The Republic of The Union of Myanmar

TECHNOLOGY NEEDS ASSESSMENT REPORT For Adaptation

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DISCLAIMER

Foreword

Myanmar is extremely vulnerable to the impacts of climate change and highly exposed to severe weather events such as heavy rains, storm surges, droughts, floods, cyclones and landslides which have increased in intensity and frequency over the last 60 years. According to the Global Climate Risk Index 2019, Myanmar was ranked the third most vulnerable country to extreme weather events for the period from 1998 and 2017. As a developing country, the impacts of climate change have already undermined the country's development. These impacts will continue to worsen in the future if these drivers of climate change are not addressed and if the most vulnerable sectors are not supported.

Recognizing these circumstances, Myanmar ratified the historic Paris Agreement in September 2017. In addition, Myanmar submitted the Intended Nationally Determined Contribution (INDC) in 2015 with two main mitigation areas – forestry and energy, to contribute toward achieving the 1.5ºC 2030 Paris Goal. To support implementation of the country's INDC, Myanmar has participated in the third phase of the "Technology Needs Assessment (TNA)" project aimed specifically at identifying priority technology transfer investments and to assess which environmentally sound technologies (EST) are most relevant for meeting the country's climate change adaptation and mitigation targets.

The Ministry of Natural Resources and Environmental Conservation (MONREC) recognizes that the TNA Project, implemented in collaboration with the United Nations Environment Programme (UNEP) and UNEP DTU Partnership (UDP), and with the Asian Institute of Technology (AIT) funded by GEF, as the first comprehensive national exercise undertaken towards assessing our climate change technology needs. The TNA process was coordinated by the MONREC through the Climate Change Division of the Environmental Conservation Department (ECD), with the consultations of relevant stakeholders, local experts and national consultants.

The TNA report then presents an analysis of barriers to the adoption of selected technologies and the potential solutions to overcome them. Finally, the TNA process has defined a Technology Action Plan (TAP) that provides a clear, informative, and a realistic road map for transferring, adopting, and diffusing the technologies in the country. Thus, the report provides an assessment of the priority technology requirements and action plans for climate change mitigation in energy and industry sectors; and adaptation in agriculture and water resource management sectors.

I am convinced that this report represents a robust assessment of the necessary technologies required to realize the vision of Myanmar's Climate Change Policy, which is to promote *a climate-resilient, low-carbon society that is sustainable, prosperous and inclusive, for the wellbeing of present and future generation*. Therefore, it gives me great pleasure to present this report to a wide range of stakeholders such as decision-makers, policymakers, developing fund holders, potential investors, technology developers, scientists and researchers.

H.E. U Ohn Winn
Union Minister
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Acknowledgement

This report was an outcome of the project on *Technology Needs Assessment (TNA) on climate change adaptation and mitigation for Myanmar,* conducted by the national TNA team of Climate Change Division, Environmental Conservation Department (ECD), Ministry of Natural Resources and Environmental Conservation (MONREC) from June 2018 to November 2020.

The TNA Project was funded by the Global Environment Facility (GEF) and implemented with technical support from the United Nations Environment Programme (UNEP) and UNEP DTU Partnership (UDP) in collaboration with the Asian Institute of Technology (AIT). First and foremost, my appreciation goes to the GEF, UNEP, UDP and AIT for their financial and technical support.

We would like to express our sincere thanks to His Excellency Union Minister of MONREC, U Ohn Winn, for his strong encouragement and leadership, as well as his invaluable suggestions and guidance throughout the period of the project.

On behalf of the government of Myanmar, we are also grateful to Professor S. Kumar (Asian Institute of Technology) and Regional Coordinator Subash Dhar (UNEP DTU Partnership) for their support, encouragement, and invaluable technical inputs for the project.

The MONREC acknowledges the important guidance made by all members of the National TNA Project Steering Committee of the Myanmar TNA Project.

Following the provided methodology and technical assistance, the national TNA team facilitated a series of the stakeholder consultation meetings, bilateral meetings, and working sessions to implement a stakeholder-led Multi-criteria Analysis (MCA) for the prioritization of technologies targeting both adaptation and mitigation sectors. Stakeholder inputs and recommendations were taken into account during all steps of the TNA process, including in the assessment of barriers to implementation of prioritized technologies and the preparation of Technology Action Plans (TAPs).

The active participation and contributions by numerous stakeholders from concerned Government Departments of various ministries, local and international non-governmental organizations, universities, research institutes, private sectors and civil society organizations played a key role in the successful completion of the TNA process. I wish to take this opportunity to express my sincere gratitude to all those who contributed to make this project realistic. Without their supports this project would never be a success. Moreover, my special thanks are conveying to the individuals from government departments and private sectors related with the agriculture and water resource management sectors for climate change adaptation; energy and industry sectors for climate change mitigation.

Since TNA is a country-driven participatory process, drawing on the diverse and combined knowledge of local expertise and international experiences, I have great confidence that this report can provide tangible solutions to support the government's achievement of international commitment for addressing the climate change-related, and in turn improve our county’s long-term economic, environmental and social development goals.

Finally, I would like to express my sincere appreciation to the national consultants, the national TNA team and the staff of the Climate Change Division for their continuous efforts to realize the TNA project.

U Hla Maung Thein
Director General
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Executive Summary

Myanmar is one of the most vulnerable countries to climate change in the world, encountering the adverse impacts which are significantly undermining its social and economic development. More droughts, irregular rains and high temperature are expected under the future climate scenario so that Myanmar has growing concerns for its current and future resilience and interest in adopting climate change adaptation. Therefore, it is a good time for Myanmar to conduct the Technology Need Assessment (TNA) project funded by the Global Environment Facility (GEF) and United Nations Environment Programme (UNEP) through UNEP DTU Partnership (UDP). The main objective of the project is to prioritize the most relevant sector of the country and its associated technologies in order to enhance the resilience to climate change. Being a developing and agrarian country, Myanmar greatly relies on its agricultural production for its economic and all round development. Currently, about 80% of the total cultivated area is under the rain-fed system, highly exposed to the climate change impact. Because of its topographic nature, the country often suffered huge impacts of climate change during the last decades; damages were most serious in agriculture sector. Similarly, fluctuated rains, storms, floods and droughts affected the "Water resource management" sector. The availability of drinking water, water transport, fishery, hydropower and other related issues were adversely impacted. Accordingly, under the TNA process, all stakeholders prioritized the "Agriculture" and "Water resource management" sectors to be the most relevant sectors for climate change adaptation in Myanmar. There exist several improved and advanced technologies directly or indirectly supporting to climate change adaptation. Due to the financing and time constraints, it is impossible to apply all these technologies at a time so that they need to prioritize. Since TNA is a country driven project, all stakeholders concerned were actively involved in each step of the technology prioritization processes. All these processes followed the guidelines proposed by UDP/UNFCCC Handbooks and several other recommended references. The technologies were given priorities, which complied with the country's existing development plans and strategies and had the adaptation potential to match with both the current and future climate change. With the use of Multi-criteria Analysis (MCA), the following three were prioritized out of the ten proposed technologies for "Agriculture" sector: (1) Solar powered drip irrigation technologies in cash crop production and plantation; (2) Conservation Agriculture (CA) technology for sustainable agriculture lands and (3) Improvement of salinity tolerance rice varieties in coastal and inland salinity areas. Similarly, the three most relevant technologies were short-listed from the nine technologies nominated in the "Water resource management" sector. They were - (1) Renovation and improvement in village ponds and tube wells for better livelihoods in Dry zone; (2) Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar and (3) Water purifying technology in remote villages of Myanmar. Almost all agricultural technologies were based on the sustainable ecosystem development, inclusion of farmers' traditional adaptation practices, providing a good productivity as well as reduced vulnerability to climate variability. In the "Water resource management sector", most technologies considered proper management practices of water resources and sustainable use of good quality and sufficient drinking and household water. Many technologies offer not only the adaptation benefit but also the mitigation co-benefits. They are also coherent with the existing government's policies and plans such as Myanmar NAPA (2012), Myanmar INDC (2015), and Agriculture Sector Policies and Thrusts (2016) etc. Therefore, the prioritized adaptation technologies, as an output of TNA project, will be well integrated into the government's development plans and strategies.

