upfront installation cost remains a barrier for some businesses, requiring strategies to address financial constraints.
2. **Skilled Technicians:** The availability of skilled technicians for installation and maintenance can be a challenge, particularly in rural areas.
3. **Electricity Supply Reliability:** In regions with limited grid access, ensuring reliable and consistent electricity supply for photovoltaic lights can be challenging.

Photovoltaic lights offer a sustainable and eco-friendly lighting solution for agro-farms, protected houses, storage houses, and processing houses. While challenges exist, their numerous benefits, including reduced environmental impact and lower maintenance costs, position them as valuable assets in climate-smart agriculture. Efforts to address challenges and promote the widespread adoption of photovoltaic lighting technology are essential for realizing their full potential in agricultural settings.

5.35 Biogas Extraction: Energizing Sustainable Farming Systems

Biogas extraction is a transformative technology that empowers farmers to harness energy from organic waste materials found on their farms, including manure, crop residues, and food waste. Developed to address the agriculture sector's need for sustainable and renewable energy sources, it offers farmers the dual advantages of reduced dependence on fossil fuels and an additional income stream through biogas sales.

Fig. 41 *Biogas extraction: Energizing sustainable farming systems*

Key Components: This technology revolves around the utilization of anaerobic digestion tanks and biogas generators. Anaerobic digestion is the process by which organic waste materials are broken down, producing biogas—a blend of methane and carbon dioxide. These gases can then be captured and used for electricity generation, heating, or both. Biogas extraction systems typically consist of large tanks and generators, tailored to suit the farm's specific needs and available resources.

Alignment with CSA Categories: Biogas extraction technology can be classified as both "Energy Smart" and "Carbon Smart" within the Climate-Smart Agriculture (CSA) framework. It promotes energy efficiency and reduces reliance on fossil fuels while simultaneously mitigating greenhouse gas emissions, particularly methane.

Primary Focus: The central aim of biogas extraction technology is to capture and harness methane gas generated through the anaerobic digestion of organic matter, such as livestock manure and crop residues. This methane is then utilized to produce electricity or heat, thus diminishing the farm's reliance on conventional energy sources.

Benefits of Biogas Extraction:

1. **Environmental Sustainability:** Biogas production significantly reduces greenhouse gas emissions, mitigating environmental impacts. It also enhances manure management efficiency, contributing to sustainable agricultural practices.

Evidence: Numerous studies highlight the environmental benefits of biogas extraction, showcasing reduced greenhouse gas emissions and improved waste management.

2. **Waste Reduction:** Biogas technology minimizes waste and enhances overall farming efficiency by converting organic waste into valuable energy.

Evidence: Farmers using biogas extraction technology report notable reductions in organic waste and increased farm efficiency.

Challenges and Limitations:

1. **High Initial Costs:** Setting up and maintaining a biogas system can be expensive, potentially deterring some farmers from adoption.
2. **Variable Gas Production:** Biogas production can be influenced by factors like the quality and quantity of organic matter, ambient temperature, and the presence of competing microorganisms, making consistent production a challenge.

Suitability: The suitability of biogas technology depends on the availability of organic matter. Regions with substantial organic waste materials, such as those heavily reliant on livestock production, are ideal candidates. The technology is also well-suited for areas with high volumes of food waste or agricultural by-products. Cropping patterns influence suitability, with regions emphasizing livestock or organic waste being strong contenders.

Impact on Smallholder Farmers and Women: Biogas extraction has a substantial impact on smallholder farmers and women. It offers an affordable and sustainable energy source, reducing poverty and enhancing overall quality of life.

Enabling Factors for Uptake:

1. **Government Incentives:** Financial incentives and grants from governments can offset the initial cost of implementing biogas systems, making them more accessible to farmers.
2. **Technical Expertise:** Access to technical training and expertise is crucial for farmers to effectively operate and maintain biogas systems, maximizing their benefits.

