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MINISTRY OF IRRIGATION
MINISTRY OF AGRICULTURE

NATIONAL GUIDELINES FOR CLIMATE SMART AGRICULTURAL TECHNOLOGIES AND PRACTICES

FOR THE DRY AND INTERMEDIATE ZONES OF SRI LANKA

Ministry of Irrigation & Ministry of Agriculture

2021

NATIONAL GUIDELINES FOR CLIMATE SMART AGRICULTURAL TECHNOLOGIES AND PRACTICES

FOR THE DRY AND INTERMEDIATE ZONES OF SRI LANKA

Compiled by:
Mr. Shantha Siri Emitiyagoda
Dr. S.H.S. Ajantha de Silva
Dr. B.V.R. Punyawardana
Dr. W.M.W. Weerakoon

Ministry of Irrigation & Ministry of Agriculture

2021

CRIWMP

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குளங்கள் கிராமங்களின் மறுமலர்ச்சி

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FOREWORD

The extreme climate aberrations, such as long spells of drought and high intensities of rainfall, result in higher temperature occurrences and floods in Sri Lanka. The resultant negative impacts on Sri Lanka's Dry and Intermediate zone cultivations, and thereby on the respective communities, prompted the Ministry of Agriculture to seek expert views on switching to agriculture practices that can withstand drastic climate uncertainties. Developing guidelines to help the respective stakeholders in Sri Lanka's Dry and Intermediate zones in the implementation of these Climate Smart Agriculture practices, thus became a vital need.

The Ministry of Agriculture highly appreciates the assistance provided by the United Nations Development Programme, Sri Lanka, through the Green Climate Fund (GCF) to develop the *National Guidelines for Climate Smart Agricultural Technologies and Practices for Sri Lanka's Dry and Intermediate Zones*.

The Expert Group and the Technical Advisory Committee appointed for this task worked with the respective regional government staff, farmer organisations and other members in the communities, to produce this set of guidelines and the training manual.

The publication, on all aspects of CSA technologies and practices, and its *Training Manual for the Agricultural Extension Staff* to be used in awareness programmes for the farming communities, are the outcomes of the collective effort of these teams' hard work. This summary has been produced in order to make the National Guidelines more comprehensible and workable at field levels.

I am hopeful that the planned training programmes and activities would help enhance not only the total ecosystems of Sri Lanka's Dry and Intermediate zones, but also the livelihoods of farming communities and working environments of other respective service providers in these areas.

Prof. Udith K. Jayasinghe
Secretary
Ministry of Agriculture

FOREWORD

Man adapting to an agricultural way of life is a significant milestone in the evolution of human civilization. Overtime, they identified the different climate and weather patterns and adapted their agricultural practices-accordingly. They were adapting to the climate conditions and became successful through a coping meshanism. However, the modern human civilization had to face the challenges of climate changes that affected their entire life patterns. It becomes obvious that this mechanism was not adequate to adjust to the extreme weather conditions that resulted from climate changes.

The intensity and frequent incidence of the climate change which had .. taken a long time to recover was another challenge. It is extremely difficult to control and challenge the geographical factors that affect the climate change. Under these circumstances there is no other alternative except adjusting for the climate changes. Hence, it becomes essential to use climate smart recovery practices. Even though the Climate Resilient Agriculture that was introduced to the agricultural sector enbanced the production and the resilience capacities, the issue of greenhouse gas emission has not been addressed.

The win-win mitigation methods also helped to increase the production capacity and greenhouse emissions, but, doesn't seem have paid attention to adaptation. In this background, there emerge the timely need for a Climate Smart Agriculture that could address simultaneously the need for the enhancement of production and resilient capacities minimizing the greenhouse gas emissions as well. This is not really strange concept as is a methodology aligning the conventional wisdom and the experience the man had accumulated until today in a more appropriate manner. It is not an individual or a negotiating process or a product. This is an approach to identify the resilience systems that existed traditionally within the community to empower and plan by aligning with the modern socio-economic systems. Climate Smart Agriculture is a more practical solution for the ch?llenges faced by agriculture sector due to climate change.

The national climate smart agriculture guidelines and the training aid has been designed by the Natural Resources Management Centre of the Ministry of Agriculture and Department of Agriculture. This has been designed through a consultative process involving stakeholders at national and local levels. This guideline has been developed under the supervision of a specially established scientific and advisory committee, with a view to understand in identifying the climate changes in our country and how they impact the agriculture sector, and how the agriculture sector should be planned accordingly. This process also provides a correct direction for the planning process in agricultur sector.

In addition, the training aid developed along with the National guidelines has been recommended by the Ministry of Agriculture for the use of relevant projects. This has also been recommended to use as a planning tool for the regional agricultural institutions as well. The Climate Smart Agriculture National Guideline and the Training Manual will be a nationally important approach and a tool.

Anura Dissanayake
Secretary
Ministry of Irrigation

MESSAGE FROM THE DIRECTOR GENERAL OF AGRICULTURE

Sri Lanka - a climate sensitive country in Asia - has prioritised the identification of possible climate related disasters and the development of plans to implement in order to mitigate the resulting negative impacts on agriculture, ecosystems, and Sri Lankans' general social and economic wellbeing.

The negative impacts of climate uncertainties on agriculture is most observed in the Dry and Intermediate zones of Sri Lanka. Therefore, the Ministry of Agriculture identified three key river basins in Sri Lanka's Dry and Intermediate zones, namely, Malwathu Oya, Mi Oya and Yan Oya for detailed studies. These river basins were chosen mainly due to their high dependency on climatic factors for farming and thereby on the respective communities. The aim is to remodel the infrastructure of these settings incorporating the views and suggestions of all parties such as experts, government officials, service providers and farming communities.

The expert group, entrusted to develop guidelines for Climate Smart Agriculture, in consultation with a 26-member Technical Advisory Committee, carried out extensive studies on the inherent features of these river basins and the relevant farming systems that have evolved over centuries. Based on its observations, the team compiled the National Guidelines and a Training Manual for Climate Smart Agriculture to be used, as appropriate, for diverse groups of stakeholders involved with Climate Smart Agriculture practices.

I take this opportunity to extend my sincere appreciation to the United Nations Development Programme in Sri Lanka and the Green Climate Fund (GCF/UNDP/CRIWMP) for the financial and technical support extended to initiate this worthwhile project in Sri Lanka.

Dr W M W Weerakoon
Director General
Department of Agriculture

MESSAGE FROM UNDP

2020 is a momentous milestone, as we enter what is called the 'Decade of Action'. Sri Lanka is making considerable strides to achieve the Sustainable Development Goals (SDGs) by 2030. Nevertheless, the challenges posed by the effects of climate change toughens this endeavour, particularly on the goals related to sustainable agriculture and food security due to the long term and gradual changes occurring in the global climate. According to global climate risk indices, Sri Lanka is highly vulnerable to climate change induced extreme weather events and climate variability.

Given that agriculture is one of the most significant sectors in Sri Lanka, with nearly 1.6 million smallholder farmers reliant on it for their livelihoods, the national need is to mainstream climate change adaptation in the development process. In this context, the introduction of the concept of Climate Smart Agriculture (CSA) is regarded as an approach to transform the country's agricultural systems to effectively support farmers and their livelihoods and to ensure food security, while reducing greenhouse gas emissions.

I am confident the guidelines developed will support the relevant authorities to make informed decisions on working towards being climate smart in agricultural interventions and to strengthen the resilience of the farmers in Dry and Intermediate zones to climate variability and extreme events.
I thank the Government of Sri Lanka for collaborating with the UNDP on this through the Climate Resilient Integrated Water Management Project funded by the Green Climate Fund. With over 50 years of experience in serving as key development partner, UNDP is pleased to be a part of building the resilience of smallholder farmers.

Robert Juhkam
Resident Representative
United Nations Development Programme, Sri Lanka

MESSAGE FROM THE PROJECT DIRECTOR

Climate Resilient Integrated Water Management Project (CRIWMP) locally known as "Wevu Gam Pubuduwa", was launched in 2017 covering seven districts in the Dry zone in Sri Lanka. The project aims to strengthen the resilience of vulnerable smallholder farmers particularly women, who are facing increased risks of rising temperatures, erratic rainfall patterns and other extreme events relevant to climate change.

Amongst numerous activities, which improve the resilience of climatic vulnerable farmers, measures to enhance the agriculture-based livelihoods of smallholder farmers have taken a very significant place. Therefore, in order to give a holistic and persuasive solution for the smallholder farmers in the Dry and Intermediate zones, the Climate Smart Agriculture (CSA) concept and approach were adapted. CSA approach was highly recognised for its strength in improving climate resilience, productivity, food security while reducing the emission of greenhouse gases.

The Ministry of Agriculture has recognised the need of a common framework for implementing CSA in Sri Lanka. As the Project Director of CRIWMP, I am privileged to have offered the project support to develop the national guidelines for streamlining CSA in Sri Lanka. I am confident that these guidelines would be of immense use for the national and provincial level agricultural agencies, as well as for existing and future agriculture development projects in Sri Lanka. I take this opportunity to extend my sincere appreciation to all government agencies that contributed to develop these important guidelines, which will be adopted in the Dry and Intermediate zones of Sri Lanka from year 2020 onwards.

Eng. Chandana Edirisooriya
Project Director
Climate Resilient Integrated Water Management Project

ACKNOWLEDGEMENTS

The National Guidelines for Climate Smart Agricultural Technologies and Practices for the Dry and Intermediate zones of Sri Lanka Training Manual and summary for Climate Smart Agriculture are the outcome of an extensive study undertaken by a team of experts nominated by the Ministry of Agriculture under the United Nations Development Programme in Sri Lanka. The study was financially sponsored by the Green Climate Fund.

The key objective of this project is to train the farming communities and the relevant service providers in the implementation of the recommended Climate Smart Agriculture interventions. The interventions are meant to upgrade livelihoods of the farming communities and also to maximise the work efficiency of relevant service providers in the given areas.

With the confidence gained through the initial stage of the project, I am positive that the planned activities would help fulfill the desired goal of achieving Sri Lanka's Climate Smart Agriculture.

I am thankful to the Provincial Agricultural Directors and staff members working in the three river basins for their valuable contribution towards this study. I also greatly appreciate not only the expertise provided by the Expert Group, but also its members' challenging work aimed at collecting the insights on existing agriculture systems in the project areas. I am also grateful to the members of the National Technical Advisory Committee for their valuable inputs, and support provided to complete this working document successfully. My gratitude also goes to the officials of respective government institutions and Civil Society Organisations for the information shared and the positive suggestions made to meet the expected targets of the project. I am, to conclude, extremely grateful to the GCF/ UNDP/ CRIWMP staff for the technical and financial support extended to complete this task.

Shantha Siri Emitiyagoda
National Consultant, Climate Smart Agriculture
Climate Resilient Integrated Water Management Project

NATIONAL TECHNICAL ADVISORY COMMITTEE

NATIONAL TECHNICAL ADVISORY COMMITTEE AND EXPERT GROUP

Mr K D S Ruwanchandra - Secretary, Ministry of Mahaweli, Agriculture, Irrigation and Rural Development

Dr Ms P W Alahakoon - Additional Secretary, Ministry of Mahaweli, Agriculture, Irrigation and Rural Development

Dr S H S A de Silva - Additional Secretary (Technology), Ministry of Mahaweli, Agriculture, Irrigation and Rural Development

Mr Sumith Alahakoon - Secretary, Provincial Ministry of Agriculture, Southern Province

Mr E M M Ekanayake - Secretary, Provincial Ministry of Agriculture, North Central Province

Dr B V R Punyawardena - Principal Scientist (Agro Climatology) and Director Natural Resources Management Centre

Mr G D Keerthi Gamage - Additional District Secretary, Anuradhapura

Ms Champika D Dharmasena - Director Agriculture, Ministry of Mahaweli, Agriculture, Irrigation and Rural Development

Mr A K Karunanayake - Director of Meteorology

Mr E M S Ekanayake - Assistant Director, Ministry of Mahaweli, Agriculture, Irrigation and Rural Development

Mr N H Wimalaratne - District Director of Agriculture, Kurunegala

Mr I W K Imbulgoda - District Director of Agriculture, Polonnaruwa

Mr R Kokuladasan - District Director of Agriculture, Mullaitivu

Dr S M Hussain - Provincial Director of Agriculture, Eastern Province

Mr M Kugadasan - District Director of Agriculture, Trincomalee

Mr A Selvarajah - District Director of Agriculture, Kilinochchi

Ms E P Eswaran - District Director of Agriculture, Vavuniya

Mr Y B Iqbal - Director of Agriculture, Batticaloa

Mr S B S K Semasinghe - Provincial Director of Agriculture, North Western Province

Mr S Sivakumar - Provincial Director of Agriculture, Northern Province

Dr R Gnanasegar - Director Planning, Provincial Ministry of Agriculture, Eastern Province

Ms K K G A Sashikala - Assistant Secretary, Provincial Ministry of Agriculture, Southern Province

Eng M M J S Wijekoon - Provincial Director of Irrigation, Uva Province

Eng P Witharana - Chief Engineer, Department of Agrarian Development

Mr S Sivalingam - Project Director, Climate Smart Irrigated Agriculture Project, Ministry of Mahaweli, Agriculture, Irrigation and Rural Development

Mr S Jasinthan - Assistant District Secretary, Mannar

Mr C A Suneth Lochana - Additional District Secretary, Hambantota

Ms I A R Damayanthi - Deputy Director, North Western Province

Mr R Weerasooriya - Assistant Director, Climate Change Secretariat, Ministry of Mahaweli Development and Environment

Mr M S A Kalees - District Director of Agriculture, Ampara

Dr Buddhika Hapuarachchi - Chief Technical Advisor, UNDP

Mr Sampath Abeyrathne - Technical Specialist, UNDP

Mr Shantha Siri Emitiyagoda - National Consultant, CSA - UNDP

EXPERT GROUP

Dr W M W Weerakoon - Agronomy

Dr S H S Ajantha de Silva - Land and Water Management

Dr B V R Punyawardena - Climate and Climate Change

ACRONYMS

AWS
Automated Weather Station

CC
Climate Change

CF
Conservation Farming

CRIWMP
Climate Resilient Integrated Water Management Project

CSA
Climate Smart Agriculture

DAD
Department of Agrarian Development

DoA
Department of Agriculture

DOFC
Department of Forest Conservation

DoI
Department of Irrigation

DoM
Department of Meteorology

DS
Divisional Secretary

EG
Expert Group

FAO
Food and Agriculture Organization

FIM
First Inter Monsoon

GCF
Green Climate Fund

GHG
Green House Gas

MASL
Mahaweli Authority of Sri Lanka

NEM
North East Monsoon

NRMC
Natural Resources Management Centre

NTAC
National Technical Advisory Committee

OFC
Other Field Crops

SIM
Second Inter Monsoon

SWM
South West Monsoon

EXECUTIVE SUMMARY

National Guidelines for Climate Smart Agricultural Technologies and Practices for the Dry and Intermediate Zones of Sri Lanka

Need for Climate Smart Agriculture Interventions

Agriculture in the Dry and Intermediate zones of Sri Lanka has been the most affected sector by the most recent and frequently experienced climate aberrations. Long and hot drought periods, high intensities of rainfall resulting in floods became very common. The farmers of river basins of Malwathu Oya, Mi Oya and Yan Oya experienced severe drought conditions from 2015 to 2018 causing them to abandon four consecutive seasonal cultivations and compelling them to depend on government relief services. Thus, arose the need for Climate Smart Agriculture interventions as a remedy to ensure food security and rural livelihoods in Sri Lanka. However, as required for any innovation, these measures require appropriate guidelines.

Therefore, the National Consultant, who was hired for the United Nations Development Programme/ Green Climate Fund, worked with the Natural Resources Management Centre of the Department of Agriculture, under the Ministry of Agriculture to develop the required guidelines.

The team also collaborated with the Expert Group (EG) specialising in Soil and Water Management, Agro Climatology and Agronomy. Their holistic approach towards the compilation of the guidelines included fact finding missions, discussions with high level government officers, Key Informant Interviews (KII), Focused Group Discussions (FGD) with key farmers and other stakeholders in the respective river basins. Literature reviews from locally and internationally available papers on CSA were also incorporated. Furthermore, insights on recommendable CSA practices gathered during visits made to other countries by EG members were also used. The outcome of these endeavours are published as the National Guidelines for CSA Technologies and Practices, and the Training Manual on CSA.

National Guidelines contain the following chapters:

1. Introduction: Key challenges faced by Sri Lanka's agriculture sector with special reference to Malwathu Oya, Mi Oya, and Yan Oya basins

2. Existing practices in the agricultural production systems and recommendations for the future

3. Climate Smart Agriculture (CSA) applications in other countries

4. CSA adoption in the Dry and Intermediate zones of Sri Lanka, with special focus on Malwathu Oya, Mi Oya and Yan Oya basins: Enablers and Challenges

5. Recommended Technologies and Practices on Climate Smart Agriculture Interventions

In addition, a National Technical Advisory Committee (NTAC) was set up under the direction of the Ministry of Agriculture. The NTAC, which represents relevant national and provincial public sector institutions, finalised the National Guidelines for CSA Technologies and Practices.

The Provincial Directors of Agriculture (PDAs) from the four Provinces (Eastern, Northern, North Central and North Western) that the CSA programme covers, developed the short and long-term plans for CSA interventions. These officials are responsible for the agriculture extension operations in the three given river basins.

These short-term plans of the CSA practices were implemented as a pilot project during 2019 Yala season in the respective provinces for validation. The findings of the pilot scale testing of these CSA practices were also used for confirmation of same and long-term plans will be made accordingly, utilising the gained experiences.

The Training Manual, which is the continuation of this publication, is to be used specifically at CSA training programmes to be held for Agricultural Extension Officers.

Chapter 1

The chapter outlines the key challenges faced by Sri Lanka's agriculture sector with special reference to the three river basins, under discussion. Starting off with an introduction to the agriculture sector and climatic zones pertaining to Sri Lanka and the three river basins, it lists farming community challenges i.e. their persistent poverty, high production costs, absence of market oriented production, threat from wild animals and stray cattle, increased incidences of pests, diseases and weeds, shrinking of arable land, inadequate use of machinery, land tenure issues, slow technological advancement and inadequate resilience to marketing issues such as low prices.

Chapter 1 also marks the lack of quality seeds, weather aberrations, farmers' lack of interest in safe and quality food, low efficiency of irrigation water use, damages to irrigation infrastructure, degradation of natural resources, salinity build-up in water bodies, over exploitation of ground water and the lowering of ground water tables, lack of reliable seasonal climate forecasts, absence of farmer-friendly insurance schemes, sand mining in cultivable areas and the lack of coherent national agricultural policies to address challenges to the agriculture sector in Sri Lanka, particularly in the three respective river basins.

Chapter 2

This chapter discusses existing agricultural production systems and the experts' recommendations for the future. Basic information on the three respective river basins and their major soil types are also listed. Furthermore, it reviews different agricultural production systems such as Rice/Rice, Rice/OFC Vegetables, Rice/OFC Vegetables under Agro-well farming systems and Bethma systems, maize production, rice cultivation in submerged zones, upland production systems, Chena cultivation with agro wells and cultivating in home gardens.
Under the recommended agriculture production systems, the third season cultivation, cultivation of short duration crops after Maha season, cultivation of semi perennial crops, toxin-free agriculture, ecological farming, agro-forestry, conservation farming and hi-tech agriculture systems are detailed.

Chapter 3

Adding an international touch to the publication other country experiences on Climate Smart Agriculture (CSA) applications are shared herein. Experts' experiences gained in several countries with similar conditions to Sri Lanka, are described in this chapter. It records the Indian experiences such as technology delivery through mobile apps, farmers' increased incomes made possible with solar-powered agriculture, traditional water harvesting systems, root zone irrigation techniques and Climate Smart Village Approach. It also details crop diversification, soil and water conservation techniques in Latin American countries, the ecologically engineered seeds in Cambodia, Bee-siness of agriculture in Kenya, mapping out of soil health in Ethiopia, improving livestock productivity in Zambia and rain water harvesting (Half Moon technique) in Niger.

Chapter 4

This chapter discusses the enablers and (anticipated) challenges in adopting CSA in Sri Lanka and specifically in the Malwathu Oya, Mi Oya, and Yan Oya basins. Policies and acts related to soil, land, water, agriculture and ministries and other government institutions that would be essentially related to CSA adoption, are also listed herein.

Briefs on other informal supporting bodies such as farmer organisations, local government institutions, organised markets, private sector companies, banks and private vendors are also added.

The agricultural communities in Sri Lanka continually face challenges such as land ownership issues, land fragmentation, lack of field level coordination, social and religious barriers, off-farm activities of farmers, youth moving out of agriculture, Climate Change itself, women opting for foreign migrant labour, and continuous changes in the political administration.

Food and Agriculture Organisation of the United Nations (FAO), defines Climate Smart Agriculture (CSA) as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes/mitigates greenhouse gas (GHG) where possible, and enhances achievement of national food security and development goals". As per the above stated FAO definition the CSA practices detailed in this publication would unquestionably contribute to the achievement of at least one or more out of the three objectives of the CSA approach, namely 1. Mitigation of GHG emissions from agriculture, 2. Adaptation of agricultural practices to Climate Change and 3. Sustainable maintenance or increase of agricultural productivity through the agriculture system in Sri Lanka, particularly in the three respective river basins.

Chapter 5

Climate Smart Agriculture Technologies and Practices recommended for the three respective river basins are detailed in this chapter. These practices can appropriately be adopted in other parts of Sri Lanka's Dry and Intermediate zones as well. They are categorised into 15 thrust areas under six thematic areas as shown overleaf.

Thematic area 1:
Tank Cascade Management

Thrust Area:
1. Tank Cascade Management

Thematic area 2:
Soil and Water Management

Thrust Areas:
2. Soil Management
3. Nutrient Management
4. Water Management

Thematic area 3:
Agronomy: Research and Development

Thrust Areas:
5. Crop Management
6. Conservation and management of genetic resources

Thematic area 4:
Climate Information and Forecasting: Research and Development

Thrust Area:
7. Climate Information

Thematic area 5:
Institutional and Social Development

Thrust Areas:
8. Management Integration
9. Agrarian Services
10. Agriculture Marketing and Value Chain Development
11. Social Development Measures
12. Risk Transferring Mechanism

Thematic area 6:
Energy and Mitigation

Thrust Areas:
13. Energy Management
14. Mechanisation
15. Post-harvest Operations

Chapter 1

KEY CHALLENGES FACED BY SRI LANKA'S AGRICULTURE SECTOR WITH SPECIAL REFERENCE TO MALWATHU OYA, MI OYA AND YAN OYA RIVER BASINS

1.1 CLIMATE OF SRI LANKA

Sri Lanka is an island located at the tip of Indian Subcontinent. There is no landmass between the Southern tip of Sri Lanka and the Antarctic. The island covers a total area of 65,610 km^2, which includes 2,905 km^2 of inland water bodies. Maximum width from East to West of the island is 240 km and length in North to South direction is 435 km. Located between 5055' to 9050 N and 79042' to 81053 'E, Sri Lanka enjoys a tropical monsoonal climate. Extensive faulting and erosion over time have produced a wide range of topographic features with three distinguishable elevation zones within the island: the central highlands, the plains, and the coastal belt. Located in the South-central part of Sri Lanka, the rugged central highlands spanning around 65 km in the North to South direction with a peak elevation at 2,524 m forms the hydrologic heart of the country. All major perennial rivers originate in the highlands spreading in a cartwheel fashion from the center towards the coast. Most of the island's surface consists of plains located between 30 and 200 meters above mean sea level. In the Southwest, ridges and valleys rise gradually to merge with the central highlands, giving a dissected appearance to the plain. The coastal belt around the country extending up to 30 m approximately above mean sea level consists of scenic sandy beaches indented by bays and lagoons.

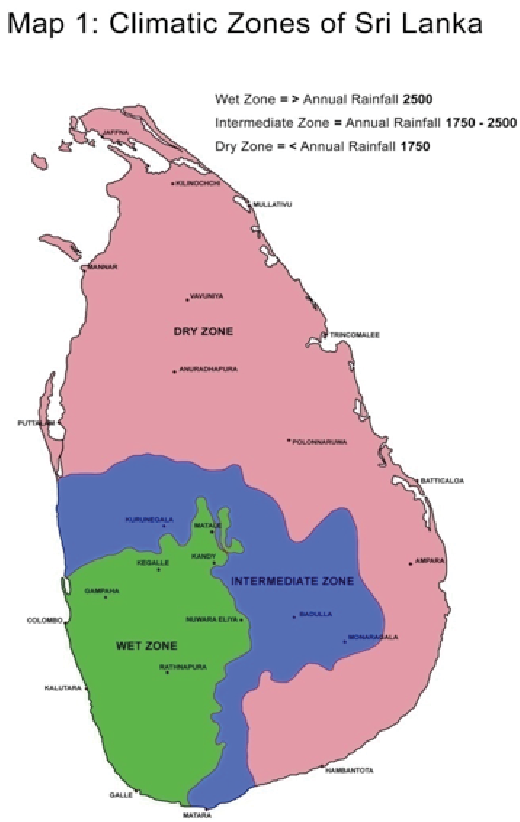
Despite its small size, Sri Lankan landmass exemplifies a variety of climatic conditions depending on the geographical setting and elevation. In general, the climate of Sri Lanka is tropical monsoonal with a marked seasonal variation of rainfall. Rainfall in Sri Lanka has multiple origins. Monsoons, convectional rains and the formation of weather systems in the Bay of Bengal account for a major share of the annual rainfall. The island's average annual rainfall varies from about 900 mm at Southeastern part of the Dry zone (e.g. Maha

Lewaya, Hambantota) to over 5,500 mm on the southwestern slopes of central highlands (e.g. Kenilworth Estate, Ginigathhena). The country receives its rainfall during four distinct seasons: the First Inter Monsoon (FIM), from March to April; the South West Monsoon (SWM), from May to September; the Second Inter Monsoon (SIM), from October to November; and the North East Monsoon (NEM), from December to February.