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List of Abbreviation

ADB	Asian Development Bank
CA	Conservation Agriculture
CBD	Convention on Biological Diversity
CSA	Climate Smart Agriculture
DAR	Department of Agricultural Research
DMH	Department of Meteorology and Hydrology
DOA	Department of Agriculture
DRD	Department of Rural Development
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DTU	Denmark Technology University
DWIR	Directorate of Water Resources and Improvement of River Systems
ECD	Environmental Conservation Department
FAO	Food and Agriculture Organization
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GoM	Government of Myanmar
INC	Initial National Communication
INDC	Intended Nationally Determined Contribution
INGO	International Non –Governmental Organization
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
IWRM	Integrated Water Resource Management

IWUMD	Irrigation and Water Utilization Management Department
JICA	Japan International Cooperation Agency
MAPDRR	Myanmar Action Plan on Disaster Risk Reduction
MCA	Multi-criteria Analysis
MCCA	Myanmar Climate Change Alliance
MCCMP	Myanmar Climate Master Plan
MCCP	Myanmar Climate Change Policy
MCCS	Myanmar Climate Change Strategy
MCCSMP	Myanmar Climate Change Strategy and Master Plan
MMDG	Myanmar Millennium Development Goals
MmWP	Myanmar Water Partnership
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOE	Ministry of Education
MOECAF	Ministry of Environmental Conservation and Forestry
MOH	Ministry of Health
MONREC	Ministry of Natural Resources and Environmental Conservation
MOSWRR	Ministry of Social Welfare, Relief and Resettlement
MOTC	Ministry of Transport and Communication
MRDS	Myanmar Rice Development Strategy
NAPA	National Adaptation Programme of Action
NBSAP	National Biodiversity Strategy and Action Plan
NECCCCC	National Environmental Conservation and Climate Change Central Committee
NDC	Nationally Determined Contribution
NGO	Non-governmental organization
NSDS	National Sustainable Development Strategy

NWRC	National Water Resource Committee
SDG	Sustainable Development Goal
SME	Small and Medium-sized Enterprises
TAP	Technology Action Plan
TFS	Technology Fact Sheets
TNA	Technology Needs Assessment
UDP	UNEP DTU Partnership
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UN- Habitat	United Nations Human Settlements Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
WASH	Water, Sanitation and Hygiene
WB	World Bank

CHAPTER 1: Introduction

1.1 About the TNA Project

Myanmar is enriched with natural resources, particularly with land, water and human resources. Presently, the country is at the transitional stage to a democracy path with open market economy, striving for its economic and all round development. Local and international investments are pouring in to seek benefits in its various economic sectors such as agriculture, energy, industry and etc. The government is encouraging agriculture sector development and farmers have been applying high inputs of agrochemicals to increase crop production. Constructions of hundreds of dams and reservoirs for irrigation as well as for hydropower were completed within a few decades. The export items of fishery, forestry, and mining sectors have been already over -exploited. As a consequence, Myanmar is now facing serious degradation of its natural resources, which is exaggerated by the climate change. With the lessons learned from the previous experiences, and recognizing the environmental conservation, Myanmar tried to develop policies and issued new laws and regulations in major socio-economic sectors.

In accordance with relevant decisions of the Conference of the Parties to the Convention, Myanmar has been making efforts to present its enhanced mitigation actions, policies, strategies and adaptive efforts to climate change, and to contribute to making the Paris Conference Agreement negotiation a great success. Myanmar highlighted that while committed to global mitigation efforts, the national priority is to adapt to the devastating effects of climate change (INDC, 2015). However, being a country of the world's least developed countries (LDC), the existing technological, financial and capacity gaps limit Myanmar's ability to achieve its vision for sustainable development. Myanmar, therefore, requires significant supports from the international community for capacity building, technology development and transfer and financial resources. As several evidences have shown, Myanmar is extremely vulnerable to climate change impacts due to its topographic nature and livelihood of the people. Thus, the TNA project is highly relevant to the country's situation and a timely intervention to cope with the current and future's climate change issues. Environmental Conservation Department (ECD), MONREC acts as an executing agency for TNA project.

The purpose of the project is to assist a participant developing country to identify and analyze priority technology needs. These technologies can contribute to adaptation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities. The main objectives of the project are:

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to adaptation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA)
2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies
3. To develop Technology Action Plans (TAPs) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participant countries.

The project covers more than 70 countries around the world, supporting US$ 20 million throughout project timeline. Myanmar is one of the participating countries of Phase III of the project which started in June 2018 and will end in November 2020. Being a country-driven participatory process, TNA team exerted strenuous efforts to stakeholder participation throughout the processes, such as prioritization of sectors, technology familiarization, applying the MCA methodology and selecting the technologies. The stakeholders included the core stakeholder groups and outside stakeholder groups related with agriculture and water sectors. They were gathered from the public and private sectors such as government agencies, local and international NGO, community based organizations, private firms, academicians, researchers etc. TNA processes followed the guidelines proposed by

UDP/UNFCCC Handbook and TNA Step by Step guidebook for countries conducting a TNA and Action Plan, 2019.

1.2 Existing National Policies Related to Technological Innovation, Adaptation to Climate Change and Development Priorities

1.2.1 National circumstances

The Republic of the Union of Myanmar is located in Southeast Asia, bordering the Andaman Sea and the Bay of Bengal in the south. It is composed of seven States and seven Regions: in general, the States are situated in border and hilly areas of the county where most ethnic nationals are residing. The current population is 51.48 million, of which 70 % live in rural areas and are engaged primarily in agriculture. Being an agricultural based country, 25.5% of total export earnings come from agriculture produce in 2015-2016 and it employs 61.2% of the labor force. Myanmar's GDP is expected to grow by 6.6% in 2019 and by 6.8% in 2020. Per capita GDP growth for Myanmar is expected to be 5.6% in 2019 and 5.9% in 2020 (DAP, 2017).

The main objective of agriculture sector is to ensure food and nutrition security and food safety. Over the last decades, the government endeavored to infrastructure development (such as, extension of road networks, construction of dams and reservoirs, and agricultural land development, increase in livestock breeding and aquaculture, etc.). Consequently, socio-economic development of the country has been increased to a considerable extent.

Correspondingly, large forest areas have been felled for timber extraction and other land use purposes, affecting the country's natural resources and environment. In addition, it contributed a negative impact to water catchment areas of hydropower energy supply of the country. The electric power generation comes mainly from hydropower (72%), followed by coal-fired thermal (4%), steam turbine (5%), gas turbine 18%. (DOP,2014). Because of the less water flow in hydropower dams, electricity supply disruptions were common across the country, especially in the summer season. The present electricity supply in Myanmar is still poor: 50% of households use electricity as their main source of energy for lighting. The disparities between urban and rural areas are striking. It was documented that a large portion of households (69.2%) were using firewood as their main source of energy for cooking. It is one of the major factors contributed to the high rate of deforestation (DOP, 2014).