Challenges in Scaling Up:

1. **Infrastructure Requirements:** Biogas systems necessitate specialized equipment and facilities, which can be costly to install and maintain.
2. **Regulatory Barriers:** Regulatory hurdles and permitting issues can pose challenges to setting up biogas systems on farms.

Biogas extraction technology offers a sustainable and eco-friendly energy solution for farming systems. Despite challenges related to costs and infrastructure, its numerous benefits, including reduced environmental impact and increased energy efficiency, make it a valuable addition to climate-smart agriculture. Efforts to overcome challenges and promote the widespread adoption of biogas technology are essential to realizing its full potential in agricultural settings.

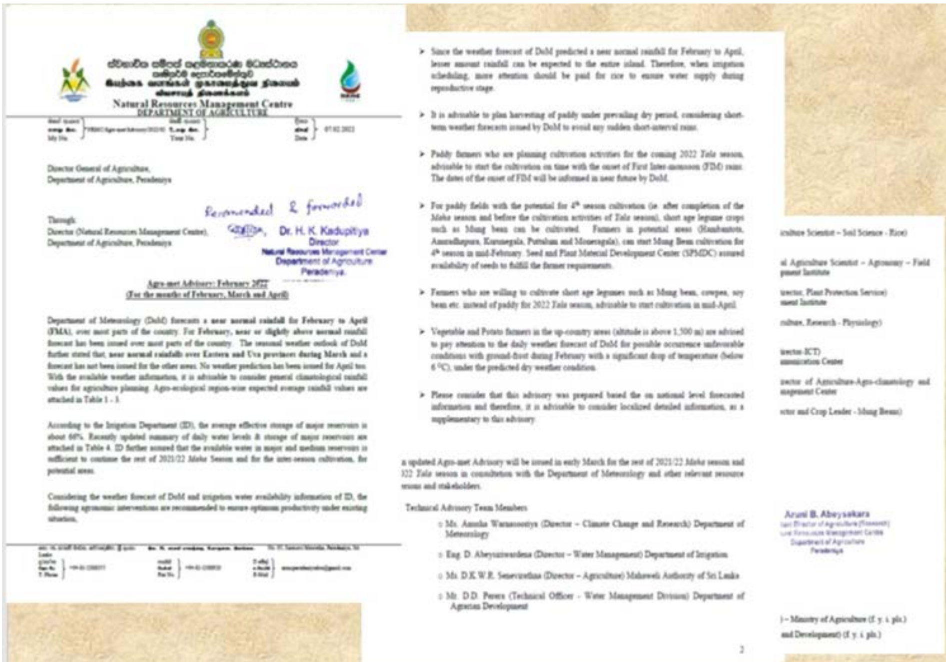
5.36 Agro-Met Advisory & Alerts: Navigating Climate Challenges in Agriculture

Agro-Met Advisory & Alerts technology is a crucial tool in modern agriculture, designed to assist farmers in making well-informed decisions related to their farming activities. Developed to address the increasing need for sustainable and climate-resilient agriculture, this technology provides farmers with valuable insights into weather forecasts and climate-related data. It empowers them to mitigate risks associated with extreme weather events and optimize their agricultural practices. Here, we will delve deeper into the various aspects of this technology.

Alignment with CSA Categories: Agro-Met Advisory & Alerts technology aligns closely with several key Climate-Smart Agriculture (CSA) categories:

1. **Weather Smart:** At its core, this technology harnesses advanced weather forecasting and data analysis to provide farmers with critical information regarding weather patterns. This empowers them to make timely decisions about planting, cultivation, and harvest, ultimately improving crop yields and reducing the vulnerability of their crops to adverse weather conditions.
2. **Water Smart:** By offering insights into precipitation and soil moisture levels, Agro-Met Advisory & Alerts aids farmers in optimizing their irrigation schedules. This contributes to efficient water use, reduces water stress on crops, and conserves this valuable resource.