Out of these four rainfall seasons, two consecutive rainy seasons define the major cultivation seasons of Sri Lanka, namely Yala and Maha seasons. The Maha season is the major cultivating season of the entire country, which begins with the arrival of SIM rainfall in mid-September/October and continues up to late January/February with the NEM rainfall. The Yala season is the combination of FIM and SWM rainfall and is considered the minor cultivation season in relatively dry areas of the country.

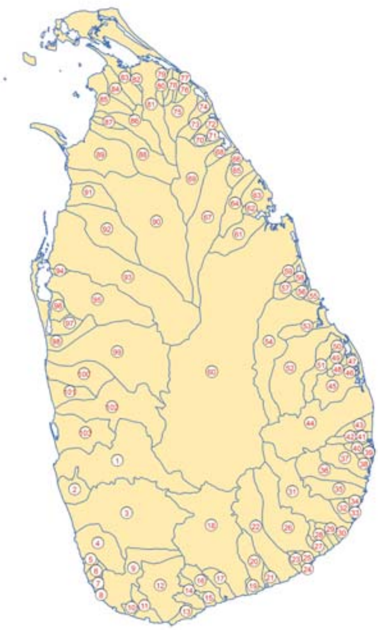
The mean annual temperature in Sri Lanka is largely homogeneous in the lowlands and decreases rapidly as the elevation increases towards the highlands. In the lowlands, up to an altitude of 100 m to 150 m, the mean annual temperature varies between 26.5 °C to 28.5°C. But in the highlands, a rapid drop of temperature is observed with the increase of altitude due to atmospheric lapse rate. This makes the highest elevations of the Central Highlands experience the lowest atmospheric temperatures. (A mean annual temperature of 15 °C at 1,800 m MSL at Nuwara Eliya, where even frost could occur in lower valleys during colder months.) The coldest month of the year in Sri Lanka with respect to mean monthly temperature is January; the hottest months are April and August.

1.2 CLIMATIC ZONES OF SRI LANKA



Map 1.1: Climatic Zones of Sri Lanka

Sri Lanka's climate has traditionally been divided into three climatic zones based largely on the annual rainfall. The Wet zone covers the Southwestern region including the Southwestern slopes of the central hills; the Dry zone predominantly covers the plains in the Northern, North central, Southeastern, Eastern parts of the country; and the Intermediate zone skirts the central highlands except in the Southwest (Map 1). Important factors defining these different climatic zones other than the annual rainfall, are a) amounts of Southwest monsoon rains, b) predominant types of soil c) land use patterns d) vegetation types and e) altitude. The Wet zone receives a relatively high mean annual rainfall over 2,500 mm without pronounced dry periods. The Dry zone gets a mean annual rainfall of less than 1,750 mm with a distinct dry season from May to September. The Intermediate zone records a mean annual rainfall between 1,750 to 2,500 mm with a short and less prominent dry season from May to September.



1	Kelani Ganga Basin	36	Heda Oya Basin	71	Chavar Aru Basin
2	Bolgoda Ganga Basin	37	Karanda Oya Basin	72	Palladi Aru Basin
3	Kalu Ganga Basin	38	Semana Aru Basin	73	Manal Aru Basin
4	Bentara Ganga Basin	39	Tandiadi Aru Basin	74	Kodalikallu Aru Basin
5	Madu Ganga Basin	40	Kangikadichi Aru Basin	75	Per Aru Basin
6	Madampe lake Basin	41	Rufus Kulam Basin	76	Pali Aru Basin
7	Telelwatta ganga Basin	42	Pannel Oya Basin	77	Maruthapillay Aru Basin
8	Ratgama Lake Basin	43	Ambalan Oya Basin	78	Theravil Aru Basin
9	Gin Ganga Basin	44	Gal Oya Basin	79	Piramenthal Aru Basin
10	Koggala Lake Basin	45	Andella Oya Basin	80	MEthali Aru Basin
11	Polwatta Ganga Basin	46	Tumpan Keni Basin	81	Kanakarayan Aru Basin
12	Nilwala Ganga Basin	47	Namakada aru Basin	82	Kalwalappu Aru Basin
13	Sinimodara Oya Basin	48	Mandipattu Aru Basin	83	Akkarayan Aru Basin
14	Kirama Oya Basin	49	Pathatoppu Aru Basin	84	Mandakal Aru Basin
15	Rekawa Oya Basin	50	Vett Aru Basin	85	Pallavarayan Kaddu Basin
16	Urubokka Oya Basin	51	Unnichchai Basin	86	Pali Aru Basin
17	Kachchigala Basin	52	Mundeni Aru Basin	87	Chappi Aru Basin
18	Walawe Ganga Basin	53	Miyangolla Ela Basin	88	Parangi Aru Basin
19	Karagan Oya Basin	54	Maduru Oya Basin	89	Nay Aru Basin
20	Malala Oya Basin	55	Puliyanpota Aru Basin	90	Aruvi Aru Basin
21	Embilikala Oya Basin	56	Kirimechchi Odai Basin	91	Kal Aru Basin
22	Kirindi Oya Basin	57	Bodigolla Aru Basin	92	Moderagam Aru Basin
23	Bamdawe Ara Basin	58	Mandan Aru Basin	93	Kala Oya Basin
24	Mahasiliwa Oya Basin	59	Makarachchi Aru Basin	94	Moongil Aru Basin
25	Butawa Oya Basin	60	Mahaweli Ganga Basin	95	Mi Oya Basin
26	Menik Ganga Basin	61	Kantalai Aru Basin	96	Madurankuli Aru Basin
27	Katupila Ara Basin	62	Palampotta Aru Basin	97	Kalagamuna Oya Basin
28	Kurundu Ara Basin	63	Panna Oya Basin	98	Rathambala Oya Basin
29	Nabadagas Ara Basin	64	Pankulam Aru Basin	99	Deduru Oya Basin
30	Karambe Ara Basin	65	Kunchikumban Aru Basin	100	Karambala Oya Basin
31	Kumbukkan Oya Basin	66	Palakutta Aru Basin	101	Ratmal Oya Basin
32	Bagura Oya Basin	67	Yan Oya Basin	102	Maha Oya Basin
33	Girikula Oya Basin	68	Mee Oya Basin	103	Attanagalla Oya Basin
34	Helawa Ara Basin	69	Ma Oya Basin		
35	Wila Oya Basin	70	Churiyan Aru Basin		

Map 1.2: River Basins of Sri Lanka *(Source: National Atlas of Sri Lanka, 2007)*

1.3 RIVER BASINS OF SRI LANKA

There are about 103 distinct major river basins in Sri Lanka. They have radial drainage patterns diverging from the Central Highlands in all directions. It resembles the spokes of a wheel or a cartwheel. In the highlands, river courses are frequently broken by discontinuities in the terrain, where they encounter escarpments creating numerous waterfalls and rapids with eroded passages. Once they reach the plain, the rivers slow down and the waters meander across flood plains and deltas. The upper reaches of the rivers are wild and usually un-navigable, and the lower reaches are prone to seasonal flooding. The Southwestern part of the island, the so-called Wet zone has seven major river basins with catchment areas ranging from 620 km^2 to 2,700 km^2. They are, from North to South: Ma river (1,528 km^2), Attanagalu river (736 km^2), Kelani river (2,292 km^2), Kalu river (2,719 km^2), Bentota river (629 km^2), Gin river (932 km^2) and Nilwala river (971 km^2). An exception to the radial pattern is the largest basin, that of the 335 km long Mahaweli river, which has a catchment area of 10 448 km^2. After leaving the Central Highlands, it runs almost North for 90 km from Minipe to Manampitiya and then a further 70 km through several distributaries as far as Verugal and Muttur on the East Coast. Most of Sri Lanka's river basins are small. Only 17 of the 103 basins exceed 1,000 km^2 with 12 of them carrying about 75 percent of the mean river discharge of the entire country. Human interventions have altered the flows of some rivers in order to create hydroelectric, irrigation and multi-purpose artificial tanks and reservoirs.

1.4 MALWATHU OYA BASIN

Malwathu Oya is ranked the second longest river in the island with 164 km in length. This can be divided into four parts. The first section originates and collects water from areas around Ritigala mountains near Habarana and feeds the ancient Nachchaduwa Tank, South of Anuradhapura. The second section, which outflows from Nachchaduwa Tank passes between Anuradhapura's commercial district and the Sacred City towards the Northwest continuing onto the East of Thantirimale, collecting rain waters from Mahakanadarawa Tank, East of Mihintale up to Medawachchiya region. The third section collects rain waters from Medawachchiya to Vavuniya with several small ephemeral streams joining the main river course after Thanthirimale. The last section is from the Thekkama diversion (an ancient stone anicut). Malwathu Oya is then referred to as Aruvi Aru and it joins the sea at Arippu. The Thekkama diversion is located at 35 km from its river mouth and it delivers the water of Malwathu Oya to Yodha Weva (Giant Tank) in Mannar District via a 19 km long channel. Both these ancient hydraulic structures had been built by King Dhatusena in the 5th century and then restored by the Great King Parakramabahu in the 12th century.

The embankment of Yodha Weva is over 7 km in length with a height of about 5 m. This is comparatively a low height compared to the country's other reservoirs of the same size. Hence, it is apparent that ancient irrigation engineers had mastered the way of increasing the storage tank volume by increasing the area of water spread without increasing the depth of the tank. However, due to the same reason, this tank is now being subject to frequent and complete drying out during severe drought conditions. It is, nevertheless, a common occurrence in this area, which is subject to a varying climate. The tank, presently, covers over 4,550 ha and provides irrigation facilities to more than 32,422 ha of paddy lands through 223 medium and small tanks, approximately, in the area.

1.5 MI OYA BASIN

Mi Oya which originates from the hilly regions of Dambulla, located in the boundaries of Matale, Kurunegala and Puttalam districts has a river course of 109 km in length. Mi Oya meets the Indian Ocean at Puttalam Bay in the Western coast (Table 1.1). It meanders mainly across Kurunegala and Puttalam Districts in the Dry zone of Sri Lanka. The major irrigation functions of the river basin include Inginimitiya Tank, which provides irrigation facilities for about 2,600 ha of land, out of which over 1,850 ha are newly developed land. The rest comes under the existing village tank systems such as Andara Weva, Kallan Kulama, Verungoda, Uriyawa, Gal Kulama and Mun Kulama. The other major irrigation reservoir in the basin is the Tabbowa Tank, which has been constructed across the Nanneri Oya, a tributary of Mi Oya. The Tabbowa Tank provides irrigation facilities to about 650 ha of land.

Mi Oya and Deduru Oya are two adjacent river basins located in the North Western Province. More than 80 percent of the water of Mi Oya basin is utilised for cultivation purposes despite frequent and intense drought occurrences. But, in Deduru Oya basin, its water as a resource has not yet been fully utilised. Therefore, Deduru Oya reservoir is currently being developed to fully utilise its water sources in the catchment thus improving the cropping intensity of existing agricultural lands under minor irrigation schemes and also to develop new arable land in both Mi Oya and the Deduru Oya basins. The purpose of this exercise is to enhance the overall agricultural productivity of both river basins. The right bank channel of the 36.5 km of Deduru Oya reservoir diverts to Mi Oya basin. This channel is expected to provide irrigation water to about 2,640 ha of the Inginimitiya reservoir, which often faces acute water shortage issues. This channel would also provide irrigation water to another 3,000 ha of land, while the Radavibendi Ela Project would supply irrigation water to about 400 ha. Subsequent to this trans-basin diversion to Mi Oya basin Thabbowa Tank will provide irrigation water to another 865 ha.

1.6 YAN OYA BASIN

Yan Oya originates from the hilly areas of Dambulla and Sigiriya in the Matale district and is 142 km long. The catchment area of Yan Oya is about 1598 km^2 (Table 1.1) spreading mainly across the North Eastern part of Sri Lanka. The catchment area of Yan Oya receives its highest rainfall during the October - February period with a mean annual rainfall of 1,645 mm. In addition to the tributary network of the river, drainage water from several tank cascades and several major reservoirs, mainly from the Wahalkada Tank drains into Yan Oya.

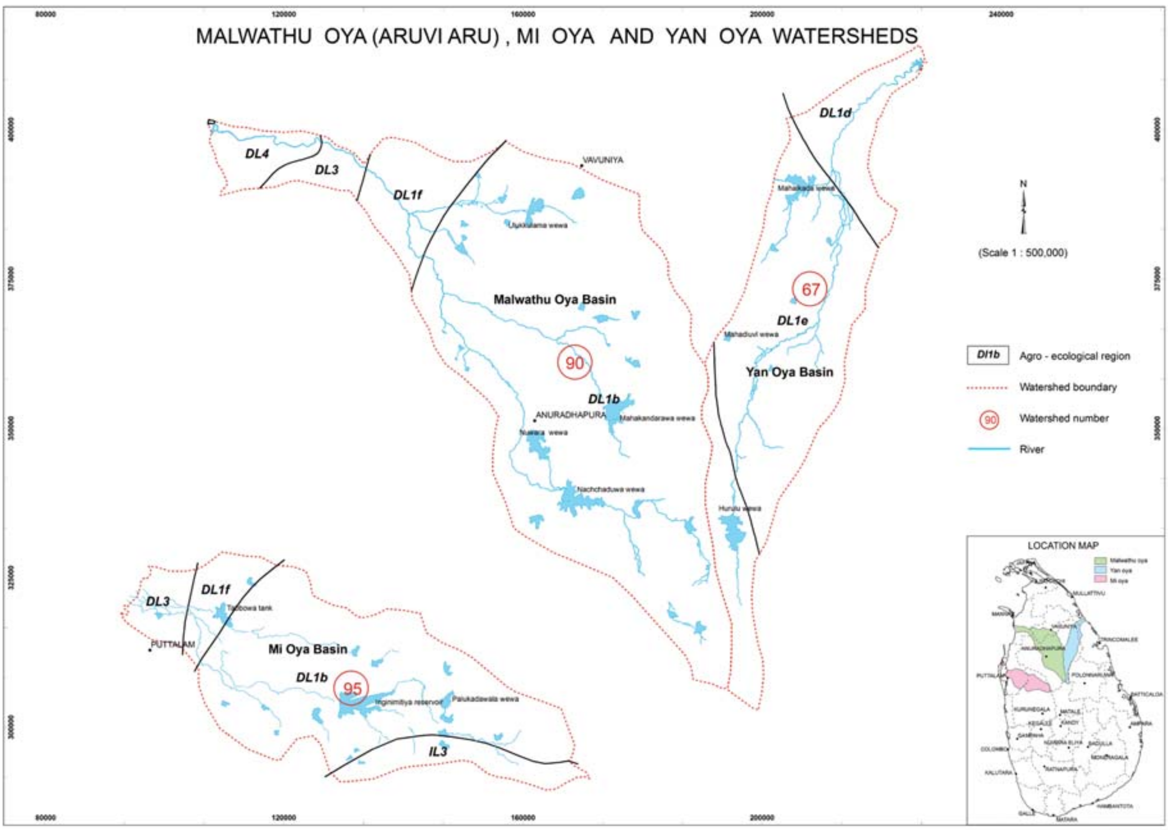
There are no trans-basin diversions in the Yan Oya basin. However, a new in-basin reservoir is being constructed across Yan Oya with a total dam length of 5.944 km (a main dam with four saddle dams). It will provide irrigation water for 4,192 ha in the right bank and 1,812 ha in left bank with a total irrigable area of about 6,000 ha of both newly developed and existing rice lands under Padaviya and Wahalkada irrigation schemes. The construction work of this project is still in progress and is near completion. However, there is strong resistance for this project by environmentalists due to the vast area of submergence of natural forests, archeological sites, existing rice lands along with a fear on the possible escalation of human-elephant conflicts and the fate of precious Ilmanite mineral resources at sea-mouth-fall of Yan Oya at Pulmudai in the Eastern coast.

Out of 103 river basins, Malwathu Oya, Mi Oya and

Table 1.1: Characteristics of Three River Basins Covered by the Study
(Source: Manchanayaka & Madduma Bandara, 1999 – Water Resources of Sri Lanka)

Basin No.	Name of the river basin and length	Catchment area (km^2)	Mean annual rainfall volume (MCM)	Average annual discharge volume to the sea (MCM)	% discharge from the catchment rainfall
90	Malwathu Oya (164 km)	3,284	4,573	566	12.4
95	Mi Oya (109 km)	1,533	1,925	199	10.3
67	Yan Oya (142 km)	1,598	2,476	482	19.5

Yan Oya are mainly spread across the Sri Lanka's Dry zone, where annual average rainfall is less than 1,750 mm with a distinct dry period from May to September. About 85% of the total basin area of Malwathu Oya is spread across DL1b Agro Ecological Region (AER) in its upper reaches while the rest, the far lower reaches lie across the Dry zone's drier parts such as DL1f, DL3 and DL4 AERs (Map 3 and Table 1). Similarly, about 74% of the total basin area of Mi Oya lies across the DL1b AER, and the rest of the basin area lies across relatively dry AERs of the Dry and Intermediate zones of the country. (e.g. DL1f, DL3 and IL3 regions.) About 65% of the Yan Oya basin lies across the DL1e AER in its mid reaches while the rest is equally spread across DL1b and DL1d AERs (Map 1.3 and Table1.2)



Map 1.3: Three River Basins of the Study across Agro-Ecological Regions of Sri Lanka

Table1.2: Spatial Distribution of the Three River Basins Across Agro-Ecological Regions of Sri Lanka

Watershed	Agro-Ecological Region	% Area
Malwathu Oya	DL1b	84.8
	DL1f	8.2
	DL3	2.7
	DL4	4.3
Mi Oya	DL1b	73.9
	DL1f	8.6
	DL3	6.5
	IL3	11.0
Yan Oya	DL1b	17.3
	DL1d	17.5
	DL1e	65.2

1.7 AGRICULTURE SECTOR OF SRI LANKA

Sri Lanka, a member of the South Asian Association for Regional Cooperation (SAARC), is an emerging economy with a per capita GDP of USD 4,065 in 2017 (Central Bank of Sri Lanka, 2017). Agriculture has been the mainstay in Sri Lankan economy over centuries. Both rain-fed and irrigated agriculture form the backbone of rural livelihoods. Due to the increasing share of the service and industrial sectors to the GDP, the contribution of agricultural sector was calculated at 6.9% of the national GDP in 2017. There are 21.446 million people in Sri Lanka, of which 77.4% live in agriculture-dominant rural areas. About 27% of the population is engaged in agricultural primary production, which is gradually reducing from 34% since 2008. This has been well noted in the government policy documents of each successive government from the time of Independence in 1948.

Spanning over 65,000 km^2 land area as an island in the Indian Ocean at the tip of the Indian Sub-continent, Sri Lanka historically used to be predominantly an agricultural country up to the last quarter of the 20th century. The traditional farming system of Sri Lanka has often been described as a subsistent and self-sufficient system based on wetland rice farming, rain-fed upland cultivation known as Chena and home gardens. Wetland rice and upland Chena were seasonal crops whereas home gardens consisted of both seasonal and perennial crops.

The British invasion in Sri Lanka, (then Ceylon) during the early 16th century brought significant structural changes to the composition of domestic agriculture of the island. The British rulers were quick to develop plantation crop-based export agriculture in large estate plantations, initially of coffee to be followed by tea, rubber and coconut through private investments. They brought about various policy strategies such as Crown Land Ordinance (1840) and forced migration of South Indian labourers to work in up-country plantations.

Over the years, the plantation sub-sector turned out to be the backbone of the national economy. Simultaneously, the other sub-sectors of agriculture, especially rice cultivation, became neglected leaving the national food security in jeopardy. The overarching policy of the British rulers was to meet the food needs of the Ceylonese (Sri Lankan) population by importing the essential food commodities from their other colonies in the region using export earnings from the plantation agriculture. However, with the increasing population over the years, it caused heavy budgetary pressure to the colonial government compelling the British government to embark upon ambitious programmes involving land settlement, irrigation and rehabilitation. These were aimed at self-sufficiency in major food items such as rice. Initiated in the 1930s and pioneered by Hon. D S Senanayake, then Minister of Agriculture, the irrigated land colonisation schemes became the backbone of Sri Lanka's agricultural policy throughout the 20th century, which culminated after the completion of the accelerated Mahaweli Development Programme in the mid 1980s. This was followed by some other minor interventions in recent times. All three river basins under this CSA project had benefitted from such development interventions from time to time resulting in improved land and water productivity, while alleviating poverty to some extent.

At present, Sri Lanka has around 885,000 ha of asweddumised rice lands (Department of Census and Statistics, 2015), a majority of which is located in the Dry and Intermediate zones of the country. Out of this total rice land extent, about 45% of asweddumised lands come under major irrigation schemes, 25% under minor irrigation schemes and about 30% under rainfed systems. Out of these three rice-eco-systems both minor irrigation schemes and rainfed systems are highly vulnerable to Climate Change, especially in the three river basins of the project area. Importantly, the farmers in these rice growing regions of the country, especially both in the Dry and Intermediate zones are engaged in the cultivation of Other Field Crops (OFC) such as chilli, onions, vegetables, pulses, tuber crops, maize and other cereals. The extent of these small-scale cultivations add up to an approximate total of 150,000 ha under rainfed conditions and/or with supplementary irrigation from shallow ground water sources. This indicates that the country's total land extent under agriculture is about one million hectares. It is roughly one sixth of the land cover and is mainly spread in the drier regions of the country.

About 750,000 ha of lands in the Wet and Intermediate zones of the country are under plantation crops such as tea, rubber, coconut with sugarcane and oil palm in a lesser extent. Out of these five crops, the first four crops are mainly in the hands of smallholders. The estate plantations are seemingly going through a declining trend due to irrational management issues. Though this sector is usually identified as export agriculture, noteworthy is the fact that a major share of coconut production is now used locally for both household consumption and coconut-based industries. Even though statistics are scarce, over one million hectares of land come under home gardening that cater to food security of the households as well as the export income of the country through supplies of products such as pepper, cinnamon, cardamom and clove. Another important feature of home gardening is that they provide a major share of the fruits consumed locally.

Furthermore, a significant number of farmers, a majority of whom are engaged in one or more of the above forms of agriculture, are also engaged in dairy cattle, cattle, poultry and other forms of livestock thus contributing to the food security of the population. Hence, the above account of Sri Lanka's agriculture sector can be summarised into four major sub-sectors, namely, Food Crop Sub-sector (Rice, OFCs, Vegetables and Fruits), Plantation Crops Sub-sector, Multi-functional Home Garden Sub-sector and lastly, Livestock and Poultry Sub-sector. Even though the internationally accepted broad definition of the agriculture sector includes both forestry and fisheries sectors, they have not been discussed in this document given the currently insignificant relevance of those two components in community livelihoods in the three respective river basins of the study.

Although tea, rubber, coconut, sugarcane and oil palm are crucial components of domestic and plantation sectors in Sri Lanka's agriculture, the plantation sector is not predominant in the three river basins that come under the project purview except for some low-productive coconut lands in the Mi Oya basin. Hence, only the domestic agriculture sector is discussed in this section.

Rice is the main crop in the domestic sector, and its cultivation is the most important economic activity for majority of the people living in the country's rural areas, including the project area. Furthermore, it is the single most important crop occupying an approximate total area of 0.885 million ha (Department of Census & Statistics 2015). Rice cultivation gives the country an average yield of 4.4 mt/ha. About 0.89 million farmer families (Department of Census and Statistics, 2002) are engaged in rice cultivation island wide. Sri Lanka currently produces about 4 million metric tons of rice annually and satisfies around 95–98% of the domestic requirement. The rest is being imported mainly from India, Myanmar, Thailand and Pakistan. Rice provides 45% of total calorie and 40% total protein requirement of an average Sri Lankan. The per capita consumption of rice fluctuates around 110 kg per year depending on the price of rice, bread and wheat flour. During the last five decades the rice sector grew rapidly and output was more than tripled. There has been a sharp increase in rice production in the country during recent times. Increased areas under cultivation due to several irrigation development projects countrywide, introduction of high yielding varieties, some favourable policy changes such as the fertiliser subsidy scheme and the end of 30 - year civil conflict in major rice growing regions in the North and East, are seen as the main reasons for this increase.

The non-rice crops such as big onion, red onion, chilli, green gram, cowpea, black gram, maize, sesame, groundnut and soybean are the most important Other Field Crops (OFCs) in Sri Lankan agriculture. All these crops are widely grown in the project areas during both Yala and Maha seasons. But the latter is mostly confined to rice cultivation in the middle or lower positions of the catena landscape due to the availability of phreatic and irrigation water throughout the growing season. However, the country has never been self-sufficient in these OFCs due to various technical, social and policy-related issues. Nevertheless, the rice production fluctuates around the national requirement depending on the weather conditions during respective cultivating seasons. At present, the balance of the national requirement of major OFCs is being imported. Among OFCs, chilli and onions are major import commodities. Sri Lanka has spent about US$ 59.6 million and 65.3 million respectively to import these two commodities, in 2015 alone.