1.2.1.1 Physical environment

Geography

Myanmar is the largest country in mainland Southeast Asia with a total land area of 676,577 km^2 (261,228 sq miles), and is located between Latitudes 9°28' and 28°29' north, and Longitudes 92° 10' and 101° 10' east. Its estimated length is approximately 2,100 km from North to South and its width is 925 km from East to West. The physical geography of the country is diverse, having the topography of steeper mountain ranges, upland plateaus and hill valleys in the eastern, northern and north-western regions. The undulated central dry zone is surrounded by the western coastal range and lowland deltaic region in the lower part of the country. A narrow coastal strip lies in the further south and a long coastal line of 2,832 km is facing the Bay of Bengal and Andaman Sea. Therefore, Myanmar is endowed with large freshwater and marine resources, 8.2 million ha of inland water bodies, and 0.5 million ha of swamp areas. (IWMI, 2015). From the North to South, four major rivers are associated with the complex terrain formed by the large drainage systems and their wider tributary networks. Along with its geographical complexity and diversity, Myanmar is enriched with natural resources, particularly agriculture and forest resources and biodiversity.

Land resources

The country as a whole can be divided into three main agro-ecological zones: i) Central Dry; ii) Coastal; and iii) Hilly. These zones can be further subdivided into eight physiographic regions: i)

Northern Hilly; ii) Central Dry; iii) Rakhine Coastal; iv) Western Hilly; v) Eastern Hilly (Shan Plateau); vi) Ayeyarwaddy Delta; vii) Yangon Deltaic; and viii) Southern Coastal (including Tanintharyi coastal strip).

Regarding land utilization, the net sown area of crops and plantation cover around 17%, while the forested areas (reserved and non-reserved areas) cover the remaining 47.4% in 2015- 2016 (Table 1). The lowland regions are covered with alluvial soils of silt and clay. Myanmar's richest soils are situated in a narrow alluvial strip along the Bay of Bengal, while streams irrigate the land in the wide Irrawaddy River and Sittoung River valleys. These deep soil deposits form a vast, fertile belt favourable for rice cultivation (NBSAP, 2015).

Table 1. Land Utilization

Particular	2015 -2016 (000' ha)	Percent
Net area sown	12,008	17.7
Fallow Land	450	0.7
Cultivable waste land	5,247	7.8
Reserved forests	18,555	27.4
Other forest area	14,742	21.8
Other land	16,659	24.6
Total	67,659	

Source: Department of Agricultural Land Management and Statistics, MOALI, 2016

The problem soils also occupy an area of about 2.4 million acres, accounting for about 5.3% of the total cultivable land area. It includes about 0.74 million acres, which are acid sulphate soils, degraded soils, peat soils, and swampy soils, while saline and alkaline soils account for the remaining 1.63 million acres. Furthermore, soil erosion is a key factor in making agricultural land vulnerable to land degradation. About 10% of total cultivated land in the country is estimated to be vulnerable to severe soil erosion. Severely affected areas are found in Shan State, Sagaing Region and Chin State (MOALI, 2015).

Water resources

The major fresh water sources of Myanmar are by rains and rivers. The four major rivers, namely Ayeyarwaddy, Chindwin, Sittoung and Thanlwin, provide abundant water resources and catchment area of ~737,800 km^2. The rivers have large seasonal variations in water discharge and water surface level between wet and dry season. Apart from the access of rivers and streams, the country has significant groundwater resource. However, only about 10% of the total water resources available to the country are utilized, and 90% of which is used for irrigation. In addition to fishing, Myanmar's inland waters have massive hydropower potential, of which only around 1% is currently exploited (INC, 2012).

The rainfall pattern in general is that 80% of rains fall during the monsoon (May- October) and 20% during the dry season (November- April). Under the face of climate change, the onset and duration of monsoon rainfall which results in significant implications for the water resources are highly affected. The water availability is highly variable temporally and spatially. Seasonal water scarcity and flooding are the serious challenges across the country.

The extensive coastal and delta areas accommodate some half million hectares of brackish and freshwater, swamp land and huge areas of mangrove trees. These areas support essential ecological functions and habitats for the flora and fauna such as spawning, nursery, and feeding grounds of fish and prawns. These ecosystems, however, are experiencing significant degradation, largely by the encroachment of agriculture and aquaculture and the extraction of timber and fuel wood collection. In addition, due to more occurrences of storm surges, tidal intrusion and sea level rise under climate change, and coastal and riverine flooding is the most common phenomena in these days and ecosystems were severely affected.

1.2.1.2 Climate

Myanmar has a tropical to subtropical monsoon climate throughout the year. It has a dominant tropical monsoon climate and seasons are influenced by the southwest monsoon. The southern parts of the country are affected first by the southwest monsoon starting in May, with the entire country experiencing the rainy season by the beginning of June. Three seasons can be defined as follows. i) hot, dry inter-monsoonal (mid-February to mid-May); ii) rainy southwest monsoon (mid-May to late October); and iii) cool relatively dry northeast monsoon (late October to mid-February) (NAPA, 2012).

Climate variability and agro-climatic regions within the country are largely shaped by their topography. There is significant spatial variability in annual rainfall, with levels as high as 5,000 mm in the coastal and delta regions, the lowest in the Central Dry Zone (500-1000 mm per year). Mean annual rainfall increases in the Eastern and Northern Hilly regions, and is the highest in the Southern and Rakhine Coastal regions (2,500 – 5,500 mm). Seasonally, the temperature ranges in most parts of the country between 32°C and 38° C during the dry season, 25° C and 35° C during the rainy season and 10° C and 25° C during the cold season. In the Central Dry Zone temperatures range from a maximum of 40-43°C in the hot/dry season to 10-15°C in the cool/relatively dry season. Myanmar's west coast is subject to frequent tropical storms and cyclones during October to December with a secondary peak in April to May (NAPA, 2012).

1.2.1.3 Forest

Along with its timber products, forest provides a number of ecological services, such as sequestering carbon, regulating micro- climates, protecting top soils from erosion and providing habitats for animal and plant species. Myanmar rural households are relying on (Non –Timber Forest Products (NTFP) from nearby forests. However, Myanmar's forests have been facing deforestation, degradation since several decades ago, mainly caused by the improper management of timber extraction, expansion of agriculture, aquaculture, mining, dam construction, urbanization, infrastructure development and etc. Deforestation pressures also included fuel wood collection of local communities who do not have access of electricity. It was also aggravated by traditional farming practices of slash-and-burn or shifting cultivation in hilly areas. Regarding with forest area change in Myanmar, the 57.97% of forest cover was recorded as in 1990 and it has declined to 42.92% in 2015 (FRA 2015).

1.2.1.4 Agriculture landscape

Since agriculture is the backbone of the country, Myanmar's economy highly relies on the agriculture sector. In 2015-2016, agriculture contributed 20.1% (GDP), while livestock and fishery contribution was 8.5% GDP. Rice, a staple food, generally covers about 50% of the total sown areas of 16.72 million ha (DOP, 2017). With a wide variety of agro-ecological regions, more than

60 different tropical and temperate crops are widely grown. Myanmar is endowed with numerous agricultural resources – land, water and favourable climate. The Ayeyarwaddy delta acts as a rice bowl for the country while the Dry Zone is well known for its huge production of oil seed crops and pulses. Vegetables and flowers are concentrated in hilly areas of Shan States, and Taninthayi Region, the coastal strip of southern most part, is suitable for oil palm, rubber and fruit trees. Rice is a predominant and favoured as a national crop, and it grows well across the country. In 2015-16, rice area was recorded as 7.21 million ha with the yield of 3.97 t/ha and total production of 28.21 million tonnes. The other major crops are pulses and beans (black gram, chickpea, soybean, pigeon pea), and oilseed crops (groundnut, sesame, sunflower). Other cereal crops include wheat, maize, sorghum and millet. The majority of the farmers are small-scale landholders with an average size of 2.27 ha. The crop cultivation is mostly rain-fed (about 80% of the total), therefore, the crop production is strongly affected by rainfall. The Irrigation and Water Utilization Management Department (IWUMD) documented that (786) numbers of irrigation facilities have been completed (up to March 2016), the irrigable area covered 2.14 million ha, and that is 16% of the total net sown area of the country (DOP, 2017).