3. **Carbon Smart:** Although not its primary focus, this technology indirectly contributes to carbon-smart agriculture by enhancing farm efficiency. By helping farmers avoid crop failures due to extreme weather events, it reduces the need for replanting and associated emissions from agricultural machinery and transportation.



Natural Resources Management Centre
DEPARTMENT OF AGRICULTURE

Director General of Agriculture,
Department of Agriculture, Peradeniya

Through
Director (Natural Resources Management Centre),
Department of Agriculture, Peradeniya

Recommended & forwarded
Dr. H. K. Kadupitiya
Director
Natural Resources Management Center
Department of Agriculture
Peradeniya.

Agro-met Advisory: February 2022
(For the months of February, March and April)

Department of Meteorology (DoM) forecasts a near normal rainfall for February to April (FMA), over most parts of the country. For February, near or slightly above normal rainfall forecast has been issued over most parts of the country. The seasonal weather outlook of DoM further stated that, near normal rainfalls over Eastern and Uva provinces during March and a forecast has not been issued for the other areas. No weather prediction has been issued for April too. With the available weather information, it is advisable to consider general climatological rainfall values for agriculture planning. Agro-ecological region-wise expected average rainfall values are attached in Table 1 - 3.

According to the Irrigation Department (ID), the average effective storage of major reservoirs is about 60%. Recently updated summary of daily water levels & storage of major reservoirs are attached in Table 4. ID further assured that the available water in major and medium reservoirs is sufficient to continue the rest of 2021/22 *Maha* Season and for the inter-season cultivation, for potential areas.

Considering the weather forecast of DoM and irrigation water availability information of ID, the following agronomic interventions are recommended to ensure optimum productivity under existing situation.

- Since the weather forecast of DoM predicted a near normal rainfall for February to April, lesser amount rainfall can be expected to the entire island. Therefore, when irrigation scheduling, more attention should be paid for rice to ensure water supply during reproductive stage.
- It is advisable to plan harvesting of paddy under prevailing dry period, considering short-term weather forecasts issued by DoM to avoid any sudden short-interval rains.
- Paddy farmers who are planning cultivation activities for the coming 2022 *Yala* season, advisable to start the cultivation on time with the onset of First Inter-monsoon (FIM) rains. The dates of the onset of FIM will be informed in near future by DoM.
- For paddy fields with the potential for 4th season cultivation (i.e. after completion of the *Maha* season and before the cultivation activities of *Yala* season), short age legume crops such as Mung bean can be cultivated. Farmers in potential areas (Hambantota, Anuradhapura, Kurunegala, Puttalam and Monaragala), can start Mung Bean cultivation for 4th season in mid-February. Seed and Plant Material Development Center (SPMDC) assured availability of seeds to fulfill the farmer requirements.
- Farmers who are willing to cultivate short age legumes such as Mung bean, cowpea, soy bean etc. instead of paddy for 2022 *Yala* season, advisable to start cultivation in mid-April.
- Vegetable and Potato farmers in the up-country areas (altitude is above 1,500 m) are advised to pay attention to the daily weather forecast of DoM for possible occurrence unfavorable conditions with ground-frost during February with a significant drop of temperature (below 6 °C), under the predicted dry weather condition.
- Please consider that this advisory was prepared based the on national level forecasted information and therefore, it is advisable to consider localized detailed information, as a supplementary to this advisory.

...n updated Agro-met Advisory will be issued in early March for the rest of 2021/22 *Maha* season and ...022 *Yala* season in consultation with the Department of Meteorology and other relevant resource ...sons and stakeholders.

Technical Advisory Team Members

- Ms. Anusha Warnasooriya (Director – Climate Change and Research) Department of Meteorology
- Eng. D. Abeysiriwardena (Director – Water Management) Department of Irrigation
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Aruni B. Abeysekara

Fig. 42 Pictorial presentation of Agro-met advisories of the Department of Agriculture

Key Benefits:

1. **Risk Mitigation:** Agro-Met Advisory & Alerts serve as an invaluable tool for farmers to anticipate and mitigate risks associated with extreme weather events. By providing early warnings about potential droughts, floods, or heatwaves, it enables farmers to implement preventive measures. This significantly reduces crop losses and safeguards their livelihoods.