Next to rice and OFCs, the vegetable sub-sector is another important component in Sri Lanka's agricultural sector. As in the case of rice, vegetables are also grown throughout the country, including the three respective river basins. Farmers, in large numbers, are engaged in it. The climatically cool and salubrious condition in the hill country is ideal for exotic temperate vegetables such as potato, carrot, leeks, cabbage, chinese cabbage, cauliflower, broccoli, radish, lettuce, cucumber, beet, bean, bell-pepper, tomatoes and capsicum. But these vegetable crops hardly grow in the three respective river basins except for a few crops like tomato, beans, radish, cucumber and capsicum. The Low Country Wet zone and Dry and Intermediate zones are suitable for a variety of tropical vegetables ranging from green chilli, red onion, pumpkin, bitter gourd, snake gourd, luffa, radish, okra, brinjal, gherkins, and leafy vegetables. These also include some perennial crops such as cassava, certain indigenous yams - innala (Plectranthus rotundifolius or Solenostemon rotundifolius) and kiriala (Xanthasoma sagittifolium), drumsticks (also known as moringa - Moringa oleifera) - which are considerably free of chemical inputs and thus organic by default.

Sri Lanka is considered a net vegetable exporter, its production being in excess of the domestic requirement in peak times of the growing season of the respective crops. Maldives, Middle Eastern countries and the European Union are the major buyers of Sri Lankan vegetables. Sri Lankan health authorities recommend the consumption of at least 200 grams of vegetables daily to meet the per person dietary requirement. But, most of the Sri Lankans do not adhere to this recommendation due to non-availability of vegetables in the market throughout the year at a reasonable price, and due to their traditional diet patterns. Seasonality of vegetable production in open field conditions always leads to the inability to meet the ever-growing demand from foreign countries for quality vegetables from Sri Lanka and also for domestic consumption needs.

As in the case of vegetables, Sri Lanka is also a net tropical fruit exporter to destinations such as Maldives, European Union and the Middle Eastern countries. Out of Sri Lanka's total land area only about 2.3% has been cultivated with tropical fruits, mainly, banana, pineapple, papaya, mango, guava, rambutan and lemon. Like with vegetables, Sri Lanka's health authorities' recommendation is that the daily consumption of fruits should be at least 200 grams of fruits in order to meet the individual dietary requirement. However, most of the Sri Lankans do not fulfill this recommendation due to non-availability of fruits throughout the year at a reasonable price. Local and foreign markets for the under-utilised fruits such as veralu (Elaeocarpus serratus), soursop (Annona muricate), woodapple (Limonia acidissima), mora (Dimocarpus longan), sour guava (Psidium cattleianum Sabine) and nelli (Phyllanthus emblica L) are yet to be explored considering their natural organic nature by default. There is a considerable demand for these varieties.

1.8 ISSUES FACED BY SRI LANKA'S AGRICULTURE SECTOR, WITH SPECIAL FOCUS ON THE THREE RIVER BASINS UNDER STUDY

Sri Lanka has experienced a gradual transformation from a predominantly agriculture-based economy to that of a service-based nature during the last few decades. Despite this shift, the country's agriculture sector still plays a vital role in its national economy by employing nearly one third of Sri Lanka's population -- especially the farming community -- by ensuring national food security, supplying primary inputs for agriculture based manufacturing sector, and with some minor yet crucial environmental contributions for long-term sustainability of the island's natural resources. The numerous economic and social policy transformations that keep occurring due to local and international political interests, make significant impacts on the development and expansion of Sri Lanka's agriculture sector. This is particularly true for the three specific river basins that are being discussed herein, because of their inherent geographical, demographic and socio-economic setting and exposure.

A brief yet comprehensive exercise was undertaken, as part of this study, to identify the key challenges faced by the agriculture sector during its expansion, especially in the three river basins under review. It included Key Informant Information (KII) generated through individual consultations with the country's senior agriculturists, agriculture related policy makers and planners, Focused Group Discussions (FDG) comprising of Provincial Directors of Agriculture (PDAs) and their field staff coming under the respective three river basins. They represented the North-Central, North-Western, Northern and Eastern Provinces. There were also field visits to river basins to meet and discuss with farmers on relevant issues.

The information collected as mentioned above were further consolidated with a comprehensive literature survey through the documentary information available with the Department of Agriculture, Department of Agrarian Development, Irrigation Department and Mahaweli Authority of Sri Lanka. Then the content was reviewed thoroughly by the Expert Group (EG); their comments and inputs were duly incorporated. The subsequent paragraphs give a brief summary of such collected information on key challenges to Sri Lanka's agriculture sector with special reference to the three river basins discussed herein.

1.9 EXTENSION SERVICES AND INPUT SUPPLY SYSTEM IN THE FOOD CROP SECTOR

Before setting up the Provincial Council administration system in the late 1980s, the Department of Agriculture was solely managing the agriculture extension service. It was not only the arm to disseminate the agriculture information but also the administrative body for the country's national agriculture production programme. In the past, the Agriculture Instructors (AI) were operational at an Agrarian Service Center level and Agriculture Extension Services Officers (Krushi Viyapthi Seva Niladari / KVSN) were carrying out agriculture extension under AI at village level. After the government took them out of agriculture extension and posted them as Grama Seva Niladari (GSN) to carry out the administrative work for the village, it created a huge vacuum in the agriculture extension functions at the village level.

Before the 13th Amendment to the Sri Lankan Constitution, the agriculture extension activities were completely handled by the Department of Agriculture under the Central Government. After the 13th Amendment, these activities were devolved to the newly established Provincial Councils, with an exception of the inter-provincial areas. As a result, agriculture extension was now being identified as a devolved function in the existing system. Accordingly, six inter- provincial areas had been identified and their command areas under major irrigation tanks were left under the administration of the Central Government.

As a result of these changes only Agriculture Instructors ended up at the Agrarian Service Centre level to disseminate agricultural technologies to farmers in both Provincial and Interprovincial systems. They are assigned to vast agricultural areas and each officer is responsible for more than 5000 farming families. Dissemination of agriculture information and technology updates, developed by the research arm of the Department of Agriculture (DoA) especially in response to emergency situations risen due to weather aberrations i.e. pest and disease outbreaks, hence became tough. Therefore, another separate agriculture extension system was set up in the areas under the Mahaweli Authority of Sri Lanka. Furthermore, the Department of Agrarian Development recruited a large number of field level officers in the capacity of Agrarian Research and Production Assistants (ARPA) at village level to coordinate activities related to agrarian services and input supply. The government's objective was to entrust Agriculture Instructors and ARPAs on field level agriculture extension. But extremely poor coordination has been observed among these officers; which is a major barrier in field level agricultural extension. Sri Lanka has a slow population growth rate of 1.1% (World Bank, 2016) compared to other countries, especially in the Asian region. But its consistent upward trend has caused some demographic issues. The slow population growth, despite its consistently increasing trend, along with a substantial migration of the young workforce to urban areas for better livelihood opportunities, results in an aging population in rural areas causing the shortage of skilled and experienced labour for agriculture. Subsequently, the agricultural production has become quite costly. This situation has already been observed in the three river basins that are studied.

The World Bank's report on Sri Lanka (2015) lists the average life expectancy of a Sri Lankan at birth as 74.96 years and the fertility rate per woman is about 2.06. The UNFPA has projected that by year 2030, 1 in 5 people will be above the age of 60 years. The same reports indicate that currently, Sri Lanka shows the highest proportion of elderly population in South Asia due to falling fertility rates and decreasing mortality rates.
Conventionally, agriculture in Sri Lanka has been based on three types of water sources. These types are 1. Irrigation by major tanks with a command area greater than 80 ha 2. Irrigation by minor tanks with a command area of less than 80 ha and 3. Rainfed agriculture that purely depends on seasonal rains and phreatic water of the location. Two decades ago, the primary mandate/ responsibility of Sri Lanka's water managers, namely, Department of Irrigation (DoI), Mahaweli Authority of Sri Lanka (MASL) and Department of Agrarian Development (DAD) were to provide the required amounts of irrigation water for cultivated lands in the respective season from each tank or reservoir. However, the situation has now completely been changed to prioritising the provision of domestic water needs, especially drinking water from each surface water reservoir except for a few. As a result, irrigation water scarcity has become a common feature in all of Sri Lanka's irrigation schemes at the expense of its agricultural productivity. This is particularly evident during the failed monsoonal and inter-monsoonal rainy seasons and turns out to be a common feature of the three river basins being studied.
At present, Sri Lanka's agriculture sector enjoys a major share of about 87.3% water use out of the total water withdrawal of the country (Figure 1). It is the same for the three river basins under focus. This could probably be attributed to the facts such as on-farm low water use efficiency, poor adoption of water saving techniques, high losses associated with storage, conveyance and on-farm utilisation of water and the lack of keenness to conserve water due to the state sponsored supply of irrigation water.

With the country's manufacturing and service sectors being expanded rapidly, its agriculture sector will no longer have the opportunity and the logical right to enjoy the present generous consumption of irrigation water in years to come. As a result, more pressure would be on the farming communities, who pay very little attention to the value of water, but who, at the same time, are not prepared to produce *"much with less".*

Out of the three major rice ecosystems discussed in the preceding paragraph, the major irrigation schemes account for 45% of the total asweddumised extent; minor tank irrigation accounts to about 25%, while approximately 30% of asweddumised extent comes under the rainfed conditions. Out of these three rice ecosystems, both rainfed and minor tank systems are subject to frequent crop failures, especially during the Yala season regularly, due to genuine climatological reasons. However, these are the two predominant rice ecosystems prevalent in the three river basins except for some major tanks fed by trans basin diversion of Mahaweli River Scheme in Malwathu Oya basin in Systems H and H1. Under varying climate conditions, seasonal rainfall has become highly erratic in these three river basins and thus, expected inflows to both minor and major tanks in these regions hardly become a reality resulting in increased crop failures or complete crop loss compared to the situations of two decades ago. Meanwhile, rainfed upland crop production (OFCs and vegetables) in these river basins has also become an extremely risky agricultural activity. This is due to frequent and intense droughts and excess soil moisture conditions, caused by varying climatic patterns, being experienced especially in the recent past. Extreme rainfall, droughts and floods have caused severe damages to the island's agriculture.

To add to that,the rising ambient temperatures have already made several negative impacts on the agricultural productivity in Sri Lanka including the three river basins. Spikelet sterility induced unfilled grain rice during Yala season, pollen sterilisation, disturbance to fruiting season of tree fruit crops, increased pest populations, diseases and weed infestation, salinity build-up in soils, depletion of organic matter content in soils and the loss of agro-biodiversity are of some of these negative effects. This situation requires immediate attention to ensure the sustainability of the ecosystem and national food security in general.

Sri Lanka's agriculture sector is already challenged from many aspects such as demographic issues, competition from non-agriculture sectors for irrigation water, and the abiotic and biotic shocks arising from Climate Change. The situation gets worse when several other challenges, threats and trends are added to it. It is essential that all of them be addressed in any endeavour to increase the agricultural productivity in Sri Lanka, including the three river basins being studied.

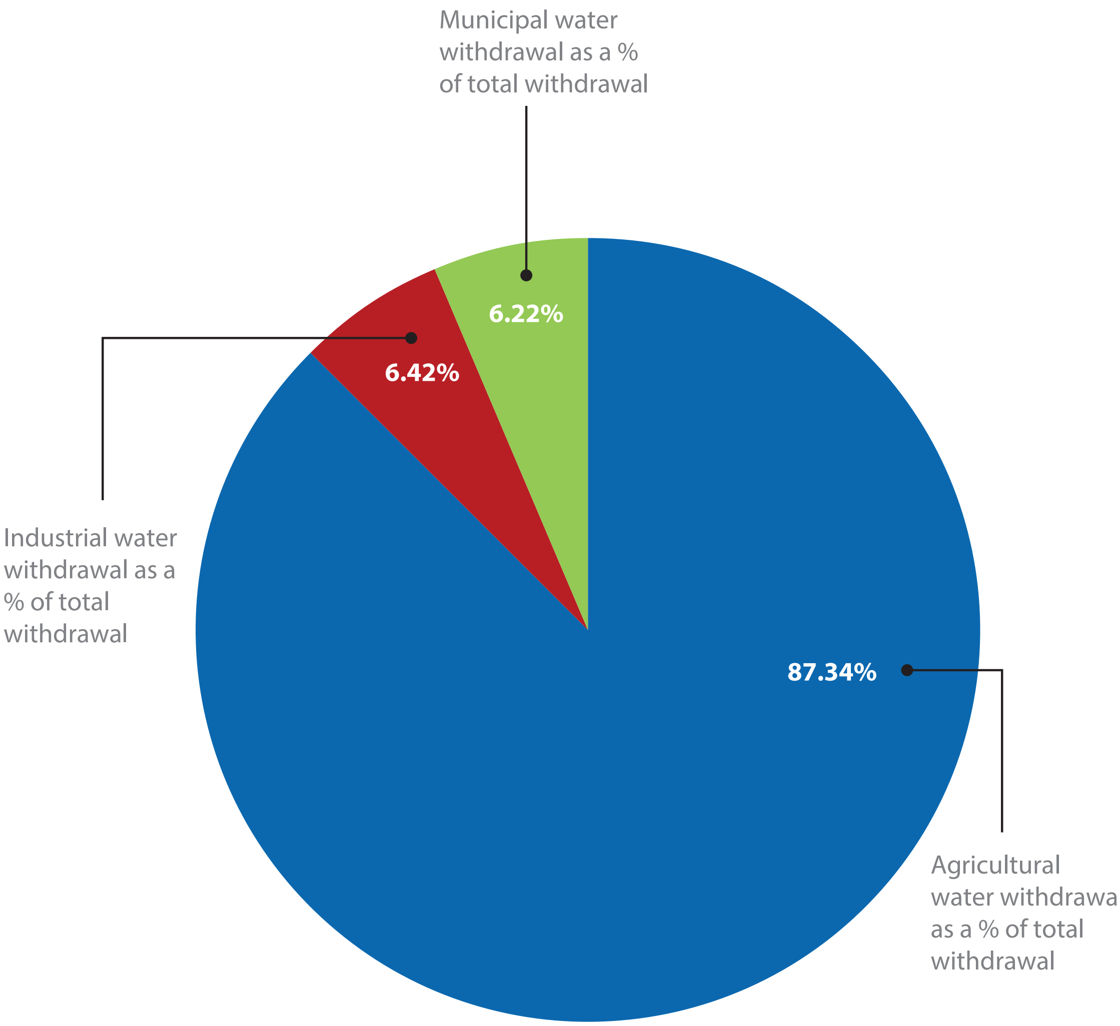


Figure 1. Water withdrawal by sector in Sri Lanka *(Source: AquaStat- FAO-2005)*

Some important issues, requiring urgent attention in order to maximise the agricultural productivity in Sri Lanka and the three river basins being discussed, are listed below:

1. Persistent poverty in rural farming communities that discourages them to break-away from subsistence levels and become commercial farmers.

2. High cultivation costs due to escalating input prices; Good Agricultural Practices (GAP) and farm mechanisation should be encouraged and subsidised as appropriate.

3. Large scale mono-crop cultivations in a specific area, with little thought given to market potential/demand.

4. Increased human-wild animal conflicts resulting in heavy crop damages and life-threatening situations to the farming community. These occur due to recurrent drought, climate aberrations and unplanned development interventions. Measures such as setting up of electric fences along with their periodic maintenance and rational land use planning in development schemes to accommodate the needs of wild animals should be given high priority.

5. Increased risk caused by pest and disease outbreaks under changing climates reducing the agricultural productivity; pest and disease surveillance, extension and awareness programmes need to be implemented with more emphasis on contingency plans to respond to unexpected (but, possible) pest and disease outbreaks during the cultivating seasons.

6. Shrinkage of arable land due to rapid urbanisation, settlements and irrational land use; intensive cultivation to be encouraged with strict enforcement of relevant acts and ordinances, thus avoiding further reduction of such lands.

7. Non-availability of farm machinery at affordable prices and at the required time.

8. Little use of farm machinery leading to high cultivation costs and delays in crop establishment. Hence, appropriate revisions to laws and regulations on land consolidation enabling efficient farm mechanisation, support to local manufacturers in making low-cost and simple farm machinery, inventions of local machinery and modifications to the foreign-made equipment with due legal accreditation should be considered.

9. Unsolved land tenure statuses leading to deteriorating farm productivity. Appropriate revisions to relevant acts and ordinances should be made with minimum repercussions and unrest among parties concerned.

10. Slow technological advancement and dissemination due to inadequate human capital, human resource development, and other physical resources such as respective laboratories and transport.

11. Inadequate adoption of disseminated advanced technology -- with potential better incomes -- due to farmers' lack of adequate start-up capital. Provision of farmer-friendly loan schemes in collaboration with development banks and relevant members of the private sector is vital.

12. Low prices for agricultural produce caused by poor marketing measures and high seasonality of crops, which can be rectified to a large extent, by making market information available at an early stage and by setting up of island wide cold storage facilities through Public Private Partnership (PPP) programmes.

13. Non-availability of quality seeds and planting material at the required time. PPP intervention is essential to bridge this gap, while self- seed production should be popularised with incentives.

14. Increasing demand among consumers for quality food due to improved social standards. Hence, farmer education on sorting, packaging and produce-friendly transport should be encouraged.

15. Increasing risk and uncertainty in agriculture, caused by crop losses mostly due to unexpected weather aberrations, and the inability to establish crops due to prolonged droughts. Options such as weather-based crop insurance schemes depending on the type of crop and mode of irrigation should be introduced.

16. Environmental impacts and associated health issues attributed to indiscriminate use of agro-chemicals. Therefore, strict adherence to respective acts and ordinances that are already in action, is strongly recommended, while continuous monitoring on community awareness should be in place. GAP (Good Agricultural Practices) needs to be followed.

17. Availability of non-agricultural employment for labour force with relatively high wages as compared to farming incomes. Setting up of small and medium scale industries using agricultural produce as raw material should be encouraged for rural areas.

18. Rapid degradation of natural resources essential for agriculture -- soil and water. Continuous stakeholder awareness, strict adherence to relevant acts and ordinances, rewarding mechanisms for soil and water conservation adoption in farmlands are recommended. Relevant institutions should encourage community forestry in farmlands while also promoting GAP measures.

19. Inefficient irrigation water consumption due to storage and conveyance losses caused by poor maintenance of the irrigation structure.

20. Frequent damages to irrigation infrastructures caused by extremely heavy rainy seasons and short duration heavy rains and changing climates. Early warning systems should be active in order to regulate tank water levels before they reach dangerous levels during stormy weather conditions.

21. Salinity build-up in lowland soils caused by increased evapo-transpiration rates and atmospheric warming should be promptly addressed. Effective irrigation and drainage interventions should be made along with appropriate agronomic measures.

22. Land degradation resulted by soil erosion during heavy rains and owing to inappropriate irrigation practices such as hose-irrigation -- with subsequent siltation of downstream surface water bodies including village tank cascade systems. The adoption of appropriate soil and water conservation measures along with micro –irrigation (e.g. sprinkler irrigation) applications should be encouraged.

23. Over exploitation of groundwater for lift irrigation. Awareness programmes and demonstrations are recommended so that the water productivity is increased, while maintaining the groundwater source at sustainable levels.

24. Crop damages by stray cattle.

25. Lack of reliable seasonal climate information forecasts with reasonable lead time and finer spatial resolution, which can considerably minimise the damage, risk and uncertainty of agriculture in a changing and variable climate. Capacity development of information generation and dissemination sectors should be appropriately enhanced.

26. Lack of coherent national policies and governance with respect to agriculture, trade and commerce; where an appropriate taxing system should be introduced for imports of agricultural produce in order to regulate the local market prices that are both producer and consumer friendly.

27. Lack of comprehensive and result–oriented, farmer-friendly agriculture insurance schemes.

28. Lowered groundwater table up to an approximate length of 4 km along either side of 36.5 km long trans-basin diversion on the right bank canal of Deduru Oya Project (it augments the inflow to the Mi Oya basin). Although this trans-basin diversion is beneficial to Mi-Oya agricultural interventions in principle, there is a huge social and economic unrest among farming communities in

Deduru Oya basin, after the structure of a 10-20 m deep canal. This is due to the complete drying out of their dug-well drinking water sources, farmlands and several village irrigation tanks.

29. A greater inundation area of the existing paddy lands under the Yan-Oya Project than the new paddy land area developed by the same project. It has also been observed that the existing paddy lands beyond the inundation area of the dam are being leased out by their respective owners for sand mining. It is quite unlikely that these paddy lands will be used for paddy or other forms of cultivation. It should be noted that permission is granted, to the private sector through government tender procedures, for lands in the Yan Oya reservoir inundation area for sand mining.

In a context where the global trends heavily influence food security and poverty, are Sri Lanka's agriculture and food systems capable of sustainably responding to the needs of a growing population and aspirations of ensuring the national food security and eradicating extreme poverty? The answer is a definite 'YES'. Nevertheless, it is essential to positively and effectively address the aforesaid tough challenges and issues. A holistic approach from the respective institutions is vital.

In order to address these highly complex issues in Sri Lankan agriculture, especially with challenges posed by changing climates, the Government of Sri Lanka has endorsed the National Adaptation Policy for Climate Change in 2012. Subsequently, a National Adaptation Plan (NAP) was approved in 2016 with wider stakeholder involvement. NAP has satisfactorily addressed the issues (with possible solutions) in the agriculture sector in its entirety. But it has not focused adequately on the spatial variation of vulnerability regarding Climate Change, particularly in the discussed river basins. Agricultural productivity, specifically in these river basins, has a definite and close relationship with Climate Change. Therefore, there is a dire need to identify climate resilient agricultural technologies to suit Sri Lanka's different agro-ecological environments, addressing its specific river basins.

Chapter 2

EXISTING PRACTICES IN AGRICULTURAL PRODUCTION SYSTEMS AND RECOMMENDATIONS FOR THE FUTURE

2.1 INTRODUCTION

The Dry zone, which covers nearly two thirds of Sri Lanka's landmass, plays an important role in the country's national agricultural production. Even though the agriculture sector's contribution to the Gross Domestic Product declined substantially during the past four decades (from about 30 % in 1970 to 6.9 % in 2017), it is the most important source of employment for the Sri Lankan rural sector workforce. From ancient times, rice is grown as the main crop during the Maha season, which is the main rainy season for the Dry zone. Based on the availability of water either rice or Other Field Crops (OFC) are grown during the Yala season. In the absence of a supplementary irrigation source, farmers usually keep their land fallow causing lower cropping intensity during the Yala season.

Traditionally, farmers practiced different agricultural systems in their lands based on the water availability, supplementary water source and the soil charterers in the farmland. The system was mainly to ensure the respective household's food security. Any excess produce was sold at the village markets and /or shared among close relatives and the community neighbourhoods. With the expansion and the modernisation of agricultural systems and the economy, farmers adopted different production systems based on the availability of resources such as water, land, manpower and machinery. But the climate in the given area has been a significant factor in deciding on their production systems.

2.2 BASIC INFORMATION ON THE RIVER BASINS – MALWATHU OYA, MI OYA, AND YAN OYA

Table 2.1: Estimated number of beneficiaries and the extent of rice lands in the three river basins

River Basin	Total catchment area (km²)	No. of Major Tanks	No. of Minor Tanks and Anicuts	No. of households	Rice land extent (ha)
Malwathu Oya	3,284	5	1,738	307,660	51,002
Mi Oya	1,533	5	1,280	194,161	23,415
Yan Oya	1,598	1	753	107,722	27,879
Total	6,415	11	3,771	609,543	102,296

2.3 SOILS IN MALWATHU OYA, MI OYA AND YAN OYA AREAS AND THEIR POTENTIAL

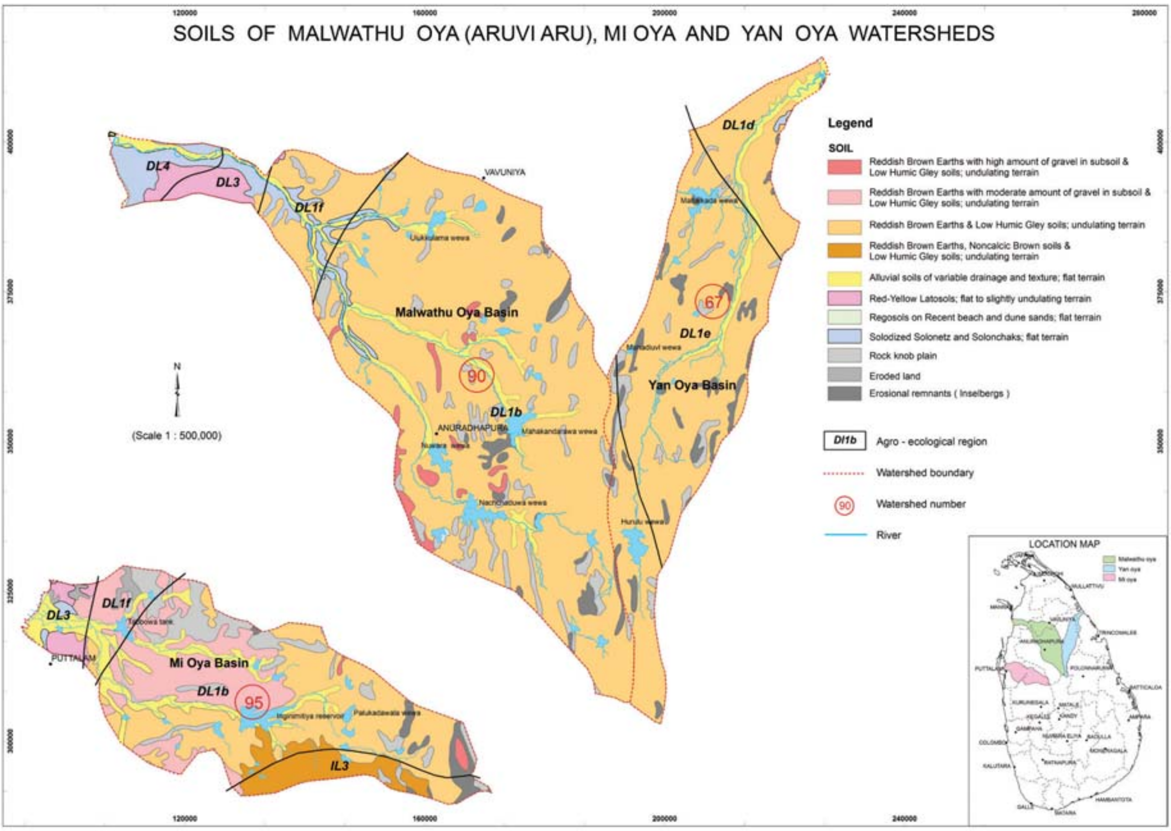


Figure 2.1: Soil characteristics of Malwathu Oya (Aruvi Aru), Mi Oya and Yan Oya River Basins

Listed here are the major soil types found in the three river basins being studied, namely Malwathu Oya, Mi Oya and Yan Oya.