Concerning the livestock sector, most rural households have local breeds of chicken, ducks, goats and pigs as small scale livestock farms while the commercial chicken farms are concentrated in towns and cities. In 2015-16, the numbers of cattle and buffalo were 16 million and 3.5 million, respectively, most were used for farm activities; a few percentage is for meat and dairy production (DAP, 2017). The numbers of draught cattle are declining, replaced by the small farm machineries. In addition, the cattle are being exported to China and India markets. It can be a good income opportunity if farmers are encouraged to establish commercial cattle farming.

1.2.2 National strategies

Myanmar is extremely vulnerable to climate change impacts and highly exposed to severe weather events with increasing intensity and frequency over the last 60 years. Myanmar has experienced the adverse effects of climate change on its productive systems, particularly in the agriculture sector. The most recent climate change projections in Myanmar confirm the increasing and changing temperature and precipitation trends; and related events such as heat waves, droughts and floods; the likelihood of intense tropical cyclones; sea level rise; salinity intrusion; and a further shrinking monsoon season among the other effects (GoM, 2019(b)). Being a large country with its diverse ecosystems, the climate change impacts are varying according to their particular geographic region. For example, the Central Dry Zone areas often encounter drought, irregular rains and flash floods while people in delta region and coastal areas are facing storms, floods, sea level rise and saline intrusion. People living in hilly regions and plain areas were diversely affected by several patterns ranging from severe droughts to heavy rains and landslides. For addressing these issues, GoM has promulgated several new climate related policies and strategies. In addition, it well recognized that climate change adaptation considerations should be integrated into future developmental policies and legislations.

The MONREC is currently drafting the “Green Economy Policy Framework” which is a guiding document for the identification of investments. It can support a green economy in Myanmar and deliver multiple benefits to people, environment and the economy. The framework can be used by sectoral ministries, as well as by multi-sectoral agencies to design medium-term development plans, to prioritize private and public investments as well as to support the development of the union and state/regional budgets. By pursuing a green economy approach, Myanmar can achieve sustainable development while protecting its natural capital, which is critical to improve human well-being and increase economic productivity (MONREC, 2019).

Moreover, the Myanmar Sustainable Development Plan (MSDP) 2018-2030 states that the “GoM recognizes that the natural environment is the foundation upon which Myanmar’s social, cultural and economic development may be sustained. Thus, the GoM is committed to a national development framework that enshrines the notion of environmental sustainability for future generations by systematically incorporating environmental considerations into the design and the

implementation of its policies and projects" (MOPF, 2018). GoM is to accomplish "the achievement of the SDGs with the objective of ensuring balance between developments in the economic, social and environmental spheres" as outlined in MSDP. Myanmar's Climate Change Strategy and Master Plan (MCCSMP, 2019) also builds on this statement by outlining a commitment to a forward-thinking approach to development: "Myanmar is ready to build climate resilient and low carbon pathways towards inclusive sustainable development" (MONREC, 2017).

Furthermore, the National Environmental Policy of Myanmar (NEP, 2019) and the National Environmental Strategy and Action Plan Strategic Framework (NESAPSF) both aim at identifying a long-term vision for environmental protection and sustainable development in Myanmar. The policy sets the basis for enhancing environmental governance in Myanmar. The accompanying strategic framework identifies how environmental protection and sustainable development should be mainstreamed into relevant sectoral policies. In its principles, NEP highlights the need for protecting and sustainably managing Myanmar's ecosystems, including environmental service provisioning in sustainable waste management, and renewable energy, climate smart approaches to development, etc. (GoM, 2019 (a)). Recognizing that the climate change adaptation strategies, particularly in agriculture and water sector, are crucial for the country's sustainable development, but more importantly, all concerned government departments and stakeholders will need to fully operationalize the planned policies and strategies.

1.2.3 Policies and actions related to climate change

1.2.3.1 Institutional framework

The National Commission for Environmental Affairs (NCEA) was established in 1990 under the Ministry of Foreign Affairs. It acted as a focal point for environmental affairs to promote the environmentally sound and sustainable development. NCEA was relocated under the Ministry of Forestry in 2004. It was responsible for development of policies, strategies and management and coordination of all activities related to climate change issues in Myanmar. It was terminated and the National Environmental Conservation Committee (NECC) was formed in 2011 to be more effective in tackling the environmental and climate change issues. The Ministry of Forestry was renamed into the Ministry of Environmental Conservation and Forestry (MOECAF) in the same year, under which environmental affairs were taken into action more effectively by the designated Ministry. In addition, the new Environmental Conservation Department (ECD) was established. Ministry of Natural Resources and Environmental Conservation (MONREC) was formed by combining the Ministry of Mines and MOECAF on 30 March 2016.

For the agriculture sector, the MOALI is the main responsible ministry under which eleven departments and four universities related with agriculture, water resource and rural development are formed. Of the structure of MOALI, the following Departments are directly related with the "Agriculture" and "Water" sectors of climate change adaptation under the TNA project.

1. Department of Agricultural Research (DAR)

For the research and development activities the following "Divisions and Sections of DAR" are taking responsibility for the specific crops.
Rice and Other Cereal Crop Division,
Oil Seed Crops and Food Legumes Division,
Industrial Crops and Horticulture Division,
Soil/Water Utilization and Agricultural Engineering Division,
Agronomy, Agricultural Economics and Statistics Division, and
Biotechnology, Plant Genetic Resources and Plant Protection Division

2. Department of Agriculture (DOA)

The main activity of DOA is to transfer the update and more efficient technologies for production. Under the DOA, "Extension Division" is divided into various specialties, for the effective supervision of the specific activities. They are: Rice Division, Seed Division, Land Use Division, Plant Protection Division, Horticulture and Biotech Division, In-service Training and State Agricultural Institutes (SAI) Division, and Sugar Crop Division.

3. Department of Rural Development (DRD)

The DRD takes responsibility for formulation and implementation of rural development works across the country. DRD is working for "Drinking water and sanitation" such as "Safe drinking water", Piped water supply, Solid waste collection" and etc., besides some other works of rural development plans of rural roads, and small and medium enterprises (SME). The DRD and other two Departments, namely Department of Basic Education and Department of Public Health are collaborating for the implementation of "National Strategy and Investment Plan (2016-2030)" for rural water, sanitation and hygiene. The task force was chaired by DRD, taking the support and input from other relevant departments.

4. Irrigation and Water Utilization Management Department (IWUMD)

For "Water Resources Management", the IWUMD is working for the water related sectors such as, Drinking water and sanitation, Agriculture and irrigation, Hydropower, Rivers and inland water transport, and Flood and cyclone hazards. Main responsibility of IWUMD is sustainable operation and maintenance of (irrigation) water management; and operation and maintenance of flood protection embankments and polders system all over the country. IWUMD operates, maintains and manages 581 irrigation facilities and 479 flood protection and drainage facilities in the country. Under the IWUMD, "Irrigation Section" is taking the responsibility of "Surface water" while "Water Resources Utilization Section" is for river water and ground water.