Evidence: Numerous case studies and reports have documented a noticeable reduction in crop failure rates among farmers who have adopted Agro-Met Advisory & Alerts.

2. **Water Efficiency:** Water scarcity is a growing concern in agriculture. This technology offers critical information on precipitation and soil moisture levels, enabling farmers to make data-driven decisions about irrigation. By optimizing irrigation practices, it not only conserves water but also reduces water and energy costs.

Evidence: Feedback from farmers highlights substantial water and energy savings and reduced crop damage, thanks to informed irrigation practices.

Challenges and Limitations:

1. **Accuracy:** While Agro-Met Advisory & Alerts provides valuable insights, the accuracy of climate forecasts can vary. Farmers may occasionally make decisions based on incomplete or incorrect information, potentially impacting their crops and yields.
2. **Cost:** Accessing and utilizing climate forecasting services can be costly. This financial barrier may limit adoption, particularly among small-scale or financially constrained farmers.

Suitability Factors:

1. **Geographical Area:** This technology is most suitable for regions characterized by diverse microclimates and cropping patterns. It equips farmers to adapt effectively to varying weather conditions, optimizing their farming practices accordingly.
2. **Cropping Patterns and Seasons:** Agro-Met Advisory & Alerts shines in regions with well-defined rainy and dry seasons. It helps farmers make informed decisions about planting and harvesting, aligning their actions with expected weather patterns.
3. **Agro-Ecosystem:** It is particularly well-suited for agro-ecosystems sensitive to weather variations, such as those dependent on irrigation or prone to drought. Farmers in such systems can benefit significantly from climate forecasting insights.

Impact on Smallholder Farmers and Women: The impact of Agro-Met Advisory & Alerts on smallholder farmers and women is profound. It equips them with valuable information that enhances crop yields, profitability, and overall farm management. Furthermore, it contributes to safety and security by helping farmers proactively address weather-related risks, which is especially vital for women who may face heightened vulnerability in poorly lit or exposed areas.

Enabling Factors for Uptake:

1. **Government Support:** Financial incentives, grants, and subsidies provided by governments play a pivotal role in overcoming cost-related barriers. They make the adoption of Agro-Met Advisory & Alerts more accessible for farmers with limited resources.
2. **Technical Training:** Access to technical training and expertise is critical for farmers to harness the full potential of this technology. Understanding how to interpret and utilize climate forecasts effectively is essential for successful implementation.

Challenges in Scaling Up:

1. **Accessibility:** Achieving widespread access and ease of use for Agro-Met Advisory & Alerts systems necessitates investments in infrastructure and comprehensive training programs. These initiatives ensure that farmers have the necessary skills and resources to maximize the benefits of this technology.

2. **Trust Building:** Establishing credibility and trust in these systems is paramount. Some farmers may initially doubt the accuracy and reliability of climate forecasts. Demonstrating the technology's accuracy and reliability through case studies and success stories is essential for building trust among potential users.

Agro-Met Advisory & Alerts technology serves as a cornerstone of climate-smart agriculture. It empowers farmers with essential weather-related information, enabling them to make informed decisions and adapt to changing conditions. While challenges related to accuracy and accessibility exist, the numerous benefits, including risk reduction and resource conservation, make it an invaluable tool in ensuring food security and sustainable agriculture. Overcoming these challenges and building trust in the technology are critical steps towards its widespread adoption and effectiveness in agricultural practices.