2.3.1 Reddish Brown Earth Soils (Haplustalfs and Rhodustalfs)

These soils, that are reddish to reddish brown in colour, are found in the upper and mid slopes of the landscape in the Dry zone. The normal depth is about 1.0-1.2 m. and its water holding capacity ranges from 100-140 mm/meter depth of soil. The steady infiltration rate ranges from 1-5 cm/hour. The percolation rates of the wet puddled soils for the first time exceed 100 mm/day and remain at a higher value of 10-20 mm/day even after six years of continuous puddling. This soil has good potential for agriculture. If the land is well drained, the area is very well suited for growing fruit crops and other non-rice annual crops.

2.3.2 Low Humic Gley Soils (Tropaqualfs)

These greyish soils are found in the valley bottoms of the undulating topography. Soils are deep and moderately fine textured. Water percolation rate remains at 2-4 mm/day after six to ten years of continuous rice cultivation with puddling. Due to the low percolation rates, the suitability for crop diversification is very low in this soil group. Rice would be the most viable crop.

2.3.3 Non-Calcic Brown Soils (Haplustalfs)

These soils are found in the upper and mid slopes of the landscape. In the scale of drainage, they stand from *well* to *imperfect*. Percolation rate varies from 1-20 mm/hour. There is high potential for crop diversification in these soils during the dry season. However, coarse textured types of this group are low in productivity. If the soil depth is shallow, the cultivation of perennial crops is not advisable.

2.3.4 Old Alluvial Soils (Tropaquents)

These soils are observed in old river terraces. In the scale of drainage, they stand in *imperfectly/poorly drained* levels, with high infiltration rates of 5-40 cm/hr. The water holding capacity is as low as 40-80 mm for a meter depth of soil. These soils are low in productivity. Based on the drainage level, these soils can be utilised for growing of rice or other field crops.

2.3.5 Alluvial Soils (Tropaquents and Tropofluvents)

These are reddish to brownish in colour, moderately fine textured. In the scale of drainage, they stand from *imperfectly* to *poorly drained* levels. Most of these soils are found in flood plains and these soils are generally deep. They are more suitable for rice cultivation.

2.4 AGRICULTURAL PRODUCTION SYSTEMS

Agricultural production systems are comprised of multidimensional components. Production sustainability is influenced by many factors that interact in a complex manner. Cropping systems vary among farms depending on the available resources, constraints, geography and climate of the farm, government policies, economic, social and political pressures, and the mentality and cultural views of the farmer.

Most of the agricultural production systems in Sri Lanka's Dry zone are rice based, since rice, is the country's staple food. From the country's ancient farming civilisation times, a guaranteed rice production at least through one season per year has been considered a crucial factor in terms of food security. Diverse agricultural production systems have come up in the Dry zone, based on the local area's water security, farmers' mindset and the market forces.

Both traditionally, and in modem times, the diversity of production systems could be understood within a meso-catchment cascade basin. In the order of importance these are (a) rain-fed upland or Chena cultivation, (b) lowland rice cultivation under small tank irrigation, (c) homestead mixed gardens, (d) cattle grazing and herding, and (e) food gathering from tank bed and similar sources and (f) game harvesting from adjacent forests.

Farming systems under minor tanks -- typically known as village tank systems -- in the three river basins of Sri Lanka's Dry zone, are three-fold. They are namely Gangoda (homegarden), Chena (shifting cultivation) and Welyaya (lowland rice cultivation). Farming systems under minor tanks are relatively homogeneous in the three river basins. They have evolved through the years based on farmers' knowledge and experience on the utilisation of the village tank system in Sri Lanka's Dry zone. The Dry zone farming system had been regarded as the most stable agriculture production system. This farming system is an outcome of risk averting alternatives from the vagaries of weather, and the subsistence nature of production using natural resources such as land and water and labour.

2.4.1 Agricultural Production Systems in Lowlands

2.4.1.1 Rice- Rice farming system:

This system (Figure 2.2) is mainly observed in areas, where the irrigation water is assured from a village tank for both cultivation seasons. The sowing and harvesting of the principal crop, which is rice, occurs during the two cultivation seasons, Maha (sowing starts in October) and Yala (sowing starts at the end of April). During Maha, the farmlands usually receive sufficient water to cultivate all rice fields. But, during Yala, farmlands mostly receive water in quantities only enough to cultivate small portions of fields.

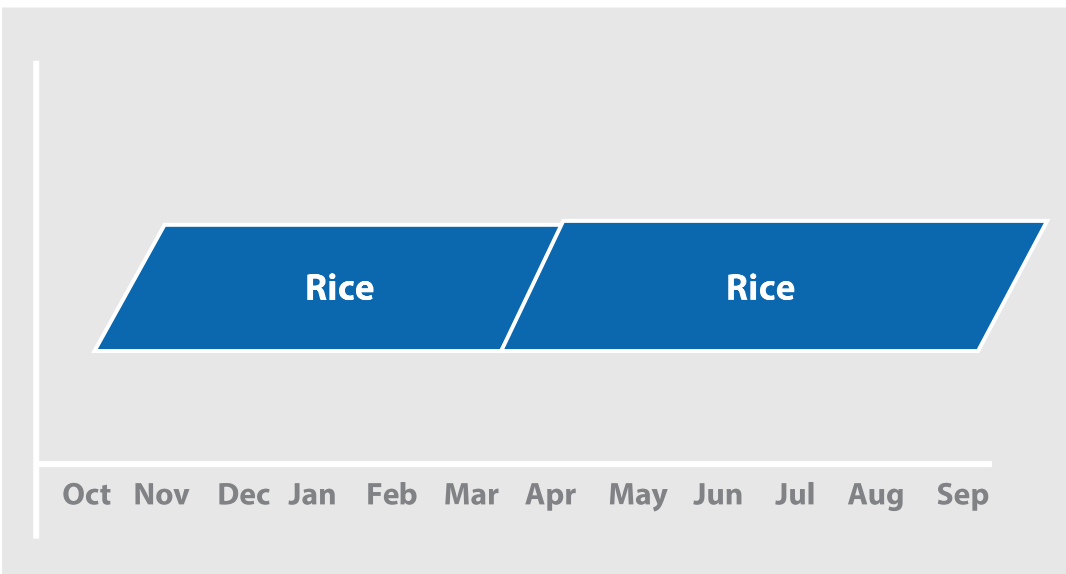


Figure 2.2: Schematic representation of rice/rice cropping pattern

Farmers are particularly affected by shortfalls of irrigation water during this season. If the farmland is supported by a dependable irrigation water supply, those farmers used to cultivate full extent of their lands even during the Yala season despite the poor inadequate rainfall. New, improved rice varieties with harvest time of 3 to 3 ½ months and occasionally with four months harvest time are cultivated during the Maha season; early maturing rice varieties with harvest time of three months or less are cultivated in the Yala season. Very few farmers opt to cultivate varieties with four months' harvest time; varieties recording 3 ½ month harvest time have become more popular among paddy farmers due to their higher yield potentials.

2.4.1.2 Rice- OFC/ Vegetables Production System:

In the three river basins under review there are many minor reservoirs with less than 80 ha of command area. These are predominantly rain-fed reservoirs, which contain the water obtained from immediate catchments. Usually, these tanks are filled during the rainy season; but the resultant water quantity in these tanks is not sufficient for rice cultivation throughout the dry season. According to the drainage classification levels most of these soils come under *imperfectly drained* or *poorly drained* categories. Hence, they are not suitable for non-rice crops. However, farmers grow Other Field Crops (OFC) under minor irrigation schemes avoiding the short rainy period (April, May) in the dry season (Figure 2.3). Harvest time for rice varieties sown for both categories of land depends on the time and intensity of Maha rains. Almost with all minor tanks in the Dry zone, rice is grown only in the Maha season; rice cultivation during Yala season in those areas, is extremely rare.

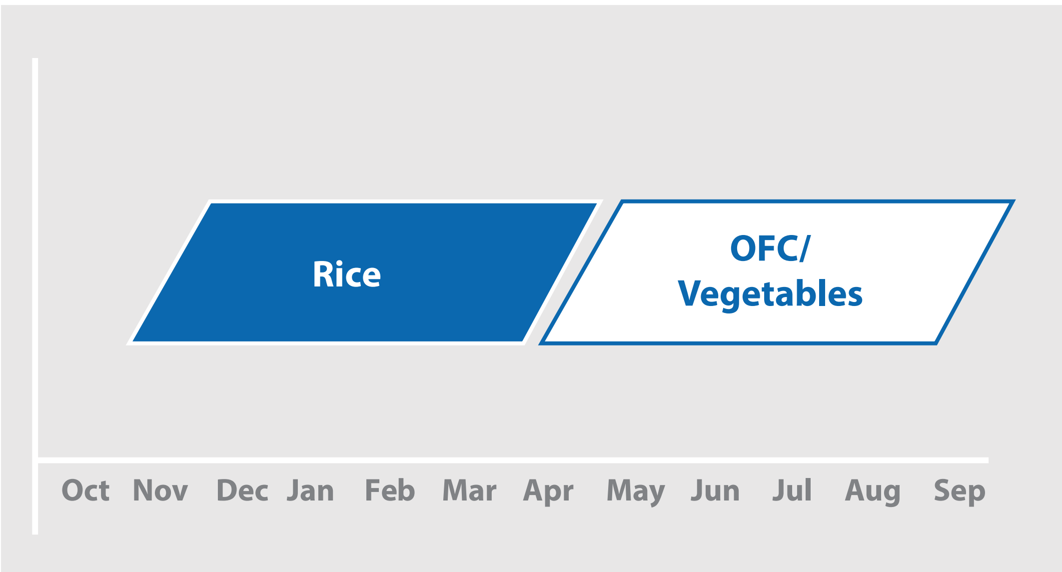
Other Field Crops are grown during Yala season especially in areas, in which enough soil moisture is retained in the rice field. Frequently grown crops are green gram, cowpea and black gram. Some of the vegetable crops that are adaptable to Dry zone conditions are also grown under this system. The success of the cultivations mainly depends on the amount and the distribution of rainfall during the cropping season.

2.4.1.3 Rice- OFC/Vegetable System Supported by Agro-Wells:

In this system, rice is grown during the Maha season since the rainfall is adequate. Rice varieties with medium or long harvest time (3 ½ month or occasionally 4 month) are grown predominantly. Land preparation is commenced with the onset of the Second Inter Monsoon (SIM) rains and farmers adopt all possible measures to use all the water received from the North East Monsoon (NEM) rainfall.

Agro-wells are often dug to tap the shallow groundwater tables boosting the availability of

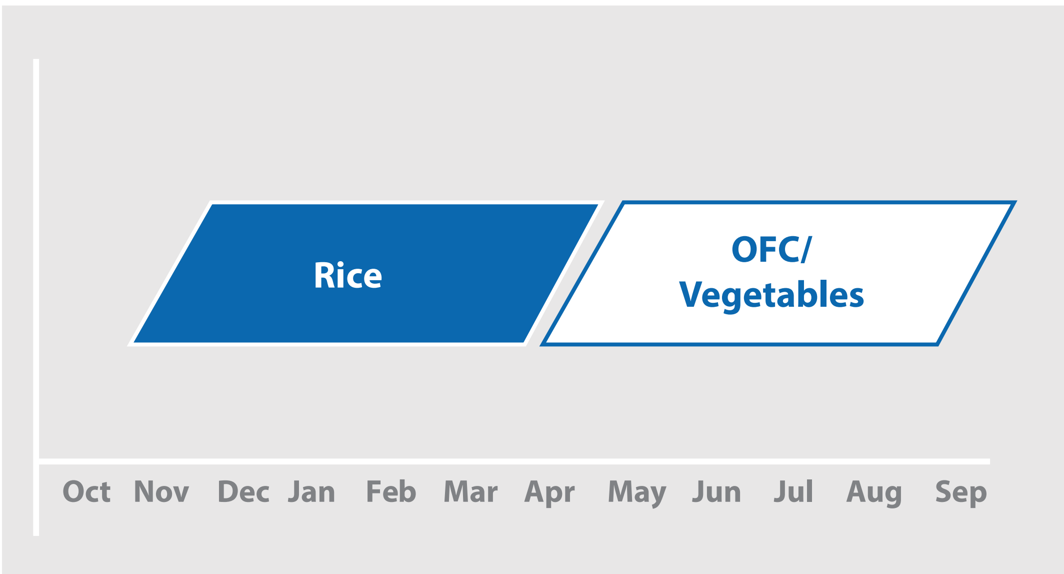
Figure 2.3: Schematic representation of different diversification patterns



irrigation water during dry periods. This is done to mainly support the Yala cultivation. Agro-wells have become very popular and currently there are several thousands of such wells, especially in the Dry and Intermediate zones. The extent of cultivation irrigated by each well ranges from 0.25 ha to 0.5 ha depending on the availability of water.

A variety of crops are cultivated using agro-wells; they range from semi-perennial fruit crops such as banana and papaya to other field crops. In certain areas, farmers choose to cultivate non-rice crops even during rainy seasons by improving the soil drainage conditions.

Figure 2.4: Schematic representation on cropping system supported by agro-wells



2.4.1.4 Bethma system

Photo 2.1: Dry ploughing being practiced by a farmer for the Bethma system in Madugaha Weva - a minor tank in the of Yan Oya basin - 2018 Yala season.

In times of water scarcity -- usually during the Yala season – when the water supply is not sufficient for the entire command area of a minor tank system, only a part of the command area is cultivated. In such circumstances, land for cultivation is allocated to farmers in proportion to the extent of land owned by them. This system is popularly known as the Bethma system. Bethma is a traditional system developed to share equitably a communally owned resource, which is tank water, in times of its scarcity. This practice, which is believed to be unique to Sri Lanka, very importantly, ensures domestic food security (Photograph 2.1).

2.4.1.5 Maize production

This is a new alternative initiated by some farmers, who have access to water through agro-wells or some other water sources, to continue a year around cultivation. Maize is grown either to harvest as green cobs or to harvest at a mature stage. Farmers use several improved agricultural technologies to achieve maximum productivity from their crops. Hybrid varieties are mostly used with some fertiliser application; but no soil conservation measures are practiced in arresting soil erosion. It is necessary to introduce sustainable soil and water conservation strategies to sustain this production system, in order to reduce the environmental impacts to the system.

2.4.1.6 Rice cultivation in submergence zone

In the flood plains of Yan Oya, there is a submerging area on either bank, developed for rice cultivation. During the peak of Maha rains (November to December), these areas become inundated for a long time. As a result, farmers are compelled to delay the crop establishment till early or mid-January, when the situation becomes conducive for seed sowing. Consequently, the respective farmers establish late Maha rice crops especially in the Yan Oya river basin. It is a farming system unique to this river basin, out of the three river basins under review. Once the late Maha season is over, farmers would practice the normal Yala season cropping calendar, provided the First Inter Monsoon (FIM) rains are set on time.

2.4.2 Agricultural production systems in upland areas

Most areas under minor tank irrigation in these river basins comprise of lowlands, which are originally developed for rice cultivation. Nevertheless, there is a considerable uncultivated extent for different uses. These uplands are occupied by the homesteads, farm roads, farm shops and for other community needs. A limited area is also allocated for sole upland cultivation, while many fruit plants and other perennial tree crops such as coconut (Cocos nucifera) and jak (Artocarpus heterophyllus) are grown in homesteads. Despite the restrictions for utilising the forest areas (Mookalana) for regular cultivations, some farmers continue to encroach these areas for growing non-rice crops and perennial crops.

2.4.2.1 Chena cultivations

Chena (or shifting rain-fed upland) cultivation is mainly practiced to ensure the household food security under varying climatic conditions prevailing in the Dry and Intermediate zones of the island. Each Chena would have several crop varieties and cultivars, which may thrive at different degrees of soil moisture. This technique ensures that some variety would fit in the changing rainfall rhythm in a season. Therefore, it is a risk averting strategy practiced by farmers in rain-fed agriculture in the Dry and Intermediate zones. The Chena production system provides some income to contribute to the household expenses of the farming communities during the season.

Chena cultivation begins with the clearing of the forest areas near the village, where the farmers shift/ change the land for cultivation. Usually, after several seasons the soil fertility becomes very low due to repeated/continuous cultivations in the same land. Coarse grains such as maize, kurakkan (finger millets), meneri (Proso millet), legumes such as cowpea, black gram, green gram, and a variety of Dry zone vegetables are the usual crops cultivated in a Chena. Upland rice is also grown by a limited number of farmers at the lowest catenal position of the Chena landscape.

In most Dry zone villages Chena cultivation is being practiced mainly during the Maha season, while during Yala (minor) season the same land is utilised for gingelly (Sesamum indicum) -- a low water consuming crop. At present, the opportunity for cultivation of Chena has become limited due to Climate Change, restrictions from the state and also due to the increasing demand for lands as required by the increasing population.

The poor incomes fetched by Chena cultivations and the increased risk posed by Climate Change have encouraged the farmers in the Dry zone to gradually move towards a commercially oriented agriculture enterprise that could be named as "modified Chena cultivation". This system is linked with technological advances such as the use of hybrid seeds, synthetic fertiliser along with organic manure and micro irrigation. This could be considered a potential CSA intervention in the three river basins that are being explored.

2.4.2.2 Farming systems supported by agro-wells

One of the extremely significant developments that have taken place at a very rapid pace in recent times, is the construction of agro-wells under numerous small tank command areas. Each of these agro-wells can irrigate between 0.2 to 0.4 ha of land by lift irrigation, and the cultivation of high value crops during the dry season has helped improve the farmers' incomes.

It must, however, be emphasised that this shallow groundwater table that is being presently exploited by agro-wells is very limited in quantity, and that it is also of a very ephemeral nature. If over-exploited, it could lead to very disastrous consequences both environmentally, socially and economically. This shallow groundwater table, which is termed as the Regolith Aquifer is restricted to a definite landscape position within a cascade of small tanks. Also, it is not abundant as commonly perceived. The small tanks within the cascade also help recharge and augment this shallow groundwater table during the rainy season, which in turn can be exploited during the dry Yala season. Reliable methods and guidelines have been introduced to assess the location, spacing and density of agro-wells in this Regolith Aquifer of the hard-metamorphic rock basement region in the Dry zone. These guidelines should be enforced and strictly adhered to in order to prevent further serious ecological and environmental degradation already occurring in this small tank cascade environment.

Photo 2.2: A modified Chena cultivation in the Yan Oya basin with supplementary irrigation - 2018 Yala season

2.4.2.3 Home gardening (Gangoda)

Home gardening in Dry zone villages (Photo 2.3) is an important component of their rural eco-complex. It provides a pleasant and environmentally sustainable system made up of a variety of multi-layered crops including perennial tree species. Although well managed home gardening can play an important role in the village tank community, the Dry zone farmers have largely neglected home gardening due to their very high involvement in lowland crop cultivation or Chena cultivation. Therefore, a systematic and appropriate home gardening layout is recommended for the Dry zone to utilise these lands in a productive manner, targeting improved farming community incomes.

Photo 2.3: A female farmer in her home garden (Yan Oya basin) - 2018 Yala season

2.5 RECOMMENDED AGRICULTURAL PRACTICES

2.5.1. Third season cultivation concept in rice fields (sandwich cultivation)

The Third Season concept was introduced by the Ministry of Agriculture, Sri Lanka in early 2010. The practice uses sowing of short duration pulse crops, mainly green gram or cowpea in the fields during the period between two major seasons, soon after the rice harvest. This method enables the use of residual soil moisture, thereby helping the early establishment of crops. In addition to the substantial income obtained through the pulse crop harvest, the soil fertility improvement enabled by this farming system is an added advantage both financially and environmentally. This concept is more suitable for rice lands with the rice-rice cropping system. However, it can also be adopted, where rice is grown only during the Maha season. This cropping system has some distinct advantages such as zero or minimal tillage requirements for land preparation and application of a minimum quantity of agro chemicals and fertiliser. It also needs less supplementary irrigation water.
This practice is more popular in Ampara, Hambanthota and Monaragala districts soon after the Yala season harvest while the opposite is true for North Central and North Western provinces.

2.5.2. Cultivation of short duration OFC subsequent to Maha harvest in the uplands

This practice has many similarities to the Third Season or Sandwich Cultivation concept. But it is practiced in the uplands with zero or minimum tillage using residual moisture soon after the Maha season harvest. This system is widely practiced for cowpea (Vigna unguiculata) cultivation in Mahaoya and Padiyathalawa areas in the Ampara District, where the First Inter Monsoon (FIM) rains help save the crops. Gingelly is usually a Yala season crop that can be cultivated soon after the Maha harvest. Short age cowpea (Vigna unguiculata) and black gram (Vigna mungo) cultivars also can be cultivated in the upland area if the areas receive a few showers from the FIM. This is another recommended CSA intervention to be adopted for the three river basins.

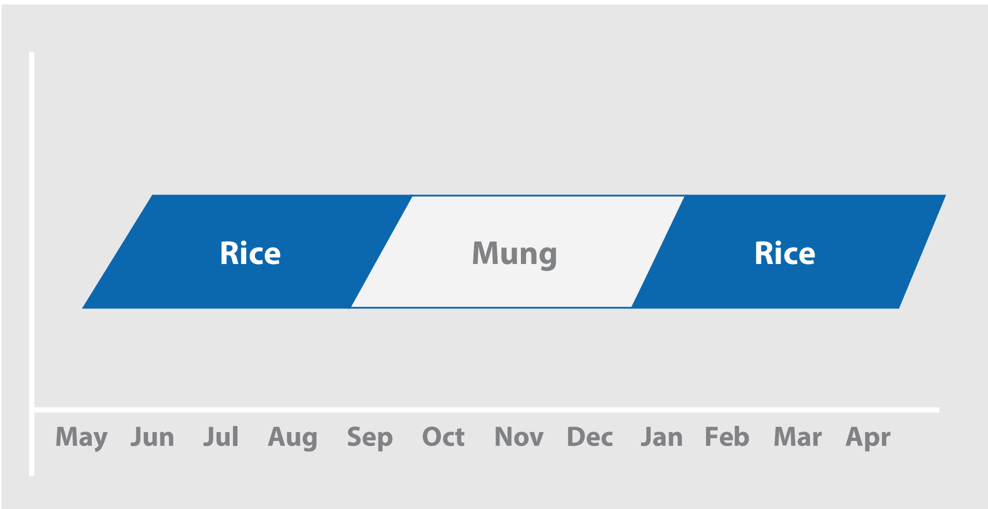


Figure 2.5: Schematic representation on the cropping system under sandwich cultivation

2.5.3. Cultivation of semi-perennial or seasonal crops with agro-well irrigation

Some farmers establish commercial scale cultivations with semi perennial or seasonal crops such as banana, papaya, watermelon, lime, mango, and vegetables including pumpkin and cucumber in the upland areas. These cultivations are supported by supplementary lift irrigation from agro-wells or natural water streams. Sometimes they use micro irrigation (mostly sprinklers) systems to improve irrigation efficiency. These farmers use new and improved agronomic practices targeting high yields with improved quality. They also have formal or informal Forward Contract Agreements with buyers to sell their produce.

2.5.4 Toxin-free agriculture

During the recent past, especially subsequent to the spread of Chronic Kidney Disease with Unknown Etiology (CKDu), widespread interest was generated to promote a system of agriculture free of chemical fertilisers and pesticides. This was initiated in some parts of the Dry zone with some policy makers advising against the use of agrochemicals citing agrochemicals as the sole reason for CKDu. In this particular farming system, only composted organic waste is utilised as fertiliser and pest and disease control are carried out with biological control measures including bio agents. Mostly traditional rice and other crop varieties are used in this farming system; where the yields are comparatively low.

2.5.5. Ecological farming

Ecological farming is recognised as the high-end objective among the proponents of sustainable agriculture. Amidst the differences it has with organic farming, both systems have many similarities. They are not necessarily incompatible. Ecological farming includes all practices applied in organic farming. It uses ecosystem-protecting approaches such as prevention of soil erosion, water infiltration and retention, carbon sequestration through humus formation techniques, and increasing biodiversity. This practice uses many techniques such as no till, multispecies cover crops, strip cropping, terrace cultivation, shelter belts and pasture cropping.

The concept of ecological farming is initially constrained by the same limitations as conventional farming. These limitations include local climate, physical properties of the respective soil, budget for beneficial soil supplements, manpower and available automation. However, the long-term water management by ecological farming methods is likely to conserve and increase water availability for the location, and in comparison, to conventional farming, requires far fewer inputs to sustain soil fertility.