1.2.3.2 Policy framework

NCEA successfully developed the National Environmental Policy which was adopted in December 1994, and formulated Myanmar Agenda 21 in 1997 and drafted the National Environmental Protection Law (NEPL) in 2000. The national policy and local plans were set up to perform the sustainable management of the country's natural resources. It would also help to provide a sound legislative basis for ensuring that environmental issues are integrated into development plans so as to support sustainable development. With the awareness and response on climate change impact, the government has laid down the national plans, policies and laws related with natural resource management and sustainable development. Furthermore, Myanmar is a signatory to a number of international agreements and conventions relating to environmental management, community rights and indigenous peoples. Some examples of key international agreements were shown in Table 2.

Table 2. International agreements related with climate change and natural resource management

Agreements/Conventions	Signatory Year
United Nations Framework Convention on Climate Change (UNFCCC)	1994
United Nations Convention on Biological Diversity	1994
Convention to Combat Desertification	1997
ASEAN Agreement on the Conservation of Nature and Natural Resources	1997

Kyoto Protocol	2005
ASEAN Committee on Disaster Management (ACDM)	2003
Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES)	2003
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)	2005
National Biodiversity Strategy and Action Plan 2015-2020	2011
Intended Nationally Determined Contribution (INDC) to the UNFCCC	2015
Myanmar Action Plan on Disaster Risk Reduction	2017
Myanmar Sustainable Development Plan (2018 – 2030)	2018

The following are existing laws, procedures, policies and strategies of various ministries directly or indirectly related with natural resources management, sustainable development and climate change adaptation.

a) Myanmar Constitution, 2008

The 2008 Myanmar Constitution provides several important references to environmental conservation and sustainable development. It states that "Every citizen has the duty to assist the Union in carrying out environmental conservation". According to Article 37(a) of the Constitution of the Government of the Union of Myanmar, "The Union is the ultimate owner of all lands and all natural resources above and below the ground, above and beneath the water and in the atmosphere in the Union." As the owner of all lands and natural resources, the Constitution further stipulates in Article 45 that: "The Union shall protect and conserve the natural environment". The new Constitution of the Republic of the Union of Myanmar was adopted in May 2008 by referendum. It includes the environment issues as shown below.

- The Union shall protect and conserve the natural environment.
- Union of Myanmar Parliament may make laws for environmental protection and conservation including wildlife, natural plants and natural areas.

b) National Biodiversity Strategy and Action Plan (NBSAP), 2011

NBSAP Myanmar is a commitment of the Government and its people to the sustainable use of biological resources and to the fulfillment of Myanmar's obligations, as a member country, to the Convention on Biological Diversity (CBD). Conserving biodiversity not only helps secure the livelihoods of a major proportion of the population, but also enhances the range of opportunities for economic prosperity and sustainable development of the nation. Therefore, the goal of the NBSAP is to provide a strategic planning framework for the effective and efficient conservation and management of biodiversity and natural resources with greater transparency, accountability and equity.

c) National Sustainable Development Strategy (NSDS), 2009

The National Sustainable Development Strategy (NSDS) for Myanmar has been prepared to provide a strategic long‑term framework for sustainable development. The three goals of the NSDS are: (1) Sustainable Management of Natural Resources, (2) Integrated Economic Development, and (3) Sustainable Social Development.

d) Environmental Conservation Law, 2012

Myanmar's legal system provided little guidance to investment projects on environmental conservation. Most conservation measures were spread across various laws, which lacked

coherence and did not provide systematic or adequate protection for the diverse ecosystems of the country. The objectives of the law are as follows:

- To enable implementation of the Myanmar National Environmental Policy
- To lay down the basic principles and give guidance for systematic integration of the matters of environmental conservation in the sustainable development process
- To enable to emerge a healthy and clean environment and to enable to conserve natural and cultural heritage for the benefit of present and future generation

The law also lays down the rules for creation of a central level Environment Conservation Committee (ECC) under the MONREC. The roles and responsibilities of the ECC and MONREC are also prescribed in the law.

e) Myanmar Climate-Smart Agriculture Strategy (MCSA), 2015

Extreme climate variability is becoming evident, natural disasters are increasing from year to year, creating significant impacts on food production. Climate-smart agriculture (CSA) technologies need to be developed urgently so that people can better adapt to and help mitigate climate change. The key elements of CSA include food security by increasing agricultural productivity, resilience of agricultural systems through adaptation, and mitigation by reducing GHG emission or enhancing carbon sequestration and managing interfaces with other land use management.

The 2015- MCSA focuses on adapting crop varieties and corresponding farming practices and managing the risk of disaster and loss of crops and income. The MOALI carries out some climate-change related measures, such as adjusting cropping systems, using stress-resistant plant varieties and maximizing water use and efficiency. Climate change adaptation in the agriculture sector will be pursued in the context of food security and nutrition. Although there are practices that hold great potential to address climate challenges, there is currently no national policy framework within which to build on and operate. Feeding the country's population in the context of climate change will require gradual and significant expansion of agricultural products. Adopting agricultural practices, that is able to withstand changes in climate as well as contribute to the GHG emissions reduction, require the application of new technologies, modification of existing ones, and revision of relevant laws and policies.

By 2030, Myanmar aims (to) achieve food security and nutrition and climate resiliency, with a globally competitive agriculture sector attaining high productivity through climate-smart good agricultural practices (GAP) resulting in higher standard of living, especially in the rural areas.

f) Myanmar Rice Sector Development Strategy (MRSDS), 2015

To achieve agricultural development, the Ministry of Agriculture and Irrigation (MoAI, presently MOALI), with technical assistance provided by IRRI, developed the MRSDS that seeks to boost rice production and thus better ensure food self-sufficiency and a larger share in the international rice trade for the country. By 2030, Myanmar envisions food-secure farmers and consumers enjoying the economic benefits provided by a transformed, dynamic, environmentally sustainable, and internationally competitive rice sector. The ultimate goal is a food-secure nation where smallholder farming households have tripled their household incomes, including income derived from rice and rice-based farming. The sustainable intensification of rice production, using efficient and effective natural resource management methodologies for higher rice productivity and profitability is the cornerstone for achieving this goal by 2030.

MOALI targets production growth that satisfies both domestic and export requirements. By 2030, production must reach at least 19.40 million metric tons, about 60% of which is for local food consumption and 40% for international trade. The target will be achieved by maintaining 7.70 million hectares (ha) of rice area harvested with an annual average yield of at least 4.20 MT/ha per cropping season. Rice of varying quality will be produced to meet both domestic and foreign market demand.

g) Second Five Year Short Term Agriculture Policies and Strategic Thrusts, 2016

The aim of these new policies and strategic thrusts, referred to as Agriculture Policy 2016, is to create the enabling environment that will promote the production of a greater and more diversified range of high value agricultural, livestock, and fishery products. The policy is "to improve food and nutrition security and food safety for all the people and to enable smallholder farmers to increase their incomes through higher productivity and diversified production in response to market demand, as well as to enhance exports through an internationally competitive private agri-business sector." Among the "Policies related to agriculture sector", the following are some policies extracted which are relevant to the TNA project.

(i) Rural Infrastructure Development Policy

(ii) Environmental Conservation and Climate Change Resilience Policy

(iii) Water Use and Management Policy

(iv) Research, Development and Extension Policy

h) Myanmar Sustainable Development Plan (MSDP) (2018 – 2030), 2018

The Ministry of Planning and Finance (MOPF) shall serve as the focal entity responsible for overseeing implementation of the MSDP. The MSDP Implementation Unit (MSDP-IU) shall be responsible for providing general guidance, approving strategic decisions, and solving strategic issues which may arise during the implementation of the MSDP. Being experienced with widespread natural disasters over the last decades, Myanmar is highly vulnerable to the risks of climate change. The Government of Myanmar is committed to the achievement of the Sustainable Development Goals (SDGs) of ensuring balance between the development of (economic, social and environment). Since the livelihoods of majority people depend on agriculture and its related sectors, increasing resilience of these sectors to climate change will contribute significantly to improve the country's economy.