6. Conclusions and Recommendations

Judicial land management planning is essential for strengthening the protection of environmental assets for sustainable development, targeting the eradication of extreme poverty and shared prosperity. The development of pilot-level landscape management plans to achieve enhanced biodiversity protection and improve the livelihoods of communities living adjacent to protected areas is one of the main aims of the Ecosystem Conservation and Management Project (ESCAMP). Institutional capacity development of implementing agencies, including the Forest Department and the Department of Wildlife Conservation, has been identified as a priority area. This study targets the evaluation of the baseline status of land management to identify the present situation, examine the impacts on conservation and management of protected areas in the project landscape, and identify opportunities for improved land management systems. During this study, all the main aspects have been evaluated through spatial investigations with presently available and accessible information. Based on the study, the observations and recommendations considered most important for effective land management planning are stated below.

- ✓ The pilot study landscape is hydrologically divided by major river basins, as well as sub-watershed and cascade systems. Therefore, it is important to integrate watershed-based management concepts into land management plans.
- ✓ More than 60% of the landscape consists of natural land systems, which are less exposed to direct human-induced destruction. These include forests, natural cover types, water bodies, wetlands, and rocky areas. Most of the lands belonging to this category are found spread over the country, and a considerable proportion of land is found scattered as patches mixed with other land cover types. It is important to have key information about all land parcels for better management. Therefore, it is better to develop a spatial information system for all natural land classes within the project landscape. The first version of the information system can be structured using all readily available ecosystem-related spatial information, such as land parcel matrix, coding system/area names, general cover details or forest/vegetation type, status of protection, governing agency/range/division, etc. Secondly, the information system can be further improved with fauna/flora biodiversity, important species (endemic/threatened/etc.), degraded or healthiness indexes, etc.

- ✓ Protected areas of the study landscape should include forest reserves, grasslands, wetlands/mangroves, wildlife reserves/corridors, coastal ecosystems, and areas with archaeological/culturally important places. Some of these areas and places are found outside the already declared and proposed protected areas. These important areas need to be properly demarcated and declared under relevant laws and legislation.
- ✓ Population density in areas bordering natural ecosystems and protected areas needs to be considered as priority areas during the formulation of the conservation plan. These areas can be identified by setting a buffering distance from forest boundaries and defining threatening land uses. The population pressure on forested lands and dependency on forest resources can be minimized by promoting village-level non-forest income generation programs, strengthening legal coverage, promoting the formulation of nature protection societies, conducting education and knowledge generation programs on ecosystem services, and other parallel programs to minimize forest dependency in villages.
- ✓ Agricultural lands found in the study landscape cover 27% of the pilot landscape. Most of the agricultural lands are paddy lands (20%) that come under major and minor irrigation systems and tank cascade systems. The paddy lands associated with forestlands and crop damage due to wildlife, especially due to elephants, is a common issue and conflict. Strengthening anti-elephant fences in strategic places may be needed to ensure threat-free human life and increase the livelihood of villages by preventing crop damage as well as protecting elephants from damages due to villagers' protective measures.
- ✓ Agricultural lands other than paddy cover only 7% of the study landscape, and they are scattered as smaller patches. Part of these lands is already under perennials and plantation crops (sugarcane, mango, cashew, coconut, etc.). Out of these lands, 5% are sparsely used chena-lands, and there is a need to investigate the potential of converting these lands into perennial or forest plantations through relevant governing agricultural agencies.
- ✓ Hundreds of small and medium-scale tanks, reservoirs, and cascade systems are found in the study landscape, and among them, 28 tanks have been recorded as abandoned in LUPPD's recently updated maps. Many of the tanks and cascade systems can be found within and adjacent to forest lands, and some of them have been recorded as abandoned. The rehabilitation of those abandoned forest tanks is beneficial for the sustainable existence of forest ecosystems and wildlife, especially during dry seasons. Rehabilitation of tanks may reduce the movements of wild animals out of the forestlands, as well as increase the potential of agriculture, which increases village income and livelihood.
- ✓ Infrastructure features can be seen crossing forest ecosystems. Proper land management plans should have enough space for wildlife corridors properly aligned with present natural paths and ecosystems.

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