2.5.6. Agro-forestry

Agro-forestry is a land use management system, in which leafy greens, fruits, and vegetable shrubs are grown around or among crops or pastureland. This planned combination of agriculture and forestry has varied benefits, including increased biodiversity and reduced erosion.

Agro-forestry shares principles with intercropping. In both practices two or more plant species (such as nitrogen-fixing plants) are placed in close proximity so that both provide multiple outputs. Consequently, overall higher yields are obtained and due to shared applications/inputs, the costs are halved. Typically, more biodiversity features are achieved through agro-forestry systems than from conventional agricultural systems. Two or more interacting plant species in a specific area create a more complex habitat that can support a wider variety of fauna. Hence, it is understood that agro-forestry provides a more diverse habitat than a conventional agricultural system does. Tropical bat and bird diversity, for instance, can be compared with the diversity in natural forests. Although agro-forestry systems do not provide as many floristic species as forests and do not provide the same canopy height, they do provide food and nesting possibilities. Agro-forestry has another added benefit where biodiversity is concerned; the germplasm of sensitive species can be preserved through this system.

Since agro-forests have no naturally clear areas, habitats are more uniform. Furthermore, agro-forests can serve as corridors between habitats. Agro-forestry can help conserve biodiversity by having a positive influence on other ecosystem services. However, the potential area for agro-forestry in Sri Lanka's Dry zone is limited to a few hectares.

2.5.7. Conservation Farming

Conservation Farming (CF), is as of late being referred to as Conservation Agriculture (CA). It is generally defined as a management system, based on three principles that should be applied simultaneously, in a mutually reinforcing manner. The three principles are: 1. minimum physical soil disturbance 2. permanent soil cover with live or dead plant material (e.g. crop residues), and 3. crop diversification (e.g. crop rotations, cover crops or intercrops with legumes).

Minimum soil disturbance is essential to maintain minerals within the soil, stop erosion, and to prevent water loss that occurs within the soil. In the past, agriculture regarded soil tillage as a key process in the introduction of new crops to a field. It was believed that tilling the soil would increase fertility within the soil through mineralisation that takes place in the soil.

Currently, tillage is considered as a killer of organic matter that exists within the soil cover. No-till farming has been regarded as a process that can save soil organic levels for a longer period, allowing the soil to be productive for longer periods. Also tilling of soil can cause severe erosion and crusting, which leads to a decrease in soil fertility. Additionally, the process of tilling can increase time and labour in the process of producing the crop. Minimum soil disturbance also reduces the destruction of soil micro and macro-organism habitats, a common occurrence in conventional ploughing practices.

The principle of managing the topsoil to create a permanent organic soil cover is that it can thereby allow the growth of organisms within the soil structure. This growth would break down the mulch that is left on the soil surface. The breaking down of this mulch produces a high level of organic matter, which would act as a fertiliser for the soil surface. Continued CF for several years would result in the buildup of ample organic matter on the surface, allowing a layer of mulch to start forming. This layer helps prevent soil erosion and ruining of the soil profile or layout. The presence of mulch also reduces the velocity of runoff and the impact of rain drops, thereby further reducing soil erosion.

Crop rotation is best used as a disease controlling measure against other preferred crops. This process will not allow pests, such as insects and weeds, to be set into a rotation with specific crops. Rotational crops will act as a natural insecticide and herbicide against specific pests. Crop rotation can also help buildup of soil structure. Establishing crops in a rotation allows an extensive build-up of rooting zones, making way for better water infiltration.

2.5.8 High-tech agricultural systems

As mentioned previously the practice of conventional agriculture is becoming economically unprofitable due to many reasons. Operations such as land preparation, irrigation, application of fertiliser and agrochemicals that are crucial for higher yields in many highland crop cultivations, require manual labour. Manual labour is becoming increasingly costly. Hence, automation is seen as a favourable option in reducing labour involvement.

High-tech agriculture uses several techniques/ measures to reduce the cost of production and increase the profitability of farming. Usually, the cost of production in conventional agriculture is mostly due to high costs involved with labour and other inputs.
The initial capital cost in high tech agriculture depends on the degree of automation. Starting from planting up to final harvesting there are several machines and techniques to reduce labour involvement and also to increase the efficiency of resources such as water and fertiliser. This system of farming is gaining popularity among commercial farmers in Sri Lanka. Cultivation under controlled environments in polyhouses or tunnels, in shade houses, in rain shelters and the use of micro irrigation (drip or sprinkler), hydroponics and aeroponics, vertical farming (with or without automation) are some current favourable high-tech agriculture systems.

2.5.9 Improvement for existing agriculture production systems in low land areas

Existing agriculture systems indicated in the sections above have evolved over a long period of time in excellent harmony with the environment. It is obvious that these systems have been very well accepted by the farming communities of the three river basins. However, given the current nature of varying climates, timely action should be devised to educate the farmers on the effective use of rainwater. Respective institutions should diligently convey to the farming communities, the ways of reducing the dependency for irrigation water. Strategies should be coined to promote Good Agricultural Practices (GAP) that are recommended by the DoA, to increase the productivity and the resilience capacity of such systems.

The diverse cropping systems and patterns practiced by farmers in the respective three river basins are noteworthy. Obviously, some of them are not climate smart per se. Therefore, it is very important to identify the promising agricultural practices that would be well adapted in the prevailing agro-ecological environments of the Dry and Intermediate zones. This course of action linked with Climate Smart Agriculture (CSA), would ensure high agricultural productivity in addressing climate challenges.

Chapter 3

CLIMATE SMART AGRICULTURE APPLICATIONS IN OTHER COUNTRIES

3.1 CLIMATE SMART AGRICULTURE (CSA) DEFINITION

Climate Smart Agriculture (CSA) is defined by the FAO as "Agriculture that sustainably increases productivity and income, adapting and building resilience to Climate Change and reducing and/or removing Greenhouse Gas (GHG) emissions when and where possible."

In some countries, Climate Smart Agriculture (CSA) addresses the challenge of meeting the growing demand for food despite changing and variable climates and the availability of little opportunity for agricultural productivity. CSA also focuses on contributing to economic development, poverty reduction and food security, maintaining and enhancing the productivity and resilience of natural and agricultural ecosystem functions. In doing so, it achieves several Sustainable Development Goals (SDG) of the 2030 agenda of the United Nations. This chapter highlights some of the promising CSA practices that are being implemented successfully in other countries such as in Asia, Africa and Latin America. These can be replicated under Sri Lankan conditions with or without modifications depending on the locality, resource availability, and state of the existing environment.

3.2 REPLICABLE CSA APPROACHES IN THE ASIAN REGION

3.2.1 Bringing technology to smallholder farmers' doorsteps through smart phone applications to improve agricultural productivity

Smallholder farmers in Gaya District of Bihar, India use smart mobile apps to upload images and other information related to their agronomical problems including pest and disease incidences to seek advice. Experts of a private agriculture extension advisory company promptly advise the farmers on ways of overcoming the problem. This is smart technology, which can be adopted in Sri Lanka as well, through the development of a similar mobile interface and a communication modality. Already, a similar mobile app has been pilot tested in the Galle District's Agriculture Extension Division to report and be promptly advised by the experts at the Rice Research and Development Institute, Batalagoda.

Developing resilience, in agriculture, to regular weather shocks in the short-term and to Climate Change in the medium to long-term is one of the biggest challenges faced by the farmers countrywide. Farmers in the aforesaid District of Bihar, India have been pilot tested on appropriate farming responses to address prevailing weather conditions. These farmers make smart decisions with the help of climate information such as rainfall, temperature and humidity, provided by an Automated Weather Station (AWS) installed in the village. For example, when the AWS shows temperatures of 35-40 degree Celsius, farmers would wait for cooler temperatures to transplant their paddy seedlings, thus preventing the death of the transplanted seedlings, in high temperatures. Bihar farmers also have been solely relying on traditional knowledge and wisdom previously. But currently, digital technology and information help them reach better decisions faster and they also get correct, timely advice on the best times for sowing, harvesting and other cultivation related activities. The decisions may be either on predictive and/or curative measures promoting sustainable agriculture practices.

Private climate information agencies, like SkyMet in India, that provide daily weather forecasts with finer spatial resolution across the country, are yet to be established in Sri Lanka. Nevertheless, the already available Agro-Met and the local Met Observation Network with over 60 observation points that record daily data of essential agro-meteorological parameters could be effectively used for a similar purpose. It is recommended that both institutions - the Department of Agriculture and the Department of Meteorology - should work hand in hand for a common goal of producing regular Agromet advisories at a finer spatial resolution at least on an agro-climatic zone basis.

3.2.2 Achieving a positive change of income through solar agriculture

A joint venture of the International Water Management Institute (IWMI) and the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) with the support from Tata Trust has set up a "Solar Pump Irrigator's Cooperative" in Dhundi village of Gujarat, India. Since its inception in 2015, it has been hailed by stakeholders as a model for reference to be scaled up for attaining multiple benefits. The benefits include income growth, regularisation of power, sustainable groundwater use and de-dieselising of agriculture leading to a curb in carbon dioxide emissions. Through this cooperative scheme, farmers' incomes have shown a sharp rise as they have been given an option to sell the generated surplus power to the local power distribution companies in the area. Ideally, this is a model for Sri Lanka, especially for river basins in the Dry and Intermediate zones. The required start-up capital, which could be significantly large, is suggested through the government or through an appropriately initiated development project.

3.2.3 India's traditional water harvesting system: climate smart agriculture of yesteryear

Since ancient times, residents of the Indian subcontinent have made efforts to understand the hydrological cycle, and the behaviour of monsoons. India gets 70 to 90 percent of its total rainfall in a period of a few days during the Southwest Monsoon. Therefore, building systems to harvest the seasonal rainfall and making it available over the remaining period until the next monsoon had been the key to survival. Such systems have been in use over generations and references to their vital role in agriculture are often found in literature. The most common structure, which is observed today is the Taal (pond). It resembles Pathaha or rainwater harvesting ponds in dryland agriculture in Sri Lanka's Dry and Intermediate zones. This system is being practiced by the farmers as an adaptation tool to Climate Change.

Meanwhile, in the driest parts of India – Thar Desert -- there is an impermeable gypsum layer, which impedes the percolation of rainwater into saline groundwater deep beneath the sand. This changes the nature of vegetation on the ground. People living in the Thar Desert have learned to tap water from the ground by observing the vegetation type. When the gypsum layer is not too deep, the soil remains moist enough to make it suitable for wheat cultivation, although the annual rainfall of the locality is only about 160 mm. However, even a modified version of this traditional technology cannot be applied in Sri Lanka since there are no such impermeable layers beneath the soil in Sri Lanka's drier regions. However, this technology suggests that the efficiency and benefits of the local Pathaha system can be improved by layering impervious artificial polythene sheets over the wall or by paving with a thick layer of compacted clay.

3.2.4 Climate Smart Agriculture Village (CSV) approach

Climate Smart Agriculture Village (CSV) approach is a community based participatory, technological and institutional intervention. This option was coined to deal with Climate Change complications in agriculture in a village or a cluster of villages. Such CSV projects have been launched by CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) in South Asia: In Bangladesh - Kuhlna, Barishul, Sylhet; in Nepal - Rupandehi, Mahotari, Nawalparasi, Dang, Barisal, Gorkha; and in India - Haryana, Bihar, Punjab, Andra Pradesh and Karnataka. These findings have revealed that a CSV approach is a smart intervention in every aspect such as weather, water, seed, breed, carbon and institutional/market approaches. In this CSV concept, community representatives and researchers work together to identify appropriate Climate Smart options for a particular village. These might include Climate Smart technologies, climate information services, local development and adaptation plans and supportive institutions and policies, all tailored to that community's needs. The community chooses its preferred options in a process that aims to be as participatory and inclusive as possible, encouraging women, youth and more vulnerable groups to participate. This novel approach is highly recommended as a CSA application in Sri Lanka to maximise the production and productivity avoiding duplications and making optimum use of limited resources.

3.2.5 Ecological engineering as a CSA tool – An Integrated Pest Management (IPM) approach

In the village of Rohal Suong in Cambodia, farmers grow rice, vegetables, and other crops which are often subject to severe floods and droughts under a variable climate. With the interventions launched by CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS), the farmers used seed cleansing and management, integrated soil fertility management and rice crop management. With an ecological engineering approach, they use in their farmlands, a versatile, stress tolerant rice variety (CAR-15). It is tolerant to heat, floods, pests and diseases, which also requires less water and fertilisers. In this exercise, along rice bunds, they planted flowering plants to attract specific species of insects that would kill the pests and diseases which are brought into the rice field. As a result, the use of pesticides in the ecological engineering fields was reduced almost by half, while the yield remained the same. This success story can be replicated in Sri Lanka without any extra effort as the IPM concept has already been instilled in farmers' minds as a result–oriented, environment-friendly practice.

3.2.6 Water conserving root- zone irrigation technique in India

A senior Civil Servant of the Government of India, Dr Korlapati Satyagopal invented a water saving irrigation technique and it has been widely accepted by farmers in the semi-arid region of India, especially with horticultural crops. It is known as the Water Conserving Root Zone Irrigation Method. This is a simple modification made to the Conventional Pitcher Irrigation Technique that is already being used by Sri Lanka's Dry zone farmers. The clay pot of the Conventional Pitcher Irrigation Technique has been replaced with four sand columns set up at the four corners of a dug-pit in which the crop sapling is being planted. Sand columns are set up using four PVC pipes of 3-4" in diameter. They would be removed soon after the sapling is covered with the topsoil in the pit at the time of planting. The four PVS tubes can be used for repeated planting of crop saplings in other dug-pits in the same procedure.

3.3 EXEMPLARY CSA APPROACHES IN THE AFRICAN REGION

3.3.1 The Bee-siness of agriculture: A success story in Kenya

People in the Mau Forest's Ogiek in Kenya, have been practicing beekeeping for generations. But their experiences had not spared them of the challenges that come hand in hand with a running business. These include: low production levels, lack of organised marketing structures, low prices due to low quality harvests, wasted hive products, and the lack of skills in improved beekeeping technologies. But now, with adequate and appropriate technical support, their beekeeping industry has improved. Honey production has increased from 2-10 kg to 15-20 kg per colony. In contrast with other traditional farming practices, beekeeping is not resource-intensive. Once the hives are built and the apiaries are correctly placed, the farmers can start harvesting after six months. Ogiek beekeepers sell honey to their respective cooperatives that process, refine, bottle, market, and sell the finished products. The efforts to improve the quality of honey, especially in post-harvest handling, have improved its marketability. Now, it has been certified by the Kenya Bureau of Standards (KEB), obtained bar coding and the Ogiek brand has been registered. A sales outlet in Mariashoni sells this product directly to customers. Environment and forest conservation are given more serious thought with the expansion of beekeeping. Beekeepers are encouraged to plant trees in their apiaries. These trees not only rejuvenate the forest and act as a carbon sink, but also produce flowers that attract bees. This CSA project is an ideal example of how traditional agricultural practices can become profitable businesses using value chain development through public-private partnerships. This also can easily be applied in Sri Lanka's Dry and Intermediate zones.

3.3.2 Mapping out Ethiopia's soil health: A path to a green economy

Ethiopia has 18 soil classes and it is estimated that 80 percent of the country is covered by nine major soil types, a situation almost similar to the Sri Lankan context. A wide range of topographic and climatic factors causes the extreme spatial variability of soils. Inadequate information on soil fertility status can often lead to erroneous applications of fertilisers, further damaging soil health and productivity. Soil analyses have shown that Ethiopian soils are deficient in one or more essential nutrients – namely, nitrogen, phosphorous, potassium, sulphur, boron, zinc, iron and copper. These findings have helped revise fertiliser recommendations at the Woreda[1] and Kebele levels, as well as to identify highly acidic soils that should be rehabilitated with the use of lime. These not only improve farming practices, but also leads to reduced use of urea, (which emits greenhouse gases) and other nitrogen fertilisers.

Since Sri Lanka's Department of Agriculture has also launched a project to provide site-specific fertiliser recommendations, this approach can be easily and effectively used as a CSA tool. This tool would increase the soil productivity and reduce fertiliser expenses. This not only benefits the farmer, but also improves Sri Lanka's overall soil and environmental health. This is a vital step in the country's path to reaching a green economy status.

3.3.3 Improving livestock productivity in Zambia: investing in animal health

In Shesheke, Western Zambia, cattle rearing is more than just a livelihood. It is a culture that is also threatened by the spread of animal diseases. As cattle share watering holes with buffaloes, particularly during the dry season, herds are at special risk for contracting Foot and Mouth Disease (FMD). The country is already faced with the challenge of low productivity in livestock. Hence, a totally disease-free animal population in the country is a prerequisite for productivity improvements. The Livestock Development and Animal Health Project (LDAHP) has allocated US$25.7 million to strengthen the country's veterinary services including surveillance, laboratory diagnostic capacity, control of animal diseases and institutional support to the livestock and agriculture ministry. The LDAHP also supports capacity strengthening of key public institutions in the livestock sector. It has the specific objective of improving the delivery of advisory and technical services to enhance the adoption of good husbandry practices and innovative technologies. The LDAHP promotes the sustainable development of the livestock sector by increasing food production, with the simultaneous reduction of GHG emissions. It has been established that contagious Bovine Pleuropneumonia has been verifiably cleared from 11 out of 18 targeted districts in Zambia with the intervention of the project, and 253,000 livestock farmers have been benefited.

The livestock sector plays a pivotal role in farming communities in the Dry and Intermediate zones of Sri Lanka. Hence, in order to improve the Sri Lankan livestock sector especially in the three river basins under review, the introduction of approaches similar to the ones taken in Zambia, is recommended. It would lead not only to a paradigm shift in productivity but also to livelihood improvement of agricultural communities therein.

[1]Districts, or Woreda, are the third-level administrative divisions of Ethiopia. They are further subdivided into a number of wards (Kebele) or neighbourhood associations, which are the smallest unit of local government in Ethiopia.

3.3.4 Rainwater harvesting in highland cultivation in Niger: A Half-Moon Technique

Millions of smallholder farmers in a major part of sub-Saharan Africa are vulnerable as they continue to live in poverty over the years, while Climate Change has further aggravated their situation. They lack security of tenure and rights to resources and continue to rely on climate-sensitive natural resources to sustain their livelihoods. This plight plunged them into further poverty. In a remedial effort, the Government of Niger launched a CSA development programme in the Maradi, Tahoua and Zinder regions. This venture followed the lessons learnt and success stories from Uganda in the sub-Saharan region. In this exercise they have sustainably managed and rehabilitated 5,498 ha of degraded pastoral land by using the "Half-Moon Technique".

The following steps make up the Half-Moon structure:

1. Find the run-off water direction that would be followed when it rains.
2. Draw a four-meter line. Create a curved line connecting the two ends of the line.
3. The curved side must be downhill from the straight side.
4. Dig 15 to 30 centimeters deep in the soil inside the half-moon.
5. Pile the soil on the edge of the arc to a height of 5 to 10 cm. For extra support, put rocks on the curved edge.
6. Put a pile of organic manure inside the half moon.
7. Mix the manure into the soil.
8. Plant seeds in the half moon after it rains.

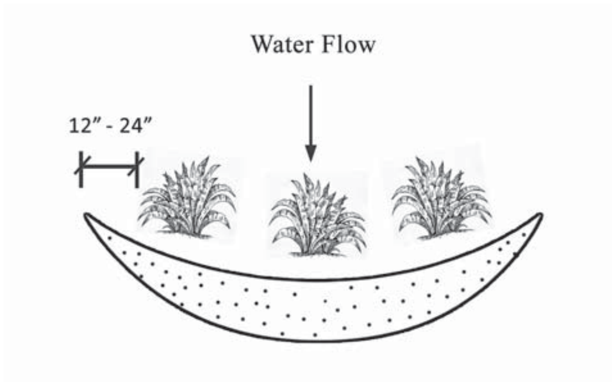


Figure 3.1: Half-Moon Technique in Niger

A similar type of water conservation technique has been introduced to the reddish brown landscape of Sri Lanka's Dry zone already. Niger's Half-Moon technique can be tried out as a CSA tool for Sri Lanka's Dry zone farmers. Its effectiveness and potential are yet to be explored.

3.3.5 Risk transfer mechanism in agriculture as a CSA tool

As emphasised previously, a key component of CSA is building the adaptive capacity to enable various partners in the agricultural production value chain to respond effectively to long-term Climate Change. This element ensures the partners' improved ability to cope with the risks associated with increased climate aberrations. Other actions may include enhancing social safety nets and adopting risk management or risk transfer instruments. Weather index-based insurance, which is being increasingly viewed as an important tool for assisting smallholder farmers to better manage climate risks by enhancing their resilience, is one such measure. Several pilot insurance programmes indicate the authenticity of the available innovative insurance mechanisms. However, a lot more is to be done to understand their effectiveness and in the substantial scale-up efforts in order to achieve a sustainable expansion of efficient agricultural insurance markets in Niger in Africa.

3.4 RECOMMENDABLE CSA APPROACHES FROM THE LATIN AMERICAN REGION

3.4.1 Crop Diversification as a CSA tool

The CSA literature on Latin America is highly comprehensive. These works elaborate Crop Diversification (CD) as a promising CSA tool, which would appropriately include rotating crops, growing different varieties of the same crop, intercropping different species together in the same plots, and employing agro-forestry methods. All these CD interventions can help in the eradication of pests and diseases, mitigate the risks of agronomic or market failures of any single crop, while alleviating the impacts arising from Climate Change. The shades created by agro-forestry systems act as a buffering mechanism to temperature variations and storm events.

In Latin American countries, a considerable portion of the staple crop production - more than 40% of cassava, 60% of maize, and 80% of beans - is grown in poly-cultures as a risk-reduction measure. Other adaptive measures include early planting, switching to cultivars that mature faster, and adopting cultivars with reduced vernalisation[2] requirements, even though the latter is not applicable to Sri Lankan conditions, especially in the three river basins being referred to. In a survey of 2,000 farmers in seven South American countries, it was found that 42 percent of the farmers operated mixed systems of both livestock and crops to mitigate risks, and that the farmers in hotter climates with less rainfall also prefer to have mixed systems.

3.4.2 Soil and water conservation in Latin American countries

Soil and water conservation -- which includes terraces, bunds, live barriers, contour cultivation, grass strips, diversion ditches, check dams, and irrigation pits -- is considered a highly effective CSA intervention in Guatemala and other Latin American countries. The purpose of all these structures is to reduce run-off and soil erosion, which can help increase the soil productivity while increasing crop yields. Terraces are earth embankments constructed at a right angle to the slope in order to create a flat surface for cultivation even on a hillside. Bunds, also called contour banks, are small banks built along the contour of a slope that help hold ponded water.

Both terraces and bunds are often combined with contour cultivation, which consists of cultivating the land on or close to the contour, and at right angles to surface water flow. Each contour bund

[2] The artificial exposure of plants (or seeds) to low temperatures in order to stimulate flowering or to enhance seed production. *https://www.britannica.com/topic/vernalization*

slows down the movement of run-off over the soil thereby giving the water ample time to infiltrate into the soil. Diversion ditches are channels dug into a slope-side that channel water during a high rainfall event, either directing the water into a natural waterway or an irrigation pit in the down-slope, a small reservoir that can be used to later deliver water to terraced land downstream.

Check dams are small dams built across the drainage ditch that help reduce gullying and allow sediments to settle within the landscape. However, there is significant overlap in the soil and water conservation literature on other Climate Smart Agriculture practices covered under CSA interventions in Latin American countries that are equally applicable in a Sri Lankan context as well. Therefore, it is more advisable to make a holistic approach of CSA activities in a region, without implementing them in isolation to achieve the intended goals.