To realize this issue, the MSDP has laid down the various strategies. Among them, Strategy (5.2) was dedicated to "Increase climate change resilience, reduce exposure to disasters and shocks while protecting livelihoods, and facilitate a shift to a low-carbon growth pathway".

Regarding with water resource management sector, MSDP mentioned the Strategy (5.3), to enable safe and equitable access to water and sanitation in ways that ensure environmental sustainability.

Access to adequate water, sanitation and hygiene are essential to ensuring the health of individuals and communities, combatting the spread of disease. Although Myanmar generally receives abundant rainfalls; water shortages often happened in the Dry Zone area of central Myanmar. Depending on the topographic condition and several other constraints, a large number of villages remain without access to improved water and sanitation facilities.

The long-term ecosystems degradation will affect water quality and ultimately disturb providing water during the dry season. The Government of Myanmar will also promote township-level water use planning and encourage healthy water use practices in order to ensure that the water supply, sanitation and hygiene needs of schools, health facilities, urban, private sector, and rural communities are met. The several Action Plans were identified to achieve this strategy.

i) National Environmental Policy of Myanmar, 2019

The GOM has adopted the new National Environmental Policy of Myanmar in 2019 with the aim of mainstreaming environmental considerations into economic and social development. The Policy will provide long-term guidance for government organizations, civil society, the private sector and development partners on the achievement of environmental protection and sustainable development objectives in Myanmar.

This Policy builds on Myanmar's 1994 National Environmental Policy and reaffirms its core values. It also builds on the 1997 Myanmar Agenda 21, the 2009 National Sustainable

Development Strategy. It is grounded in the environmental responsibilities in the 2008 Constitution of the Republic of the Union of Myanmar, and the obligations contained in the 2012 Environmental Conservation Law. This approach is consistent with the 2030 Agenda for Sustainable Development, which includes 17 SDGs to end poverty, fight inequality and injustice, and tackle climate change by 2030. Putting this Policy into action will also ensure that Myanmar makes significant progress in meeting the SDGs.

The vision of the policy is a clean environment, with healthy and functioning ecosystems, that ensures inclusive development and wellbeing for all people in Myanmar. To pursue this vision, the GoM adopts the 23 National Environmental Policy principles as the guiding framework for achieving: a clean environment and healthy, functioning ecosystems; sustainable economic and social development; and the mainstreaming of environmental protection and management. The policy also states that Gender equality and the empowerment of women and girls will be integrated into all aspects of environmental protection and management.

j) Myanmar Climate Change Policy (MCCP), 2019

Myanmar's vision is to be a climate-resilient, low carbon society that is sustainable, prosperous and inclusive, for the wellbeing of present and future generations. The purpose of this Policy is to provide long-term direction and guidance to the following.
(a) Take and promote climate change action on adaptation and mitigation in Myanmar
(b) Integrate climate change adaptation and mitigation considerations into Myanmar's national priorities and across all levels and sectors in an interactive and progressive manner; and
(c) Take decisions to create and maximize opportunities for sustainable, low-carbon, climate resilient development, ensuring benefits for all.

Recognizing the observed and projected climate change and its adverse impacts, the Government of the Republic of the Union of Myanmar formulated and adopted its Myanmar Climate Change Policy (MCCP) to provide long-term direction and guidance for government, civil society, and the private sector to undertake and promote climate change actions in adaptation and mitigation in Myanmar and to create opportunities for sustainable and low-carbon development. To this end, the MCCP mandates the adoption of actionable short, medium and long-term strategies and plans to address climate change, and in particular the adoption and implementation of the Myanmar Climate Change Strategy (MCCS) 2018-2030.

GoM will take sector-relevant measures to implement MCCP and achieve its purpose. Regarding the "Water sector" it mentions to "*Adopt and implement efficient water management and governance practices in Myanmar, including through technologies for water conservation and other alternatives to flood irrigation systems and other appropriate systems, particularly in climate vulnerable States and Regions, including mountainous areas, flood-prone areas, delta regions and dry zones*". It also ensures that IWRM and other appropriate means are taken into account to ensure the sustainability of water resources, including through the adoption of adaptation strategies to increase water storage and watershed restoration and preservation.

Recognizing that women and girls in Myanmar are disproportionately affected by climate change impacts due to their roles and responsibilities and their unequal access to resources, opportunities and rights, and that their knowledge, experience, participation and leadership at all levels are vital for developing effective climate change adaptation and mitigation responses. Under the Policy "Gender equality and women's empowerment" states to **"***Promote and protect gender equality and women's equal rights through strengthening gender-responsive climate change policy concerning adaptation, mitigation, finance, technology development and transfer and capacity building, and ensuring full and equal participation of women in decision-making"*.

k) Myanmar Climate Change Strategy (MCCS) (2018 – 2030), 2019

Following the signatory of the Paris Agreement by Myanmar on 22nd April 2016 after its adoption at the 21st Conference of the Parties in 2015, ECD has been making its strenuous efforts over the

years for strengthening the policy tools to address climate change, as well as to coordinate stakeholders across sectors and from national to local level. As an output, MCCP and its operational instrument the Myanmar Climate Change Strategy and Master Plan 2018-2030 (MCCSMP) has been formulated and adopted by the Government of Myanmar.

The MCCS (2018-2030) is to provide a roadmap for Myanmar to strategically address climate-related risks, and also seize opportunities, over the next 10 years and beyond. The MCCS fully builds on the Myanmar Climate Change Policy' (MCCP) principles and also upholds principles of: inclusive development, resource-efficient development, integrated development, results-oriented development. These two documents are the result of extensive consultations and meetings with all national ministries, high level authorities at national and state and region level, the major city development committees, communities, the civil society, the university and the development partners, through the relentless work of the Technical Working Groups (TWG), facilitated by MCCA and supported in their formulation by dedicated expertise from the International Institute for Environment and Development (IIED). In addition, it was acknowledged the generous support by the European Union and effective implementation by UN-Habitat and UN Environment.

It has been recognized that, the challenges posed by climate change can only be addressed by a partnership of stakeholders, across sectors, institutions, the private and public sector and citizens of Myanmar. The MCCP and its related Strategy must be therefore regarded as the essential instruments to ensure coordinated and effective action at national, sub-national and local level, as well as to attract and target the support by international development partners. The Policy and Strategy share the ambitious vision of transforming Myanmar into a climate-resilient, low-carbon society that is sustainable, prosperous and inclusive, for the wellbeing of present and future generations.

The long-term goal to achieve this vision is that by 2030, Myanmar has achieved climate-resilience and pursued a low-carbon growth pathway to support inclusive and sustainable development. To achieve its goal as set out above, Myanmar needs to direct its development actions (specifically in the priority sectors of its economy) along two strategic pathways that represent the two objectives of this strategy:

(a) To increase the adaptive capacity of vulnerable communities and sectors so they are resilient to the impacts of climate change, and

(b) To create and maximize opportunities for potential sectors to follow a low-carbon development pathway ensuring development benefits to households and all economic sectors.

To increase the adaptive capacity of and maximize opportunities from low carbon and climate resilient development, the strategy will guide investment in the six priority social and economic development sectors that contribute to current and planned economic and social development in Myanmar. These six action areas or sectors are: agriculture, fisheries and livestock sector; natural resource management; energy, transport and industrial systems; towns and cities; disasters, risks and health impacts; and education, awareness and technological systems.