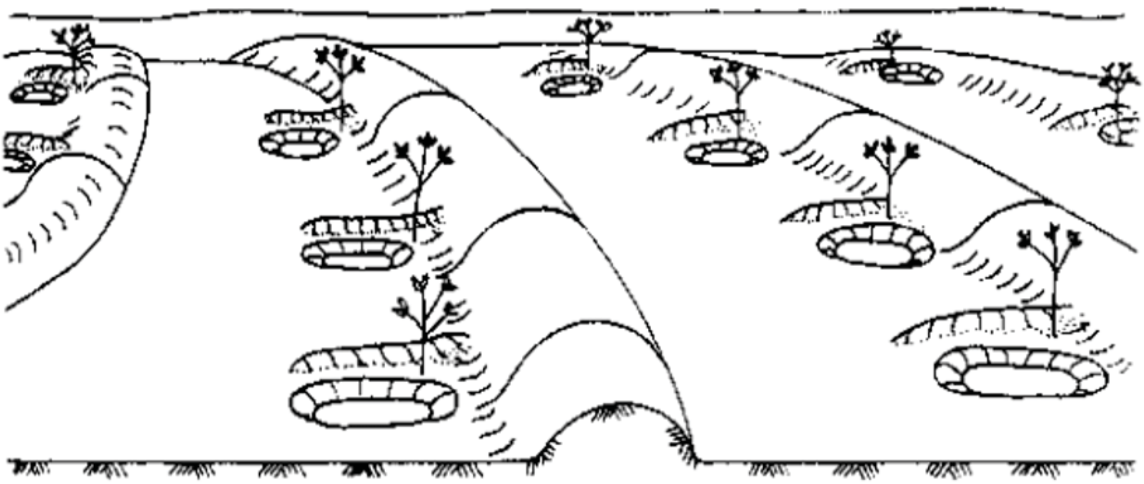


Figure 3.2: Contour bunds *(Source: FAO)*

Chapter 4

4.1 INTRODUCTION

CSA ADOPTION IN THE DRY AND INTERMEDIATE ZONES OF SRI LANKA, WITH SPECIAL FOCUS ON THE BASINS OF MALWATHU OYA, MI OYA AND YAN OYA: ENABLERS AND CHALLENGES

Adoption of CSA interventions by farmers in Sri Lanka, in the three respective river basins, needs not only thorough coordination among many agencies such as government, non-government, private sector, formal and informal power groups, but also their support. The challenges and constraints for interventions to be applied with farming fields and communities require serious attention. Therefore, knowledge on institutional and other factors supporting and challenging the CSA adoption countrywide, particularly in Sri Lanka's Dry and Intermediate zones, is essential for effective implementation of such an action plan. In Sri Lanka, a legal and institutional framework is in place for anchoring Climate Change influenced issues, by sectoral policies to address its adaptive and mitigation capacities. Sri Lanka's main national policies and frameworks concerning CSA include:

1. Forest Ordinance No. 16 of 1907
2. Land Development Ordinance No. 19 of 1935
3. Irrigation Ordinance No. 32 of 1946
4. The Soil Conservation Act No. 25 of 1951 and Amended Act No. 24 of 1996
5. The Paddy Land Act No. 1 in 1958
6. The Agrarian Services Act No. 58 in 1979 and amended as Agrarian Development Act No. 40 in 2000
7. Mahaweli Authority Act No. 23 of 1979
8. The National Environment Act No. 47 of 1980 and amended in 1988, 2000
9. Disaster Management Act No.13 of 2005
10. The National Forestry Policy - 1995
11. The National Environmental Policy, 2003
12. The National Watershed Management Policy - 2004
13. The National Policy on Wetland - 2005
14. The Action Plan for Haritha Lanka Programme, 2009
15. The National Climate Change Adaptation Strategy (NCCAS), 2011 - 2016.
16. The National Climate Change Policy (NCCP), 2012.
17. National Policy on Protection and Conservation of Water Sources, their Catchments and Reservations in Sri Lanka -2014
18. Readiness Plan for Implementation of Intended National Determined Contributions (NDCs) - 2016
19. The National Adaptation Plan for Climate Change Impact in Sri Lanka 2016 - 2025

Listed here are the government, non-government and private sector agencies that are engaged in diverse agricultural areas providing different services. They can be considered as formal and informal facilitators for CSA adoption.

4.2 FORMAL ENABLERS

4.2.1 Ministry of Agriculture

The Ministry of Agriculture, operating under the central government, is responsible for the execution and coordination of all agriculture development programmes including CSA interventions. It works in collaboration with the provincial ministries of agriculture. The Ministry of Agriculture is primarily responsible for providing policy directives for the implementation of CSA Interventions. The National Agricultural Policy, which is currently being devised, also underscores the importance of Climate Smart Agriculture in mitigating the negative impacts of climate uncertainties for crop production in Sri Lanka.

4.2.2 Provincial Ministries of Agriculture

The three river basins being discussed herein, come under four Provincial Councils namely, North Central Province (NCP), Northern Province (NP), North Western Province (NWP) and the Eastern Province (EP). Their respective Agriculture Ministries are expected to provide the directives to field staff for implementation in their relevant farming areas. The Provincial Departments of Agriculture under the purview of the respective Provincial Ministry of Agriculture, provide agriculture extension services to the farming communities in the three river basins.
Malwathu Oya or Aruvi Aru river basin is spread across the NCP and NP areas, while Yan Oya river basin lies across the NCP and EP. The basin of Mi Oya covers the drier parts of the NWP. The Ministry of Agriculture under the Central Government takes all required steps towards the well-coordinated implementation of programmes in line with national agricultural policies relevant to these provinces.

4.2.3 Department of Agriculture

Established in 1912, the Department of Agriculture (DoA) is one of the oldest government departments. It is mandated for the countrywide generation, development and dissemination of agriculture technologies along with CSA. There are 12 divisions of the DoA headed by directors. The eight institutions listed below, are responsible for functions related to CSA interventions:

1. Rice Research and Development Institute (RRDI), Batalagoda: Development of climate smart rice varieties and technologies.

2. Field Crops Research and Development Institute (FCRDI), Mahailuppallama: Development and introduction of climate smart other field crop varieties and technologies.

3. Horticultural Crop Research and Development Institute (HORDI), Gannoruwa: Development and introduction of climate smart vegetable varieties and technologies.

4. Fruit Crop Research and Development Institute (FRDI), Horana: Development and introduction of fruit crop varieties and technologies.

5. Natural Resources Management Centre (NRMC) - Peradeniya: (Focal point of CRIWM Project) Implementation of Soil Conservation Act and related interventions in the central hill area of the country. It is also responsible for the compilation of seasonal agro-climatic weather forecasts using the climate forecasts issued by the Department of Meteorology, and their respective dissemination.

6. Seed and Planting Material Development Centre (SPMDC), Peradeniya: Supply of quality assured seeds and planting materials of DoA mandated crops, to the growers. Functions in coordination with its regional stations.

7. Extension and Training Centre (ETC), Peradeniya: Management of extension activities in the six interprovincial areas and conduct agriculture and CSA related training programmes for extension officers at its in-service Training Institutes.

8. National Agriculture Information and Communication Centre (NAICC), Gannoruwa: Compilation, production and dissemination of agriculture related information through print, electronic media and other Information Technology tools.

According to the 13th Amendment to the Constitution of the Democratic Socialist Republic of Sri Lanka, the country's agriculture extension was devolved into nine provincial councils except in inter-provincial areas. The central government identified six inter-provincial areas. The agricultural extension of those inter provincial areas are managed by the Department of Agriculture. The inter-provincial area of Anuradhapura covers the agriculture extension activities of Padaviya and Srawasthipura areas, which come under major irrigated areas, along with 17 minor irrigation schemes. The agriculture extension of these areas is supervised by the Inter Provincial Extension staff units, each comprising of four or five Technical Assistants (TA).

4.2.4 Provincial Departments of Agriculture

There are four provincial departments of agriculture responsible for carrying out CSA interventions in the three river basins, being studied. Table 1 displays the Provincial Department of Agriculture and the number of Agriculture Instructors (AI) allocated for each river basin. Being mandated officials for the implementation of agriculture extension in the three respective river basins the extension staff of the Provincial Department of Agriculture is the most important cluster of officers. But as mentioned previously, in most cases, the area a single AI is responsible for, is too large to handle (about 5,000 ha of agriculture lands). One single AI is required to work with a high number of small farmers (more than 5,000), making it an extremely tough task to perform. Therefore, AIs are compelled to work with a few identified farmers, who are entrusted with the dissemination of the technical messages to their fellow farmers.

Among other drawbacks in the agriculture extension service is the large number of unfilled vacancies in the sector, and the extremely poor status of available extension resources such as transport and communication equipment.

Provincial DoA	River Basin	Admin. Dist.	No. DS Divisions	No. ASC	No. AII	No. of GN
North-Central Provincial Dept. of Agriculture	Malwathu Oya (Aruvi Aru) and Yan Oya	Anuradhapura	6	8 (Thanthrimale, Gambirigaswewa, Anuradhapura, Srawasthipura, Medawachchiya, Kapugollawe, Parangiyawadiya, Thirappane)	11	132
Northern Provincial Dept. of Agriculture	Malwathu Oya	Vavuniya	2	2 (Ulukkulam, Chettikulam)	3	29
North-Western Provincial Dept. of Agriculture	Mi Oya	Kurunegala	5	6 (Galgamuwa, Mahananneriya, Ehetuwewa, Moragollagama, Ambanpola, Giirbawa)	9	37
		Puttalam	1	1 (Nawagathegama)	1	2
Eastern Provincial Dept of Agriculture	Yan Oya	Trincomalee	3	3 (Padavi-Sripura, Morawewa, Gomarankadawala)	7	10
Total- 4	3	5	17	20	31	210

Table 4.1: Area distribution of Agriculture Instructors and Grama Niladharis in the respective river basins with details of Provinces, Districts, Divisional Secretariat Divisions (DS), Agrarian Services Centres (ASC)

4.2.5 The Department of Agrarian Development (DAD)

The Department of Agrarian Development (DAD) was established in October 1957 with an objective of providing basic services that are crucial for agriculture schemes empowered by the Paddy Land Act No. 1 in 1958. It is presently governed by the Agrarian Development Act No.40, introduced in 2000. The main functions of the DAD are: formulation and implementation of Agrarian Law to safeguard tenancy as well as land owner rights; strengthening and development of farmer institutions; agriculture land management and water resource management, especially with regard to minor irrigation schemes. DAD is also working to strengthen and develop farmer institutions such as Farmer Organisations (FO), manage the irrigation water and to strengthen the inputs supply and marketing of products collectively.

The DAD is also vested with the responsibility of the operation and maintenance of small tanks, which are less than 80 ha of the command area. Therefore, the cascade tank system in Sri Lanka is maintained and institutionalised mainly by the DAD. There are 560 Agrarian Services Centres (ASC) established countrywide. ASC is the one stop shop for agriculture services required by farmers. The department has about 9600 Agrarian Research and Production Assistants (ARPA) at grass root level to carry out the mandated functions of the DAD.

4.2.6 Agricultural and Agrarian Insurance Board

The Agricultural and Agrarian Insurance Board has been established under Agricultural Insurance Law No. 27 of 1973. It was set up as the sole state sector insurer to hold the responsibility of protecting the local agriculture and the agriculturalist in disaster situations. The services rendered by the Agricultural and Agrarian Insurance Board during the last four decades have been commendable. It has introduced agricultural insurance as a formal risk management method to the agricultural sector of Sri Lanka, minimised the economic losses suffered by the local farmer community during disasters, and helped the relevant financial institutions by granting agricultural loans to sustain their financial stability in emergency situations. An agricultural crop insurance scheme is now in place for 6 crops namely, rice, potatoes, big onions, chilli, maize and soya beans. An active insurance scheme is important for agriculture especially for smallholders, as a risk transfer mechanism to address the threat to agriculture in the event of challenging climate conditions.

4.2.7 Department of Irrigation (DoI)

A report was made by the Governor Joseph West Ridgeway, during the colonial era on the importance of an institutional body to manage irrigation tanks in Sri Lanka and it paved the way to the establishment of a department for irrigation works in 1900 which later became the Department of Irrigation. The DoI had been entrusted with the restoration and construction of all irrigation works and the maintenance of large irrigation schemes. Presently the DoI facilitates sustainable management and improvements to land and water resources for food, livelihoods and environment under the framework of government policies. The department is mandated to plan out, design, control and manage land and water resources to derive optimum benefits for irrigated locations. The DoI controls major and medium tanks in the island, that have more than 80 ha of command area.

4.2.8 Department of Forest Conservation (DOFC)

The Department of Forest Conservation is responsible for the long-term conservation of protected forests. Most of the government-owned land in the Dry zone belongs either to the DOFC or the Department of Wildlife. Some of these forestland areas have been encroached by those who live close to isolated forest patches in the Dry and Intermediate zones. This is mainly to establish rain-fed upland cultivation plots known as Chena which sustains their livelihoods.

DOFC is vigilant on this issue; recently it initiated a programme to replant the old Chenas with community participation. According to DOFC, this tool named "Farmers' Woodlots Management" turned out to be very effective in re-establishing the forest cover over marginal agricultural lands. Teak is the predominant tree species that was planted in the Dry and Intermediate zones under this project, while for the Wet zone, Eucalyptus was chosen. These forest lands and their sustainability are extremely important in the cascade systems of the three river basins being studied. Therefore, the DOFC role in CSA should be considered of high priority.

4.2.9 Department of Meteorology (DoM)

The Department of Meteorology is one of the oldest departments in Sri Lanka. Though the Department of Meteorology was established in 1948, meteorological observations in Sri Lanka have a long history, dating back to the 1850's. The major functions of the department are to provide aeronautical, oceanic, hydrological, agricultural, meteorological, climatological and astronomical information to government agencies, private sector and the general public in keeping with national interests and international standards. DoM also provides early warnings and weather forecasts reducing citizens' vulnerability with climate related hazards. Since agriculture is totally dependent on climate and weather, the role of meteorology is vital for the sustainability of agriculture in variable weather patterns countrywide.

4.2.10 Divisional Secretariats (DS)

There are 331 Divisional Secretariats (DS) and at village level, 14021 Grama Niladari (GN) Divisions in Sri Lanka. All these offices deliver government services, social welfare and all administrative services to the general public. The number of DS divisions and GN divisions under the three respective river basin areas are given in Table 4.1 as shown previously. The coordination of agricultural development activities at divisional level is also done under the leadership of the Divisional Secretary. Furthermore, the Samurdhi (the poverty alleviation programme under the Government of Sri Lanka) Development Officer, Rural Development Officer, Disaster Management Officer and Economic Development officers are also based in the DS office. Therefore, DS is a vital point for coordination and execution of CSA interventions in the river basins that are being referred to.

4.2.11 Civil Security Department (CSD)

The Civil Security Department was established initially, in 2006 in order to protect the villagers and properties during the civil conflict. Their current responsibilities also include the provision of safe drinking water through Reverse Osmosis (RO) plants. These forces play a prominent role in all the respective villages; almost all of these villages had been previously affected by the conflict. A majority of the male population in the respective villages are employed by the CSD. During the prolonged drought period, remunerations from these services provided an off-farm income for the village households. Almost every household has at least one CSD member. Hence, planning CSA interventions in collaboration with CSD authorities, from the initial stages, may be considered an effective way of getting the CSA message across to the river basin communities.

4.2.12 Samurdhi Development Department

The Department of Samurdhi Development was established under the Divineguma Act No. 01 of 2013. The main objective in establishing this Department was the eradication of poverty and the creation of a society ensuring social justice, through promotion of livelihood, economic development activities centered on the individual, the family, the group and the community.
The Deputy Director of Samurdhi Development is based at District level and the Zonal Manager is stationed at the DS office. Samurdhi Development Officers placed at a village level carry out various livelihood development programmes including agriculture-based types. These are aimed at improving the income levels of rural households.

4.2.13 Samurdhi Development Bank

There are 1074 community based Samurdhi Development Banks (SDB) in all 331 Divisional

Secretariat areas. SDB has the key function of disbursing the Samurdhi subsidies. Furthermore, the banks carry out a range of other social welfare activities such as facilitating micro finance loans to beneficiaries and low-income earners, support in maintenance of compulsory savings and guidance on more promising investments of saved funds.

4.2.14 District Secretariat (previously known as Government Agents - GAs)

The District Secretariat (the modern day Kachcheri) is the main government administrative office for each district. The District Secretariat is headed by the District Secretary. All development activities of the central government aimed at each district are coordinated and monitored through this office. Management and coordination of all activities of the Divisional Secretariat is also another function of the District Secretariat. Six District Secretariats namely, Anuradhapura, Kurunegala, Puttalam, Vavuniya, Trincomalee and Mannar, oversee the administrative functions in the respective river basins. District Agriculture Committee (DAC) meetings are held once a month at district level to review the progress of agriculture development activities in the respective district. With the onset of CSA interventions their implementation progress should be a crucial item for discussion in these fora.

The Ministry of Agriculture recently appointed a Director of Agriculture for each district. The main responsibility of the newly posted director is to ensure the smooth implementation and progress of programmes and activities of the central Ministry of Agriculture, within the district.

4.3 INFORMAL ENABLERS

4.3.1 Farmer Organisation (FO)s

The concept of Farmer Organisations (FO) was introduced during the 1978-1985 period with Gal Oya Irrigation Rehabilitation Project as a joint venture between the Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI) of Sri Lanka and Cornell University of USA. The major concepts that evolved from the project were: 1. The Bottom Up Approach in planning and organising; 2. Formation of organisations based on hydrological boundaries and 3. Use of trained catalysts to facilitate the setting up of FOs and to promote self-reliance among the farming communities. Major activities undertaken by FOs included procurement and distribution of agricultural inputs on a cooperative basis, efficient water management, adoption of innovative cultivation methods for greater productivity, enhancing credit and marketing skills and resolution of farmer conflicts.

At present the Department of Agrarian Development, Irrigation Department and Irrigation Management Division of the Ministry of Irrigation hosts about 14,000 FOs based on hydrological boundaries all over the country. There are FOs assisted by the DAD in the three respective river basins. Conducting of seasonal cultivation meetings, ensuring collective and timely cultivations, system and on-farm water management and the distribution of subsidised fertilisers among member farmers, are the main functions of the FOs. Any activity that needs the farmers' involvement, essentially requires the FO endorsement / involvement. Hence, FO involvement in CSA interventions is highly underscored. The recent establishment of women's farmer societies, mainly in the North Central Province by the MoA, is noteworthy, although their functions, mode of operation and the levels of coordination between the other existing organisations are yet to be defined.

4.3.2 Local Government Authorities (LGA)

Pradeshiya Sabha or Divisional Councils and Town Councils are the most common local government bodies found in Sri Lanka. Since they are politically appointed bodies their involvement in agriculture development activities is minimal. However, due to their political affiliations and influence they have on other members of society their existence can be significant. Therefore, support and cooperation of the LGAs are vital for the successful implementation of CSA interventions.

4.3.3 Organised Markets

The Dedicated Economic Centre, Dambulla is an organised market for agricultural produce for farmers in Matale, Anuradhapura, Kurunegala, Puttlam and other districts. Farmers and collectors bring their produce using various modes of transport such as bullock carts, two or four-wheel tractor trailers, lorries and vans to sell their produce at wholesale prices. These markets are operational mainly during the night as the perishable commodities can reach their destinations by the following morning. Similar markets are operated in Embilipitiya, Keppetipola, and Nuwara Eliya as well. Farmers' informal markets and village markets commonly known as Pola are also regarded as small-scale organised markets. In this case, farmers bring their fresh produce to a regular place and at a regular time on a fixed day of the week under the patronage of the LGAs.

4.3.4 Private Sector Companies

There are several private sector companies mostly operated at national level, and occasionally at regional level, providing various services to farmers not only through their business activities but also in their diverse Corporate Social Responsibility (CSR) programmes. These supermarket chains and mega scale rice millers buy the farmers' produce through Forward Contract Agreements and in their collection centers. These are assured marketplaces for their produce. Some agriculture-based companies provide irrigation equipment, high-tech agriculture supplies, special fertilisers and chemicals as per requirement. These underscore the fact that the private sector companies directly or through their dealers play a major role in the implementation of CSA interventions.

4.3.5 Formal Financial Institutions (Banks)

In Sri Lanka, there are many commercial banks that facilitate formal financial assistance to the farming communities in the three respective river basins. In addition, there are some development banks, which also operate under the supervision of the Central Bank of Sri Lanka. SANASA Development Bank (SDB), Regional Development Bank (RDB), Cooperative Rural Bank (CRB) are some of these development banks. They work closely with the farming communities providing micro financial assistance facilities that involve minimum paperwork, complemented by easy repayment schemes. Not only the major commercial banks, but also the Sri Lankan Government has launched special assistance for poor farmers to provide them with credit facilities for agriculture. The government has launched different initiatives to provide low interest loans to smallholder farmers to increase their resource capacity, which then encourages them to invest more on agriculture. However, the unavailability of collateral (e.g. land ownership) often disqualifies the farmers from these financial facilities offered by the government through formal banks.

4.4 INFORMAL INSTITUTIONS AND INDIVIDUALS

Some informal financial institutions have considerable influence on Sri Lankan farming communities regarding the adoption of CSA interventions. Their influence can be either positive or negative. Considering their influence in the rural agriculture sector, it is prudent and worthwhile to make them comprehensively aware of the CSA interventions that are scheduled through the project.

4.4.1 Private vendors

Private vendors play a vital role in influencing farmers in the CSA adoption process. Owners and staff at retail shops, agrochemical shops, village hotels, tea shops, agriculture produce collectors are examples for private vendors. They provide varied amounts of cash as informal loans; sell inputs like seeds, fertiliser and agrochemicals, daily rations, and groceries to the villagers mostly on credit that can be recovered from the sale income from harvest. In many occasions they also sell their farm produce to these vendors. Hence, the obvious influence of vendors becomes quite crucial to be noted in the process of adopting CSA interventions.

4.4.2 Temples and other religious organisations

Villagers have a high respect for religious leaders irrespective of their religion. Buddhist temples are the most common religious places in most of the villages. Depending on the number of people practicing diverse faiths, in many villages in the project area, there is also a Hindu kovil, church and a mosque. Most villagers get blessed by their respective religious leaders and/or in places of worship whenever they commence a new activity in their day to day life; this very importantly includes agricultural operations. Therefore, religious places and the incumbent leaders are important social components in the adoption process of CSA interventions.

4.4.3 Farmer groups/ community groups

For a few generations, some informal community groups such as thrift societies (Seettu Groups), rice production groups (Yaya groups), commodity-based production societies, death donation societies, and farmer women's groups have been in practice in village contexts. They are prominent and active in their own village society and their involvement is extremely crucial in CSA interventions as well. It is observed that women's groups work with a greater sense of responsibility and that they are more devoted towards a common goal, especially when it comes to financial matters. Therefore, serious thought should be given to involve all farmers' and women's groups in CSA interventions, if such groups exist in the respective villages.

4.4.4 Media and word of mouth

Media plays an important role in any society in influencing its members to accept and adopt changes. Traditionally, the main types of media disseminating news have been print (newspapers) and broadcast (radio and television). However, the use of social media -- despite its lesser use among rural communities in comparison with their urban counterparts -- is worth mentioning. Even among villagers the use of smartphones, that offer social media functionality is widespread. Social media differs from traditional media in many ways including, quality, reach, frequency, interactivity and usability. Some of the popular social media sites among Sri Lankans are Facebook, YouTube, Instagram, WhatsApp, and Twitter. Observers have, however, noted a wide range of positive and negative impacts of social media use.

The traditional media outlets have their respective provincial reporters well placed in all districts. These provincial journalists are a crucial link in CSA delivery, by being vital agents carrying news to the entire country about the positive changes to be brought in by successful CSA interventions. Passing of information from person to person using oral communication is known as word of mouth communication. In rural contexts, this informal communication mode plays a very crucial role. It is advised to highlight the importance of providing the right information at the right time to all these formal and informal players.

4.4.5 Informal Credit Providers

Medium or small-scale entrepreneurs operating in villages and individuals, who have been playing the role of informal money lenders exist in almost every rural context. Villagers borrow money from these informal money lenders not only for urgent agricultural requirements but also for personal or family needs. Borrowers are forced to pay considerably high interests to these lenders, in addition to pledging some asset as collateral. There are some rural banks such as SANASA Bank, Samurdhi Bank and certain microfinance agencies, which are gradually moving to rural areas to replace the informal credit providers therein. Nevertheless, these money lenders continue to play a significant role in any new activity, viz. CSA measures, due to the influence they have been making in their respective villages.

4.5 CSA RELATED CLIMATE CHANGE ADAPTATION PROJECTS, FUNDED BY INTERNATIONAL DONORS DURING RECENT TIMES

Climate Change has become a crucial topic for discussion globally. Many scientists have identified agriculture as a sector, largely challenged by Climate Change. Therefore, many donors have supported programmes related to agriculture threatened by Climate Change. Most of these projects are focused on boosting the resilience of agriculture related beneficiaries subject to changing climates. Therefore, it is important to look at the ongoing projects, their goals and activities -- particularly in the river basins being explored and countrywide -- in the process of planning the CSA interventions. It is important to avoid duplications and resulting complex situations.

In view of Climate Change related weather aberrations, the resultant extreme weather events (both droughts and floods) are becoming increasingly common in Sri Lanka. Farming communities being the worst affected, the Small Grants Programme of the Global Environmental Facility (GEF/SGP) of UNDP has executed several community-based adaptation projects across the country during the last decade. Out of those projects, those undertaken during the 2010-2014 period with the financial assistance from Australian AID implemented by a number of Community Based Adaptation (CBA) initiatives are of special significance. Most of these initiatives were mainly similar to CSA; they strengthened the climate resilience of selected rural communities.

In general, these projects could be considered among the country's first scientifically designed responses to manage risks of Climate Change-induced changes to weather patterns and natural resources depletion. It should also be noted that these projects had small budgets (a maximum of USD 50,000 for a 2-year period of operation).

Successful adaptive practices that have shown positive results in these pilot projects of the CBA have been up-scaled by the UNDP to two major projects. They are described in the two paragraphs below. The current GCF funded project itself is also a result of up-scaling of experiences and lessons learnt from those CBA initiatives.

A climate adaptation project titled "Addressing Climate Change Impacts on Marginalised

Agricultural Communities Living in the Mahaweli River Basin of Sri Lanka" has been funded by the Adaptation Fund of the United Nations Framework Convention on Climate Change (UNFCCC). The project had been executed through the World Food Programme initially, and then by the UNDP under the close monitoring mechanisms of Ministry of Mahaweli Development and Environment. The total grant amount of this project was approximately USD 7,989,727 and it targeted the Nuwara Eliya District (Walapane – DS) and Polonnaruwa District (Medirigiriya and Lankapura DSs). The project aimed to benefit about 14,000 farming families in those three DS Divisions. Its overall objective was building diversified and resilient livelihoods for marginalised farming communities in the Mahaweli river basin through effective management of land and water resources. Most of the activities identified under the two project components are seen as appropriate CSA interventions. They aim to enhance the resilience of the marginalised communities to Climate Change in the Mahaweli river basin. This project was initiated in 2015 and was expected to be completed by the end of 2018 with an already granted no-cost extension. The project was extended and is due to end 30th April 2020.

Another Climate Change adaptation project in Sri Lanka has been funded by the Special Climate Change Fund (SCCF) of the UNFCCC. The project objective is to enhance rural livelihoods in three districts of Sri Lanka, namely, Kurunegala, Puttalam and Ratnapura. While many communities are withstanding climate related shocks these three districts have been identified as the most vulnerable in Sri Lanka for climate shocks among a total of 25 administrative districts. The project was originally executed by the Ministry of Economic Affairs from 2014 and later the responsibility was vested upon the Ministry of Disaster Management under which the project concluded in 2017. The project mainly focused on rehabilitating the rural irrigation infrastructure, Climate Change adaptation awareness programmes, value chain development and capacity development.

The Climate Resilience Improvement Project (CRIP) was commenced in 2014 with the financial assistance from the World Bank. It was implemented in collaboration with the Ministry of Irrigation and Water Resources Management. Other partnering institutions were the Department of Irrigation (DoI), Road Development Authority (RDA), Mahaweli Authority of Sri Lanka (MASL), National Building Research Organisation (NBRO) and Provincial Road Development Department (PRDD) in Uva Province. The project mainly focuses on the establishment of a process that would build a more climate resilient economy through an in-depth understanding of impacts of climate, and flood & drought modeling and scenario analysis. In addition, the project supports to implement urgent climate mitigation investments required to ensure the short-term integrity of flood control and irrigation infrastructure, transport network and critical education facilities at risk especially with landslide occurrence. Even though most of the interventions of this project are not directly related to CSA concepts, due to their degree and scale, some of them are still in line with the CSA principles.

4.6 CHALLENGES

Many organisations that come under government and non-government agencies supply goods and services, such as cultivation and produce marketing, to farmers in the Dry and Intermediate zones. Despite the availability of these supporting services, the barriers described below make it harder for farmers to obtain goods and services of quality. It is essential to identify the challenges that exist at grass root level. By doing so, a smooth delivery of goods and services aimed at better agricultural production, especially under challenging climate conditions, is ensured.

CHALLENGES FACED BY FARMING COMMUNITIES:

A. Problem of land ownership/tenure.

B. Land fragmentation from generation to generation resulting in small land blocks that might show poor CSA adoption.

C. Most of these lands come under areas where ancient civilisations existed. Hence, digging of any wells or pits to increase the water storage for farmlands is often misjudged by the relevant authorities labeling the farmers as treasure hunters. Often, they are faced with subsequent legal proceedings.

D. Lack of field level (ground level) coordination among relevant agencies.

E. Social and religious barriers pertaining to animal farming.

F. Most of the farmers in the respective river basins are engaged in off-farm activities currently and farming is not their main livelihood. Therefore, little attention to CSA interventions is given.

G. Less youth involvement in agriculture leading to possible poor adoption of CSA.

H. Climate Change itself poses a higher risk on agriculture resulting farmers to wean-away from farming and therefore, they would not opt for innovative CSA interventions.

I. Women leaving as migrant workers creating not only a shortage of women's labour for CSA, but also a series of social implications, especially household instability and child insecurity.

J. Constant changes in the facilitating environments and political situation, which hampers the planning of CSA interventions.

Chapter 5

RECOMMENDED TECHNOLOGIES AND PRACTICES ON CLIMATE SMART AGRICULTURE INTERVENTIONS

Climate Smart Agriculture technologies and practices suggested by the NTAC for the adoption in three river basins; Malwathu Oya, Mi Oya and Yan Oya basins are listed below. These practices are also applicable to other areas in Sri Lanka's Dry and Intermediate zones. Categorised into 15 thrust areas, they are classified under six thematic areas.

Please note: A few technologies and practices are listed under more than one thematic area. This repetition is due to the role played by those technologies/ practices under each thematic area.

Thematic area 1: Tank Cascade Management
Thrust Area:

1. Tank Cascade Management

Thematic area 2: Soil and Water Management
Thrust Areas:

2. Soil and Land Management
3. Nutrient Management
4. Water Management

Thematic area 3: Agronomy: Research and Development
Thrust Areas:

5. Crop Management
6. Conservation and Management of Genetic Resources

Thematic area 4: Climate Information and Forecasting: Research and Development
Thrust Area:

7. Climate Information

Thematic area 5: Institutional and Social Development
Thrust Areas:

8. Management Integration
9. Agrarian Services
10. Agriculture Marketing and Value Chain Development
11. Social Development Measures
12. Risk Transferring Mechanism

Thematic area 6: Energy and Mitigations
Thrust Areas:

13. Energy Management
14. Mechanisation
15. Post-harvest Operations

The FAO definition on CSA, has three specific objectives which are as follows: 1. Mitigation of GHG emissions from agriculture 2. Adaptation of agricultural practices to Climate Change and 3. Sustainable maintenance or increase of agricultural productivity. Therefore, the CSA practices proposed in the National Guidelines should have the ability to provide at least one or more benefits out of the three FAO listed objectives, to Sri Lanka's agriculture system, especially to the three river basin areas.

5.1 TANK CASCADE MANAGEMENT

Technologies and Practices	Benefits
1. Tank cascade management: Instead of individual tank focused rehabilitation activities, it is recommended to consider a cascade approach, where tanks in forest areas (e.g. Kulu Wev, Olagam Wev), village tanks, anicuts making up one eco-system are included for rehabilitation.	Ensures sustainable rehabilitation of the entire cascade system.
2. Boundary demarcation on village tanks: This prevents unauthorised cultivations in the tank catchment area, by which the smooth runoff flow to the tank from the catchment area is ensured. We recommend identification of land ownership and establishing a proper management approach before boundary demarcation.	Enhanced water productivity.
3. Establishing Gass Gommana and Wev Thavulla: Having suitable perennial trees in the "Gass Gommana" and "Wev Thavulla" will help enhance water availability in tanks. It will also ensure a smooth runoff flow to tank with a minimum amount of sediment.	Facilitates proper management of the tank. Enhances water quality, quantity and productivity.
4. Renovation of tank bunds and developing of access roads: This would guarantee maximum water storage of the tank, while ensuring the easy access to the tank for regular maintenance. Future climatic scenarios and extreme weather events should be taken into consideration while designing the tank bund and other head works.	**An adaptation intervention.** Ensures food security through water and social security.

Technologies and Practices	Benefits
5. Establishing and conservation of Kattakaduwa with suitable tree species: This intervention is important to arrest seepage of salt from the tank minimising the downstream salinisation of soils.	Improves the soil, land and water quality and productivity.
6. Improved catchment yield to the tanks with reforestation and afforestation: Depleted catchment cover of almost all village tank cascades of the Dry and Intermediate zones, is the main reason for low cropping intensity in these regions of the country. A zero-catchment encroachment approach for village expansion is not realistic. Therefore, strategies are needed for proper conservation and maintenance of private lands in the catchment areas. Hence, a tree planting programme with community participation, coupled with the adoption of appropriate soil and water conservation measures should be in place in homesteads situated in village tank catchments. Its purpose is improving the inflow to those village tanks during both rainy and dry seasons.	**An adaptation intervention.** Ensures food security and social security.
7. Establishing/ strengthening of tank cascade Operations and Maintenance (O & M) systems: For effective Operation and Maintenance of a tank cascade system coming under a respective tank, it is advisable to get the respective Farmer *(continued overleaf)*	**An adaptation intervention.** Improves food security of the river basin, by ensuring water security in the given area.

Technologies and Practices	Benefits
7. Establishing/ strengthening of tank cascade Operations and Maintenance (O & M) systems (cont'd): Organisation involved in the decision-making process. Awareness programmes for other users of the tank eco system (fishermen, firewood collectors, free grazing livestock keepers) need to be conducted regularly in order to ensure the sustainability of the tank cascade system.	**An adaptation intervention.** Improves food security of the river basin, by ensuring water security in the given area.
8. Implementation of soil conservation measures in the upstream: Soil and water conservation measures should be promoted in the in-catchment areas to avoid siltation of tanks while increasing the catchment yield.	Improves the land and water quality, and productivity.
9. Systematic de-silting of village tanks: A scientific and systematic de-silting technique for the village tanks can improve the tank storage and thereby the overall system performance, if other required rehabilitation activities on structures like bund, spill, sluice and canal network are also undertaken simultaneously. It should also be supported with institutional capacity building of the farming community under each tank.	Improves the land and water quality, and productivity.

Technologies and Practices	Benefits
10. Establishment of wind breaks with timber trees: A tree belt established around the tank circumference had been an essential element of a village tank during ancient times. The purpose of this tree belt was to reduce the evaporation losses from the tank surface, by slowing down wind velocity over the tanks. However, in most of the tank cascades this tree belt has by now disappeared due to unethical anthropogenic interventions. Re-establishment of this essential tank component would reduce water losses from the tanks during the dry season (conservation at the source), while adding an aesthetic value to the tank environment.	Improves the land and water quality, and productivity.

5.2 SOIL AND LAND MANAGEMENT

Technologies and Practices	Benefits
1. Land preparation with Incipient rain or before rains as appropriate: This helps utilise the rainfall for land preparation saving water in the tanks for future operations.	Uses available soil moisture for land preparation and dry sowing.
2. Land leveling with laser technology: Proper leveling is essential in increasing the uniformity of surface irrigation. Use of laser leveler will lead to a uniform surface of the land for evenly distributed water in the land. But this should be done where the land consolidation is possible.	**An adaptation intervention.** Laser leveling increases the land and water productivity.

Technologies and Practices	Benefits
3. Contour soil bunds in uplands: Contour bunds would reduce the kinetic energy of runoff thereby reducing the surface soil loss (soil conservation).	Improves land productivity; reduces sedimentation of downstream water resources.
4. Mulching with crop residues and trash: Mulching will increase the water retention of the surface soil layer for longer periods after irrigation. This is caused by reduction of evaporation from the land surface, while enhancing the soil fertility in the long run.	Enhances land and water productivity.
5. Boundary demarcation of village tanks: This would prevent the unauthorised cultivations in tank catchments, allowing smooth runoff flow to the tank from the command area above. It would also facilitate the proper management of the tank.	Enhances water productivity.
6. Provide adequate drainage (Kunu Ela): Drainage is crucial in minimising the salinity buildup. It would also facilitate surface drainage from cultivated areas while avoiding the stagnation of water that would otherwise buildup soil salinity.	Improves land and water productivity in a sustainable manner.

5.3 NUTRIENT MANAGEMENT

Technologies and Practices	Benefits
1. Integrated Plant Nutrition System (IPNS): This technique, known as IPNS, supplies essential nutrients by using organic and inorganic supplements (including slow release fertiliser) to meet the crop nutrition requirement.	Increases productivity, reduces the farmers' production cost, and facilitates the **mitigation benefit.**
2. Site specific fertiliser recommendation: Soil and leaf analyses are done using portable testing kits and leaf colour charts. It avoids the dumping of excessive fertiliser to the soil, which can reduce GHG emissions.	Increases productivity, reduces the overuse of fertiliser and facilitates the **mitigation benefit.**
3. Recycling of straw and stubble: Burning of straw and stubble increases the release of carbon dioxide to the atmosphere. Hence, straw and stubble should be used as a soil ameliorant; and mulch would improve the physical and chemical fertility of soil, while reducing GHG emissions.	Increases the productivity, reduces the overuse of fertiliser and enhances the **mitigation benefit.**
4. Production and use of compost with available crop residues: This step increases the soil organic content while improving the soil's physio-chemical status.	Increases land and water productivity and has the **mitigation benefit.**

Technologies and Practices	Benefits
5. Foliar application of nutrients as and when required: The practice prevents the excessive fertiliser application to the soil, while increasing the production of the cultivated crop, especially under drought conditions when the root system is undergoing physiological malfunctioning.	Increases the land productivity with **mitigation benefit.**
6. Non-conventional fertiliser sources: This advice refers to bio-fertiliser sources, bio agents such as nitrogen fixing bacteria, phosphate solubilising bacteria and Azolla.	Increases land and water productivity and has a **mitigation benefit.**

5.4 WATER MANAGEMENT

Technologies and Practices	Benefits
1. Application of rainwater harvesting techniques: This tool is mainly for the rainfed upland farming system. The traditional rainwater harvesting pond system – Pathaha-- is recommended for wide use in the Dry and Intermediate zones. It would direct all the rainwater into a single collection pond made of stone or soil bunds and ditches, preventing the loss of rainwater; also, it would obstruct the rainwater from leaving the respective farm field. In order to minimise the percolation loss of the collected water, the plan is to layer the surface of the collecting tank with a polythene sheet of appropriate thickness or plaster with a non-Montmorillonite clay layer.	**An adaptation Intervention.** If systems are coupled with solar powered water pumps for irrigation same intervention can have a **mitigation focus against Climate Change.** Ensures increased land productivity and food security.

Technologies and Practices	Benefits
2. Improved pitcher irrigation: This method is to be used instead of the conventional pitcher irrigation technique. Four sand columns are to be built in a pit of 2' X 2'. It should be filled with compost and topsoil enabling fruit crops to be irrigated with lesser amounts of water without allowing root zone concentration in a single side of the pit. This tool is for a rainfed orchard system.	**An adaptation intervention.** Ensures increased land productivity without soil moisture stress for the orchards. It is an ideal technique to be adopted in Dry and Intermediate zones. If coupled with solar powered lift irrigation facilities, it also qualifies for **mitigation focus** of the CSA approach.
3. Roof rainwater harvesting: Rainwater falling on a roof-catchment is directed to a PVC tank of large capacity to be used for bucket irrigation of home gardens, food crops and tree saplings during the dry period. This tool is for roof rainwater for home gardening.	**An adaptation intervention.** Ensures home gardening productivity and household food security.
4. Agro-wells and tube wells with appropriate well density: Agro-wells can play a vital role in providing supplementary irrigation water during unexpected dry spells. However, they should be dug with appropriate density for a given area unit, in order to ensure environmental sustainability and the continuous supply of water as per the natural recharge rate of the geographical settings of the location.	**The tool is useful for rainfed upland farming.** Ensures household and national food security; this approach would substantially **contribute to Climate Change mitigation.**
5. Appropriate micro irrigation techniques supported by solar powered pumps: Agriculture is the mainstay of the economy for Sri Lanka's Dry and Intermediate zones. *(continued overleaf)*	Ensures farming productivity and household food security. *(continued overleaf)*

Technologies and Practices	Benefits
5. Appropriate micro irrigation techniques supported by solar powered pumps (cont'd): They are often subject to dry weather conditions. Supplementary irrigation for rainfed upland crop cultivation is essential, especially during the Yala season. Fortunately, these two regions are blessed with abundant sunlight during most parts of the year, except in October to the mid-January period. Hence, the generation of renewable energy through solar power is strongly proposed. The cost involved is considerably high; but sustainability is assured in the long run provided that the right technology is used.	Ensures farming productivity and household food security. Used during drought or unexpected long dry spells especially in rainfed upland cultivation to ensure food security. Increases the land productivity while ensuring food security. Moreover, due to its use of gravity for irrigation support, it may qualify as the **mitigation aspect of CSA** as well.
6. Bucket drip-kits with grow bags: As a counteracting measure against the impact of frequent dry spells on the performance of high value crops, they can be raised in especially made polythene grow-bags of appropriate dimensions. Their management is relatively convenient as it is a controlled environment. The performance of growing systems of this type, can be further improved by provision of simple bucket drip irrigation technique. A water storage tank in an elevated place ensures at least one bar water pressure along the water distribution network.	May act as **a mitigation tool** where inorganic fertiliser use is minimised. Ensures food security through water security.
7. Use of traditional varieties and farming practices when and where applicable: Weather lore appears to be somewhat obsolete in Climate Change related weather aberrations, and related forecasts currently. *(continued overleaf)*	**Low cost adaptation intervention.** May act as **a mitigation tool** where inorganic fertiliser use is minimised.

Technologies and Practices	Benefits
7. Use of traditional varieties and farming practices when and where applicable (cont'd): Such is the case with many traditional crop varieties and practices regarding the vulnerable cropping systems. However, some of these practices (e.g. about land productivity) have turned out to be reliable although they have existed for generations.	**Low cost adaptation intervention.** May act as **a mitigation tool** where inorganic fertiliser use is minimised.
8. Adjusting of irrigation intervals and quantity by taking the prevailing rain spells into account: This technique can save large quantities of irrigation water available in tanks/reservoirs if dry spells occur in the immediate future. This had been practiced even in ancient times in irrigation schemes (Please refer to Kondawatuwana Inscription in Gal Oya during the reign of King Dappula IV (AD 934).	Ensures food security through water security.
9. Restoration of irrigation infrastructure including spills and sluice gates: Most of the irrigation infrastructures located in the Dry and Intermediate zones, especially in the case of minor tanks, have not been subject to systematic and appropriate restoration processes, except for some ad-hoc attempts. Hence, it is suggested that all minor tanks along with their respective irrigation canal networks must be repaired thereby reducing their conveyance loss and increasing the water productivity. Wherever appropriate, tank bunds along with spills should be raised to increase the command area.	**An adaptation intervention.** Ensures food security through water security.

Technologies and Practices	Benefits
10. Strict adherence to cultivation meeting decisions: The decisions of Kanna meetings are always aimed at increasing both land and water productivity of a given tank. Measures should be introduced to have strict action against those who violate Kanna meeting decisions. Such action can enhance collective performances.	**An adaptation intervention.** Ensures food and water security.
11. Improved water inflow to the tanks with reforestation and afforestation measures: Addressing the low cropping intensity, reason for which the reason is the depleted catchment cover of almost all village cascades, we propose to have workable strategies for conservation and maintenance of land in the catchment areas. One such step would be tree planting activities with community participation, which can be coupled with the adoption of appropriate soil and water conservation measures. This would improve water inflow to those village tanks during both rainy and dry seasons.	Ensures food security through both water and social security.
12. Recharging of groundwater through percolation pits: Groundwater recharging assisted by percolation pits is recommended to achieve adequate groundwater levels in dry weather conditions. It also supports the perennial vegetation, and dry weather inflow of streams. This would lead to the improved recharging rate of dug and agro-wells of the respective area, facilitating increased sub-surface water storage for community use.	Ensures food security through both water and social security.

5.5 CROP MANAGEMENT

Technologies and Practices	Benefits
1. Crop diversification: Using soil drainage classification, the well-draining areas can be brought under Other Field Crop (OFC) cultivation thereby maximising the water efficiency.	Increases the land and water productivity.
2. Crop rotation: It is proposed that farmers should be encouraged to change the crop group i.e. shift to nitrogen fixing types such as legumes. This method would improve the soil health, which would eventually enhance land productivity.	Reduces the cost of production, enhances land productivity while **supporting adaptation.**
3. Systematic home gardening: Systematic home gardening is a well recommended step that maximises the utilisation of land, water and other resources.	**Supports adaptation**, reduces production costs, improves land productivity. Ensures safe food supply, thus enriching overall livelihoods.
4. Cultivation of fruit crops such as papaya and guava: Papaya, cashew, pomegranate, citrus, pineapple (under shade) and guava are well adapted to Dry zone conditions, hence better yields and farmer incomes can be ensured.	Enhances livelihoods and increases land productivity.
5. Grafted fruit plants cultivation: Grafted fruit plants are early bearers and would result in good yields in relatively short periods.	**An adaptation intervention.** Adds **a mitigation benefit** as well. Improves land and water productivity and enriches livelihoods.

Technologies and Practices	Benefits
6. Traditional yam cultivation: Yams are well adapted to grow in environments with water shortage and would also provide ample yields to support livelihoods.	**Includes a mitigation benefit.** Improves the land and water productivity.
7. Bee keeping: Bee keeping is a much-recommended occupation for farmers and their families assuring satisfactory supplementary incomes to farmer families.	**Has a mitigation benefit.** Improves the land and water productivity.
8. Sandwich cropping systems using short - age legume types (third season cultivation): Cultivation of early maturing crops such as green gram or cowpea soon after the main rice harvest, thereby making use of the residual moisture, should be considered. This system would supplement farmer incomes while increasing the cropping intensity.	Reduces crop losses; improves land and water productivity.
9. Cultivation of climate smart crops: Early maturing and drought/ heat/salinity tolerant and climate-smart crop types are proposed to be cultivated in the three river basins that are being studied.	Ensures an eco-friendly crop production process.

Technologies and Practices	Benefits
10. Biotic stress management: We recommend Integrated Pest and Weed Management (IPM) as an effective CSA intervention, due to its ability to control damages caused by pests, weeds and other pathogens in an economical and environmentally sustainable manner.	Reduces crop losses; improves land and water productivity, with an added mitigation benefit.
11. Parachute method of crop establishment: Transplanting of paddy seedlings using Seedling Broadcasting Method instead of the traditional direct sowing and machine transplanting have been regarded as a very effective transplanting method.	An adaptation intervention with an added mitigation benefit. Improves land and water productivity.
12. Crop protection from wild animals: Solar powered electric fences and live fences with species like bougainvillea, citrus, agave sisilana, and palmyrah and/ or beekeeping have been identified as effective measures to prevent or minimise damage by wild animals. If the other protection measures are not effective, the use of air rifles can be an alternative.	An adaptation intervention. Improves land productivity.
13. Self-seed production: This step ensures the ready availability of region-specific seeds and other planting material at the beginning of the season.	An adaptation intervention. Improves land productivity.

Technologies and Practices	Benefits
14. Pot culture of crops: Pot culture is considered a climate resilient cultivation practice aimed at saving water and sustaining production especially under adverse weather conditions.	Improves land productivity.
15. Cultivation under controlled environments such as net houses and rain shelters: Cultivation using net houses and rain shelters is also considered one of the climate resilient cultivation practices that save water and other inputs, sustaining and improving production especially under erratic weather conditions.	Improves land productivity and includes a mitigation benefit.
16. Shared cultivation (Bethma Method) When the water supply is not adequate to irrigate the entire command area of a minor tank system, only a part of the command area is cultivated. Then, a smaller portion of the command areas adjacent to the tank bund is shared among the farming community. Land allocation for farmers is in proportion to the extent of land owned by them. This system is popularly known as the Bethma system. This unique land sharing system had been in practice since ancient times as a counter mechanism for natural climatic variability, which can be appropriately applied under unpredictable climates as well.	Improves land productivity and an adaptation strategy.

Technologies and Practices	Benefits
17. Intercropping with leguminous crops that have a nitrogen fixing ability: This measure would provide the supplementary requirement of nitrogen, which would reduce the inorganic nitrogen requirement.	Improves land productivity.
18. Bund cultivation with vegetable crops in paddy fields: This practice would increase the unit land productivity, thereby enhancing community livelihoods.	An adaptation and mitigation intervention.
19. Application of appropriately chosen deep ploughing: Deep ploughing increases the physical, chemical and biological fertility of the soil, thereby increasing its productivity in the upland area.	An adaptation and mitigation Intervention.
20. Food forest system for abandoned uplands: Food forest system is a new holistic approach, which is similar to the Kandyan Forest Garden, where seven layers of trees and crops are planted. (More details in - Agroforestry www.thewire. inagriculture: *Indian farmers are creating "Food forest" to minimise the impacts of Climate Change.*)	An intervention with both adaptation and mitigation effects. Improves productivity.

Technologies and Practices	Benefits
21. Application of Biochar: Biochar is the solid, carbon-rich material obtained through a process of chemically decomposing organic materials at elevated temperatures in the absence of oxygen. Partheenium, and water hyacinth are recommended. However, certain tests need to be carried out to screen heavy metals in these plants before being applied to the soil. (Spot Plant Tissue Analysis)	Improves productivity.
22. Silage making: Promoting silage making among the farming communities is a recommended intervention. Silage is a type of fodder made from green foliage crops, which has been preserved by acidification, achieved through fermentation. This silage can be used for animal feed during the dry season.	Improves productivity.

5.6 CONSERVATION AND MANAGEMENT OF GENETIC RESOURCES

Technologies and Practices	Benefits
1. Use of genetically diverse crop varieties: We recommend the use of multi-resistant varieties to counter biotic and abiotic stresses. This process can ensure the resilience of the farming system against Climate Change impacts.	**An adaptation intervention.** Ensures food security through improved land productivity and minimises input cost.
2. Conservation of wild relatives of crops: This initiative would lead to the conservation of existing genetic resources. It would ensure high resistance of the crops against biotic and abiotic stresses such as Climate Change, and pests and diseases. The wild species could be used in future breeding programmes. It should be noted that most of such genetic resources are nearing extinction or on the verge of extinction due to Climate Change. Hence, their conservation via in-situ or ex-situ is an investment for the future.	**A future focused adaptation intervention.** Ensures food security through improved land productivity; minimises input cost. Ensures global food security under unpredictable climates. This would support future research on CSA.
3. Introduce drought resistant herbs of ayurvedic value The introduction of herbs such as Katuwelbatu (Wild Eggplant -Solanum virginianum) Thippili (Long pepper - Piper longum) at commercial level with proper Forward Contract Agreements is suggested.	A future focused adaptation intervention. Increases land productivity.

5.7 CLIMATE INFORMATION

Technologies and Practices	Benefits
1. Strict adherence to seasonal climate forecasting and Agro-Met Advisory service: The Department of Agriculture and Department of Meteorology regularly issue notifications basing on the Agro-Met Advisory Service and Seasonal Climate Forecast (SCF) specifically focusing on the farming communities. Although this combined effort is made by all these sectors, this service is yet to be fully made use of by the target groups. Some farmers are not aware of these services and some still prefer to depend on their traditional knowledge on climate. The importance in following these government issued notifications should be conveyed/ driven to the farmers.	Improves the irrigation water use efficiency, improves productivity and production levels while reducing the climate risks in varying climates.
2. Appropriate training to FOs on Climate Change adaptations: Arriving at right decisions on the potential extent of cultivation using the Agro-Met Advisory Service and Seasonal Climate Forecast (SCF) is of prime importance to the farming communities. FO members should be adequately trained to use the SCF and accordingly use available storage of the village tank cascade system. Along with the FOs other parties like field level extension and agrarian officers should also be familiarised on these adaptations. An appropriately drawn up media campaign would serve useful in this venture.	Improves both and water productivity and facilitates the optimum use of other inputs.
3. Improved capacity development within DoM: Human resources and infrastructure facilities should be enhanced at the DoM focusing on a state – of – the - art climate information dissemination system at the DoM. *(continued overleaf)*	Improves the efficiency and effectiveness of the regularly issued notifications making them result – oriented.