The action areas identified above will deliver significant transformation in priority sectors to ensure that current and future investments are resilient to the impacts of climate change and can unlock opportunities from climate-resilient and low-carbon development, including opportunities related to green and inclusive job creation, sustainable revenue generation and innovative business models.

l) Myanmar Climate Change Master Plan (2018 – 2030), 2019

The Myanmar Climate Change Master Plan (2018-2030) has been formulated and adopted with the view toward mainstreaming a series of prioritized sectoral short, medium and long term actions identified in the Myanmar Climate Change Policy and Strategy. It showcases the result of extensive in-depth sectoral consultations and bilateral discussions by line ministerial departments and enterprises, city development committees, research and academia, private and non-

governmental organizations, civil-society organizations, development partners from national and international agencies, experts, technical working groups of Myanmar Climate Change Alliance (MCCA) as well as comments from relevant subnational stakeholders.

The MCCMP clearly defines a series of high-priority activities, their respective strategic indicators, and the responsibilities of involved stakeholders across six specific sectors prioritized in Myanmar Climate Change Strategy defined as:

(1) "climate-smart agriculture, fisheries and livestock for food security,
(2) sustainable management of natural resources for healthy ecosystems,
(3) resilient and low-carbon energy, transport and industrial systems for sustainable growth,
(4) building resilient, inclusive and sustainable cities and towns in Myanmar,
(5) managing climate risks for people's health and well-being, and
(6) building a resilient Myanmar society through education, science and technology"

The ECD has great confidence that this master plan will provide a guiding roadmap for proactive sectoral preparedness in tailoring and scaling down the responses needed to address annual climate-induced natural disasters facing with Myanmar as well as stimulating opportunities for long-term economic development along low-carbon pathways. In addition, it serves as an operationalizing framework for ensuring Myanmar's achievement of its Nationally Determined Contributions (NDC) to the 2015 Global Climate Change Paris Agreement.

As a national cross-sectoral framework, ECD strongly urges all ministerial and sub-national governments, and investments from private and public organizations to incorporate the Myanmar Climate Change Master Plan (2018-2030) objectives and targets, and necessary budgetary allocations within their respective short and long term development plans, aligning with the specific targets set for 2020, 2025 and 2030. In addition, ECD strongly encourages private sector and development partners to support the government through developing its capacity in terms of technology, finance and human resources.

Although not a comprehensive list of all the actions possible in these broad sectors mentioned in the Master Plan, they represent key entry points, with tangible and measurable outputs, that will contribute to achieving the MCCS's overall goal: 'By 2030, Myanmar has achieved climate-resilience and pursued a low-carbon growth pathway to support inclusive and sustainable development'.

1.3 Vulnerability Assessments in Myanmar

Due to its topographic setting, Myanmar has a southwest monsoon climate, heavy rain induced floods often occur across the country. The coastal area, located at the eastern side of the Bay of Bengal and the Andaman Sea, is prone to cyclones and associated strong wind, heavy rain and storm surge. Moreover, drought is a frequent event, particularly in the dry Zone of central Myanmar. About 70% of total population resides in rural areas and their livelihood is engaged with agriculture, livestock and fishery and forest resources, all of which are largely influenced by climate conditions. Accordingly, the country's economy and development are highly sensitive and vulnerable to climate change.

1.3.1 The INC Project Report, 2012

The INC Report documented that Myanmar has proved as a carbon sink nation in the base year of 2000, which was made possible by its vast forest resources. Accordingly, it can be assumed that, the urgent need for Myanmar is to adopt adaptation strategies to lessen the adverse climate impacts, rather than the mitigation options. Improved productivity and resource efficiency of agriculture sector will contribute to country's economic growth and increasing farmers' income, which will in turn support their adaptation potential**.**

The INC report produced the maps of potential hazard levels for climate change in different regions and vulnerability indices of the overall key socio-economic sectors of Myanmar. Vulnerability

index was calculated for a given region by systematic consideration of climate change impact parameters on each socio-economic sector. The climate parameters identified by the DMH were: cyclone and strong winds, flood and storm surge, intense rain, extreme day temperature, drought and sea level rise. Three indicators were used for evaluating vulnerability scores of each of the key socio-economic sectors. The Vulnerability Level (VL) of climate change impacts identification and justification was presented in Table 3.

The Vulnerability and Adaptation (V&A) Team members identified six key socio-economic sectors, of which each sector had three indicators that were to be used for evaluating vulnerability scores. These indicators were determined, based on the available baseline data, and assumptions were made by experts' judgment. The data used in the indicators of the sectors to assess the score of Confidence Levels (CL) were based on the statistics of Myanmar progressive report, agriculture statistics, Department of Health, Department of Fisheries, Forest Department and Chronicle of national development comparison between period proceedings 1988 and After 1988 (up to 31-12-2008). Table 4 showed the sectors and their appropriate indicators for Confidence Level of various key economic sectors.

Table 3.Vulnerability Level of climate change impacts identification and justification

Sr.	Type of hazard	Vulnerability Level (VL)	
		Criteria	**Identification and Justification**
1	Cyclone/Strong Winds	High	Coastal region which have the cyclone landfall history.
		Medium	Region having common border with cyclone landfall region, and region with frequent strong winds history.
		Low	Region which has strong wind damages due to squalls etc.
2	Flood and storm surge	High	Low flat region flooded at least every other year by one of the large river systems of Ayeyawady, Chindwin, Sittoung and Thanlwin or due to storm surges.
		Medium	Regions with moderate flood and flash flood history.
		Low	Region that has the flash flood history.
3	Intense rain	High	The region having long exposure to the southwest monsoon flow from the Bay of Bengal and the Andaman Sea.
		Medium	Regions with some intense rain history.
		Low	Regions with a few heavy rainfall histories.
4	Extreme day temperature	High	Regions with high annual mean temperature.
		Medium	Regions close to high annual mean temperature region.
		Low	Mountain region and regions with low annual mean temperature.
5	Drought	High	Central dry zone area.

		Medium	Bago region and Eastern mountainous regions.
		Low	Remaining areas except Yangon and Taninthayi Divisions.
6	Sea level rise	High	Coastal deltaic region with extensive flat low land.
		Medium	Coastal region with little low lying areas.
		Low	Region with tide effects and coastal with higher grounds.
		None	Inland areas.

Table 4. The Indicators for Confidence Level of Various Key Economic Sectors

Sectors					
Agriculture	**Public health**	**Water resources**	**Forestry**	**Coastal zone**	**Biodiversity**
Indicators					
• Crop yield and production change • Crop pattern change • Pest and disease	• Malaria • Diarrhea • Unavailability of safe drinking water	• Irrigation works and beneficial areas • Hydro-power • Rural water supply coverage (Number of villages)	•Forest cover •Forest fire •Species composition	• Fish yield and production changes • Mangrove ecosystem • Coral reef	• Forest biomass growing stock • Habitat loss(closed forest from 1975-2006) • Fishery species composition

The Vulnerability Level (VL), the Confidence Level (CL) and Affected Level (AL) were applied for the calculation of Vulnerability Indices (VI). The scores were "High, Medium, and Low", and numerically "3, 2 and 1" were considered. "Criteria and Scores" for each key socio-economic sector in each State and Region were judged by the meteorologists and climatologists of DMH and the V & A team. As an output of INC project, the maps of potential hazard levels (vulnerability maps) for climate change of key socio-economic sectors for all States and Regions were created (Fig. 1). With the use of specified equation and "Population density of the States and Regions", the map of "Vulnerability indices of the overall key socio-economic sectors for States and Regions of Myanmar" was also produced, as shown in Fig.2.