Technologies and Practices	Benefits
3. Improved capacity development within DoM (cont'd): The importance of finer spatial resolution and reasonable lead time which is made more appropriate for the farming communities is underscored.	Improves the efficiency and effectiveness of the regularly issued notifications making them result – oriented.
4. Surveillance system for pest and diseases emergence: Climate Change may induce the emergence of new and existing pest and disease types to uncontrollably dangerous levels. Therefore, a surveillance system should be established to alert farmers during such situations.	Improves land productivity and an adaptation strategy.

5.8 MANAGEMENT INTEGRATION

Technologies and Practices	Benefits
1. Integrated farming of crop and livestock: It is a well-established fact that animals are less sensitive to weather aberrations than annually planted crops. Therefore, the integration of livestock and poultry into annual cropping systems is seen as a suitable way of increasing the resilience of farming systems against Climate Change. This method also has some other additional benefits such as the availability of organic manure and animals for farm needs. This is not a new concept for the Dry zone farmers in Sri Lanka. Dairy cattle has been an integral component of farming households in the Dry zone. Moreover, this system turns economically beneficial during total crop failures due to drought, flood, or pest and disease outbreaks in their seasonal cultivations.	An adaptation intervention. Ensures food security while contributing to a GHG reduction in a minor or lesser extent.

Technologies and Practices	Benefits
2. Upgraded technology in the livestock sector: Intensive farming systems for integrated agriculture are proposed as another CSA intervention. Also, energy sources such as bio gas, solar power, should be introduced and widely utilised. Farming communities should be guided towards innovative methodologies in livestock breeding, improvements to rearing, management practices and value addition to farming systems.	Ensures food security while contributing to GHG reduction.
3. Crop insurance as an essential factor: Risk-transfer mechanisms such as crop insurance are globally accepted adaptation strategies addressing Climate Change. However, it is up to the insurance firms to design more customer specific schemes -- such as a weather index-based insurance scheme for the Dry zone -- as opposed to blanket schemes set for the entire country. In highly vulnerable regions the farmers' premium should be subsidised by the government to ensure the sustainability of the scheme. The following criteria should be considered: A. Include a wider range of crops, including vegetables and OFC as crops to be insured. B. Make the insurance providers' attendance in cultivation meetings crucial. C. Provide insurance only for the agreed crops and extents. D. As previously mentioned, consider weather index- based insurance schemes as applicable.	An adaptation strategy.

Technologies and Practices	Benefits
4. Conversion of Chena lands to perennial gardens as appropriate: The traditional Chena or shifting cultivation, which used to be rainfed was found to be a good adaptation strategy before the farming communities faced Climate Change impacts. But in the present contexts, Chena cultivation – being only a rainfed system – does not provide rejuvenation solutions because no shifting of land takes place. For annual crops grown in a Chena, moisture stress is a common feature with the impacts of global warming. Hence, in order to improve land productivity, these cropping systems should be transformed to a more resilient series of perennial crops, e.g. to orchards with supplementary micro-irrigation facilities.	Enriches farming community livelihoods/ the country image and thereby a higher possibility of FOREX earnings. Ensures food security, while contributing to GHG reduction.
5. Agro-Eco tourism: Sri Lanka's agricultural region can harness the potential for Agro-Eco tourism. In order to meet such requirements, appropriate infrastructure facilities and capacity building should be provisioned. Ideally, farmer federations should be set up and they, as opposed to individual farmers, should be linked with the relevant members in the corporate sectors such as the hospitality industry. Farmers would then feel more confident, more empowered with a sense of entrepreneurship that would give them additional incomes. Developing country - friendly arrangements such as Fairtrade can be attractive in these approaches. Also, Chena systems, would be potential tourist attractions. Nevertheless, the national government's crucial role in such steps is emphasised herein.	**An adaptation intervention.** Ensures food security. This approach enables farmers to have more control over their lives and decide how to invest in their future. The country would be more recognised in arrangements such as Fairtrade, thereby qualifying to earn more in global markets.

5.9 AGRARIAN SERVICES

Technologies and Practices	Benefits
1. Adherence to Seasonal Climate Forecasting (SCF) and Agro - Met Advisory Service: As mentioned in a previous section (under Climate Information in 5.5) the Agro – Met Advisory Service and SCF notifications should properly reach the farming communities. Media advisories containing both current (Agro – Met Advisory Service and SCF notifications) and appropriately picked traditional knowledge are encouraged. Provincial media outlets (radio, in particular) working in respective areas in the Dry zone may be good partners to work with.	Improves irrigation water use efficiency, increases land productivity and production levels.
2. Appropriate outreach and training to farmers and Farmer Organisations (FO) to help them determine the potential extent of cultivation depending on SCF and available water storage of village tanks: In addition to the above-mentioned media campaigns, display boards – erected in appropriate locations of the river basins -- with relevant and timely message in local languages which target field level extension officers, agrarian officers and all farmers are proposed.	Improves efficiency of irrigation water use and overall productivity.

Technologies and Practices	Benefits
3. Due recognition to agriculture extension officials at Kanna meetings - (Minor Irrigation): In many situations, official recommendations (agrarian and agriculture) are not adhered to and not implemented fully or partially, resulting in total or partial crop failures. We recommend compulsory adherence to those notifications. Attendance at Kanna meetings by agriculture officers, assigned to the project areas, is seen as one definite way of overcoming above mentioned issues.	**An adaptation intervention.** Improves productivity.
4. In-kind support in times of disaster: Frequent flash floods coming from the runoff of torrential rains, is a common occurrence in the areas being studied. These rains can damage freshly sown rice crops, requiring re-sowing and re-fertilising. In such situations, provision of in-kind support is highly recommended. Examples to such support are seed paddy of same or different varieties; parachute trays to assist in broadcasting of seedlings in the same or lesser age groups. Assistance of this nature helps the affected farmers recover rapidly from the shocks caused by weather aberrations.	Helps in the adaptation of CSA practices. Improves productivity.
5. Quick rehabilitation of irrigation infrastructure of disaster hit tanks: This irrigation intervention should be accomplished in parallel with Component 1 of the CRIWMP.	Helps achieve high percentages of adopted CSA practices.

Technologies and Practices	Benefits
6. Strengthening of existing Farmer Organisations (FO) while setting up new FOs: The crucial role played by FOs in the successful introduction and implementation of CSA interventions is reiterated herein. In addition, where applicable, new organisations should be formed, in consultation with the Department of Agrarian Development.	Helps achieve a high success rate of CSA practice adoptions.
7. Awareness of CSA activities among all river- basin communities: For the successful execution CSA interventions all river basin communities should be made aware of the project activities and get them appropriately involved. A comprehensive communication strategy that includes climate programmes for schools, climate group meetings, media programmes and media campaigns should be devised. These community awareness programmes should target people of all age groups.	Helps increase the adoption rate of CSA practices.
8. In depth awareness of land use laws among the people: Most land users are unaware of the laws pertaining to land use. Hence, extremely comprehensive awareness programmes involving all village communities are recommended. *(continued overleaf)*	Helps increase the adoption rate of CSA practices. Increases productivity.

Technologies and Practices	Benefits
8. In depth awareness of land use laws among the people (cont'd): Informative sessions would enable them not only to take respective action against those who violate land laws, but also educate them on refraining from going against the law. Areas of special interest should be the use of water bodies, land reservation, agro-forestry, reserve forests and farmlands.	Helps increase the adoption rate of CSA practices. Increases productivity.
9. Online networking for all agricultural inputs, outputs and other resources: All information pertaining to agricultural inputs, outputs and other related matters should be at the farmers' fingertips. These should be made easily accessible online so that all stakeholders can make prompt and well-informed decisions on their relevant agricultural requirements. For purchase and marketing of both agricultural inputs and outputs the private sector companies are a definite partner of the farmers. Hence, the relevant corporates should be a sure link in the network. To facilitate this network, we recommend setting up of village level cyber centres, providing free Internet access to the farmers.	Helps improve overall productivity, avoid gluts and the short supply of agricultural produce, thereby helping desired marketing while improving profitability.

5.10 AGRICULTURE MARKETING AND VALUE CHAIN DEVELOPMENT

Technologies and Practices	Benefits
1. Farmers organised into commodity groups and linked with the relevant members of the private sector: Productivity improvement is one of the three objectives/pillars of CSA. Solving the issues in agricultural marketing plays a significant role in adopting CSA practices. To make marketing more effective it is recommended that smallholder farmers be organised into commodity groups, and those groups be linked with the relevant members of the private sector for marketing of fresh produce.	Enhances the adoption of CSA interventions by farmers, whose produce gets a guaranteed market.
2. Promote Village Fairs (Pola) in town areas of the river basins: The village market is an appropriate intervention (location and concept wise) for CSA villages in the river basins. Farmers would sell their produce in the open market, which is held at a specific time, on a specific day of the week, in a conveniently accessible location. The other advantage of this Village Fair is the value addition opportunities given to farmers' produce, by groups of enterprising villagers. Examples of these value-added items are dried fruits and vegetables, packed products such as rice, green gram, cow pea, kurakkan (finger millet or African millet) flour, livestock products and prepared foods made with local ingredients like pickles and curd. Those products have a significant demand in the urban set up; hence this arrangement benefits several parties. *(continued overleaf)*	Helps the adoption of CSA interventions by farmers through assured markets.

Technologies and Practices	Benefits
2. Promote Village Fairs (Pola) in town areas of the respective river basins (cont'd): Some intervention is required, often, to facilitate space for the farmers at these weekly fairs, which reduces their food miles.	Helps the adoption of CSA interventions by farmers through assured markets.
3. Value chain management through processing and value addition: It is proposed to introduce methodologies to bring farmers' agricultural produce to more usable forms viz. food, feed, fiber, fuel aimed at conservation. This set of techno-economic activities which is seen as agro processing, can improve many components of their livelihoods. Value addition in general, is the process of changing or transforming a product from its original state to a more valuable state. Methodology used in value addition is called processing; both value addition and processing are hence, interconnected.	The profitability of farming increases; farmers gradually become small entrepreneurs, and would also get motivated to improve their productivity, which is an essential component of the CSA.
4. Forward Contract Agreements (FCA): All steps, from land selection to final delivery of the entire agricultural production cycle, should be included in the FCA. Enacted in 1896, this legal tool, if run smoothly, brings the farmer, buyer and the facilitator to a win-win situation.	Helps improve the marketing component, which leads to farmers' enthusiasm to improve productivity.

Technologies and Practices	Benefits
5. Quality assurance procedures such as GAP and GMP: Food safety is a major concern for the present-day consumer. Good Agriculture Practices (GAP) promoted by the DoA, will make sure the produced crops are safe. Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Participatory Guarantee Systems (PGS) and organic quality assurance procedures should be promoted among farmers as CSA practices.	Contributes to mitigation effect. These practices improve the profitability and productivity of agricultural operation which is essential in CSA interventions.
6. Introduce value addition and value chain development for varieties such as tamarind (Tamarindus indica), woodapple (Limonia acidissima), orange and mango: These are commonly found fruits in the Dry and Intermediate zones. Value addition industries using these varieties should be encouraged.	Enhances people's entrepreneurial skills; thereby improving productivity and profitability. Improves profitability and productivity of agricultural operations. This is essential in CSA interventions and helps to increase productivity.
7. Entrepreneurship fostered from within: Selected entrepreneurs from the village should be provided training with the required assistance so that successful entrepreneurs, who would use locally produced raw materials/ ingredients would emerge from the river basins.	Enhances entrepreneurial skills, thereby improving productivity and profitability.

Technologies and Practices	Benefits
8. Processing technologies and the concept of regional branding: Latest technologies to apply for value addition and processing should be introduced and promoted. Regional branding of products (e.g. "Mi Oya Tamarind Paste") should be encouraged.	Enhances entrepreneurial skills, thereby improving productivity and profitability.
9. Warehouse receipt system: These are new community-based storage systems promoted by regional development banks in Sri Lanka, where farmers can safely store their agricultural produce. Farmers can use the receipt obtained for the produce as a Document of Guarantee for a credit facility with a bank. Once the price goes up after some time, they can sell the produce at a higher price.	Facilitates higher incomes for produce. Enhances profitability.

5.11 SOCIAL DEVELOPMENT MEASURES

Technologies and Practices	Benefits
1. Strengthened extension services: Availability of a well-integrated and efficient extension approach is crucial for the promotion of CSA practices among farmers. There are several government, non-government and private sector agencies involved in agriculture extension, delivering their services in an un-coordinated manner. However, in the three river basin areas, the provincial agriculture extension system is the existing institutional and official system for the implementation of agriculture extension.	**An adaptation intervention.** Improves productivity.

Technologies and Practices	Benefits
2. Improved agriculture extension activities: Improvement and strengthening of the present extension delivery system should immediately happen in consultation with all stakeholders involved in delivering CSA practices to the end users.	**An adaptation intervention.** Improves productivity.
3. Effective use of ICT: Use of information Communication Technology (ICT) for the extension delivery, which makes the extension service more effective and efficient, is highly recommended. Most of the farmers and/ or their family members use smart phones. Therefore, using ICT such as mobile apps, and extension strategies for related activities can be delivered without extra expense or effort. Reviewing of the existing apps and developing of new apps for planning, implementation and marketing should also be a definite focus.	Enhances adaptation. Improves overall productivity.
4. Farmers organised into commodity groups: Marketing of produce is a serious issue that farmers currently face. Formation of commodity groups/ societies would improve their bargaining power and in meeting their marketing challenges. Once established, these societies would federate from village to divisional levels. They can be guided to focus on the productivity, marketing and appropriate improvements to processing of their commodities. These farmer societies should be strengthened through diverse skills enhancement programmes on subjects such as leadership, accounting, bookkeeping and technology issues. Required support should be given to have them officially recognised, so they can directly deal with banks and other institutions.	**An adaptation intervention** Improves overall productivity.

Technologies and Practices	Benefits
5. Crop clinics: Crop Clinics are the agricultural version of health clinics for humans. Crop clinics are considered an important mechanism in the service delivery to farmers. It is recommended that these clinics are arranged for farmer groups so they can deliver product or area specific advisory services coupled with other related services such as agricultural inputs.	Facilitates better adoption of CSA interventions.
6. Village mobilisers: Implementation of field level activities through a village-level mobiliser is a recommended practice, used in most agriculture development programmes. This involves a minimal cost and has a participatory approach. A young farming community member can be selected for this purpose and employed after a brief hands-on training.	Contributes to better delivery of CSA practices and better adoption.
7. Support from mass media, digital and other traditional communication tools, as appropriate: In situations where large numbers of farmers are to be reached, with a limited number of extension officers at service, media (all types) becomes the ultimate delivery tool. Currently, there are many choices available : smart phone apps that are specifically developed for farmers, SMS alerts, provincial radio stations for a wider audience, social media and other ICT tools; and locally - display boards, appropriate print media (posters, banners, leaflets), and the use of public addressing systems.	Contributes to better delivery of CSA practices and better adoption.

Technologies and Practices	Benefits
8. Capacity development of relevant officers: Capacity development of officers makes a better delivery system. UNDP sees capacity development as the 'process through which individuals, organisations and societies obtain, strengthen and maintain the capabilities to set and achieve their own development objectives over time.' As opposed to frequently provided inappropriate and non – technical training activities organised by numerous agencies, the field officers working in these respective river basins, should receive a well-coordinated and agriculture-specific technical exposure programme. In parallel, their leadership and management skills should be honed. We also recommend that these officers' mobility and other resources needed for an efficient extension delivery be improved.	**An adaptation intervention.** Improves better delivery of CSA practices and helps towards better adoption. This would also improve the accountability of the extension workers.
9. Removal of agriculture advisory service from non-technical agencies: This action had been suggested often in the past by many respective sectors. When non-technical agencies provide technical advice to field officers in general, it upsets the respective government technical delivery flow, thereby creating confusion and inefficiency in the entire procedure.	This is an accepted CSA strategy used in many countries.
10. Climate-smart Farmer Field Schools: The Farmer Field School (FFS) is an approach based on people–centered, experiential learning, and it is highly recommended in a Sri Lankan context. *(continued overleaf)*	Facilitates better adoption of CSA technologies.

Technologies and Practices	Benefits
10. Climate-smart Farmer Field Schools (cont'd): The group may consist of 20-25 farmers from the village who meet weekly throughout growing seasons at a test-field of climate-resilient technology. They would share views, concerns, experiences such as the use of in-situ moisture conservation, establishment of community seed banks and other practices, soil conservation, reforestation, and agro-forestry as steps to increase crop production.	Facilitates better adoption of CSA technologies.
11. Farmer to Farmer Extension (F2FE): This system has been in practice in many countries to promote Climate Smart Agriculture interventions due to its proven success. Farmer to Farmer Extension (F2FE) empowers the farmer as a change agent and helps improve adaptation. An inclination to learn fromor follow their fellow-farmers rather than the extension officers has been a common observation.	Improves productivity and better adoption of CSA technologies. These programmess contribute to overall CSA, i.e. they help improve productivity, build resilience and reduce GHG emissions.
12. System of revolving funds: The farmer groups should be assisted with a Revolving Funds Scheme, to which the member farmers contribute a certain amount of cash. These revolving funds can be utilised for the procurement of inputs needed for agriculture production. Later, the funds used by each farmer member should be recovered from the income through the sale of produce.	Improves overall productivity.

5.12 RISK TRANSFERRING MECHANISM

Technologies and Practices	Benefits
1. Climate-smart village concept with wider stakeholder participation: Climate-smart village approach concentrates all recommended practices in one village for the entire farmer community, which is widely used to apply and promote CSA practices. The accepted strategy to promote CSA in many countries is followed here as well.	**An adaptation intervention.** Globally accepted CSA strategies should be promoted as appropriate.
2. Encourage the use of notifications assisted by Seasonal Climate Forecast (SCF) and Agro-Met Advisory: Agriculture Department issues regular notifications from the Agro-Met Advisory Service supported with Seasonal Climate Forecast (SCF) issued by the Metrology Department of Sri Lanka. This service is not widely made use of by the farmers. This is either due to unawareness of the services and/ or due to their heavy dependence and loyalty to traditional knowledge. Farmers should be educated on the importance of SCF and the Agro-Met Advisory Service through a media campaign after establishing a user-friendly and state-of-the-art SCF and Agro-Met Advisory Service for determination of suitable crops varieties, and the extent of land, depending on SCF and available storage.	**An adaptation intervention.** Farmers' adherence to seasonal climate forecast in their farming activities results in increased productivity overall.

Technologies and Practices	Benefits
3. Systems to recognise and appreciate farmer performances and a proper M & E methodology: The introduction of an official Monitoring & Evaluation (M&E) system for the farming communities on CSA, is highly recommended. The farmers, who adopt CSA practices at above average level, should be recognised for their exemplary work and publicly appreciated in some manner. The same conferring is suggested for the field officers, who set an example through high performance with CSA interventions. Private sector companies, financial institutions involved in different phases of CSA practices, and broadcast media promoting agriculture can be potential sponsors for such events. Later, the identified best practices along with their respective achievers could be featured in relevant media as models for other farming communities and, their work documented for future reference.	Knowledge on CSA practices would be widespread and better accepted. Improves productivity.
4. Mechanism to regulate the extent and production: The agriculture sector in Sri Lanka often faces situations of gluts and shortages of many crop varieties. This often creates huge marketing issues that require strategic addressing. Out of the two most workable options, the regulation of seed issue in coordination with the private sector is seen as one. The other option is allowing all crop extents and productions to be decided on, at the cultivation meetings under the close supervision of an identified village level government official, who would work in collaboration with Farmer Organisations and societies.	Helps increase the adoption rate of CSA interventions.

Technologies and Practices	Benefits
5. Inclusion of CSA in curricular of agriculture education: It is strongly proposed that CSA should be included in all the curricular of agriculture schools and agriculture universities.	Helps students understand CSA and would also improve its efficiency.
6. Reinforcement of acts and ordinances related to agriculture, water, land and environment: Reinforcement of all existing acts and ordinances pertaining to the country's agriculture sector is essential.	Policy level Intervention.
7. Cottage Industries such as artisanal handicraft using sedges, clay and wood: Off - farm incomes invariably bring supplementary benefits to farming communities. Therefore, cottage industries using locally available raw materials such as Pan (Cyperaceae family), clay and wood should be promoted among the farmers and their families along with assistance in the marketing of these products.	Off farm incomes facilitate the adoption of recommended CSA practices.

5.13 ENERGY MANAGEMENT AND MITIGATION

Technologies and Practices	Benefits
1. Solar power as an energy source: As previously mentioned, solar power can be extremely effective when used in several phases of the entire agricultural value chain. For example, solar power is ideal for lift irrigation, drying of agricultural produce, and as the energy source for domestic power in households that are off the national-grid supply.	**A mitigation intervention.** Contributes to productivity enhancement. Due to reduced running costs this helps increase productivity.
2. Wind for energy supply: Even though the potential of wind energy in the interior locations of Sri Lanka's agricultural regions such as the Dry and Intermediate zones, is relatively low, mini wind turbines would still be a potential candidate to establish small lift irrigation systems.	This is again a **mitigation aspect** of the proposed CSA interventions.
3. Bio energy: Bio gas using crop residues and animal waste generating from integrated farming systems could be used as an energy source for drying and other forms of energy uses in the river basin households. Even though these communities have a significant knowledge and experience on the use of this natural energy source, its introduction as a cost-effective and an efficient technology has to come along with a subsidy. Left-over material from bio gas plants can be directly used as organic manure.	**A mitigation intervention** towards the achievement of CSA.

5.14 MECHANISATION

Technologies and Practices	Benefits
1. Introduction of appropriate mechanisation: Mechanisation brings in timeliness and precision to agricultural operations, greater field coverage over a short period, cost-effectiveness, efficiency in the use of resources and applied inputs. Mechanisation has an added advantage of attracting the younger generation to agriculture. However, care should be taken to introduce the appropriate machinery to the respective river basins.	Helps improve the productivity and profitability of agricultural operations and attracts the younger generation into a career in farming.
2. CBOs and the private sector to establish machine hiring centres: One of the serious constraints faced by the farmers is the non-availability of appropriate machinery for use at the right time at an affordable fee/ rental. It is proposed that CBOs and the private sector venture together to set up specific machinery hiring centers in the villages, for agricultural machinery. The most needed machinery and instruments are four-wheel tractors, two-wheel tractors, motorised transplanters, rotary tillers, zero till drillers, drum seeders, multi-crop planters, power weeders, and combine harvesters.	This would help farmers to engage in agriculture in a timely manner; and would also improve productivity.

Technologies and Practices	Benefits
3. Rewards to deep plowing as appropriate: Deep plowing (up to 10 inches), when and where necessary is required for productivity improvement of annual crops. Farmers tend to use only rotavators, which would break the soil only up to 4 inches, which is not enough for the root zone development of most annual crops. However, there are certain limitations for deep plowing. If it is carried out once in every season there can be a salinity build-up on the soil. Deep plowing can also increase water losses if the hardpan layer underneath is damaged.	This will improve the productivity of the crops and a deep root zone means higher adaptability to drought which minimises the use of added fertiliser hence mitigation is also done.
4. Use of farm machinery by land and plot consolidation: Most of the rice fields in the project areas have been fragmented through successive generations. Farmers are unable to use machinery in small plots due to the presence of several bunds and these plots are low in productivity. Research has shown that consolidation of small plots can bring a 10% increase of land extent. The project is advised to help the farmers practice plot consolidation. It would facilitate the use of heavy machinery leading to improved efficiency, without affecting the land extent and the ownership.	Helps improve the productivity and reduces the amount of water use due to efficient water management.

5.15 POST-HARVEST OPERATIONS

Technologies and Practices	Benefits
1. Post-harvest processing through farmer federations: In the absence of the private sector in value addition ventures, the farmer federations should be encouraged towards post-harvest processing. It is suggested that the processing facilities are arranged with farmer groups/ farmer federations, making sure adequate quantities of the primary produce are constantly available in the processing factory for continuous operations.	Improves sustainability of agriculture and improves productivity. Helps improve overall productivity, avoid gluts and the short supply of agriculture produce, thereby helping the desired marketing objectives while improving profitability.
2. Reduction of post-harvest losses with the help of appropriate tools such as collapsible crates: Use of crates reduces losses to fresh produce during transport. Previously, the transport space required for empty crates after delivery of produce had been a significant barrier. Collapsible crates have ideally addressed that issue, and hence are highly recommended.	**An adaptation intervention.** Reduced post-harvest losses will improve productivity; also has a mitigation effect.
3. Collection centres with cold storage facilities at regional and community level: Collection centres at regional level with or without cold storage facility - in collaboration with the private sector - are a good way of ensuring the market for agricultural produce. However, for areas where perishable produce is harvested, cold storage facilities are an investment in order to store the surplus in good condition. Depending on the crops grown in the areas, collection centres with or without cold storage facilities should be established and state support should be compulsory for this intervention.	**Involves a Mitigation effect** due to the use of lower quantities of chemicals. The profitability of farming increases; farmers gradually become small entrepreneurs, and would consequently get motivated to improve their productivity, which is an essential component of the CSA.

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