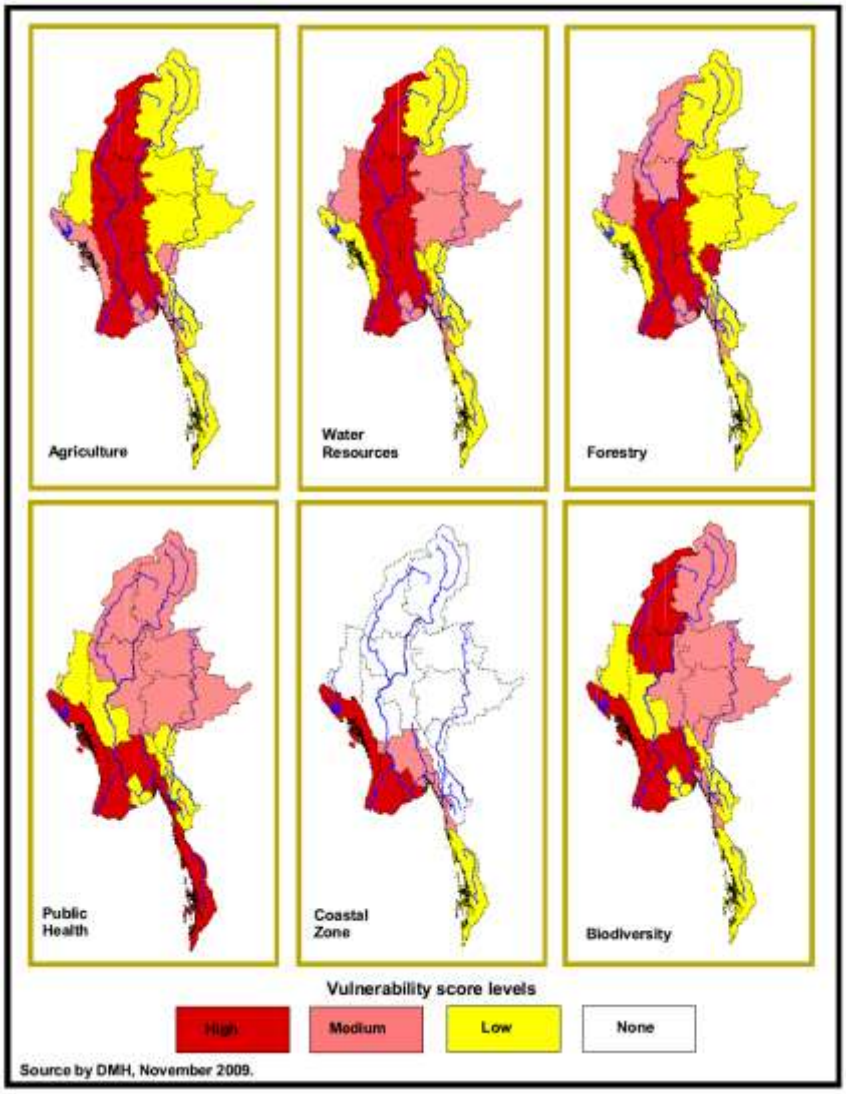

Figure 1. Vulnerability scores of the key socio-economic sectors for the States and Regions of Myanmar (INC, Report 2012)

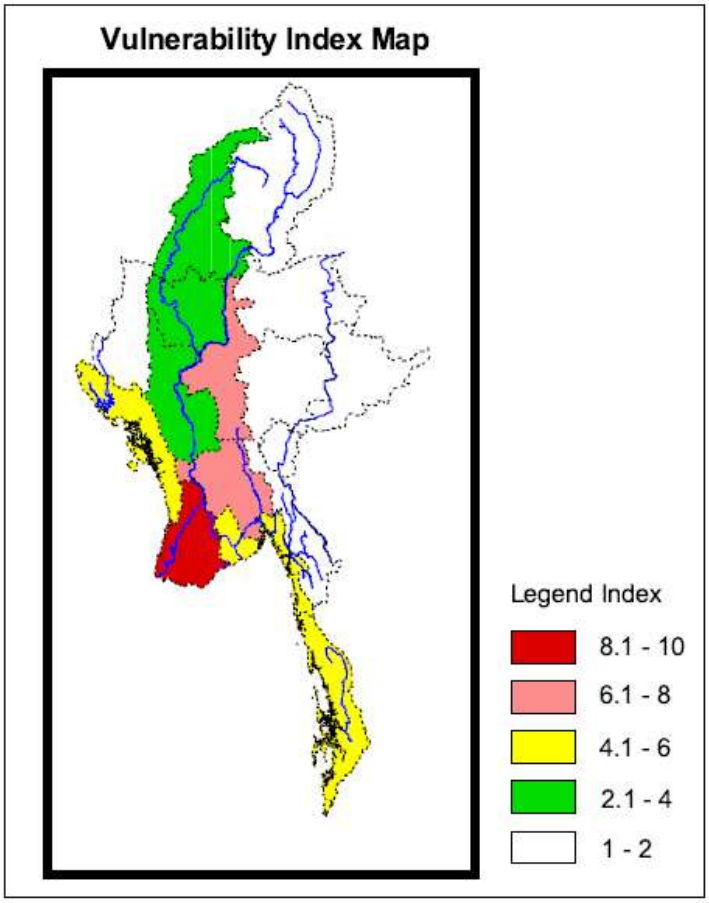

Figure 2. Vulnerability indices of the overall key socio-economic sectors for the States and Regions of Myanmar (INC, Report 2012)

Vulnerability assessment results

The INC report stated that, the highest sector score for vulnerability was "Public Health" sector followed by Biodiversity, Water Resources, Forestry, Coastal Zone and Agriculture sectors, in the descending order. In "Water Resources" sector, maximum Vulnerability Level score was obtained in Mandalay and Bago Regions followed by Sagaing, Ayeyarwaddy and Magway Regions. Kachin and Rakhine States showed the minimum score. In "Agriculture sector", maximum score was found in Ayeyarwaddy Region followed by Bago, Sagaing, Mandalay and Magway Regions, while Chin State had the minimum value.

Regarding with the "Vulnerability index" of the overall key socio-economic sectors, the results showed that the Ayeyarwaddy Region has maximum with the value of (6.13) while Chin State has minimum value (1.19). The index is relatively high in Ayeyarwaddy and Yangon Regions followed by Mandalay Region, Mon State and Bago Region. Sagaing Region and Rakhine State have relatively low.

It was noted that the vulnerability assessment was conducted, based on the data of during the time from 1998 to 2008, which will vary with the conditions of later years. At present, Myanmar has been implementing its Second National Communication (SNC) project. The SNC report will present the V & A analysis with the base year of 2010 (the time range of 2005 to 2015). The stakeholders involved will be aware of the updated results of the vulnerability assessment to properly identify the impact of climate and the climate change trends which are likely to be dominant in their particular regions. As a result, they will apply adaptation and resilience technologies more efficiently and effectively.

1.3.2 Assessing climate risk in Myanmar, 2017

To support Myanmar to address the climate issues, in 2013 the European Union funded the Myanmar Climate Change Alliance (MCCA) Programme, implemented by the United Nations Human Settlements Programme (UN-Habitat) and United Nations Environment Programme, MONREC and its ECD. Its main goal is to mainstream climate change in the political, institutional and development agenda of the country. In 2015, MCCA in agreement with several national and local stakeholders selected one township from each of the country's three different agro-ecological zones to assess vulnerabilities (Horton, et.al., 2017). Based on these assessments, it will launch a Township Climate Change Adaptation Programme to help communities adapt to the negative climate change impacts in the short, medium and long-term. The selected townships were Labutta in the Ayeyawady Region (Delta Area), Pakokku in Magway Region (Central Dry Zone), and Hakha in Chin State (Hilly Area). The study analyzed current vulnerabilities, and by projecting changes in climate, anticipates further vulnerabilities in the future up to 2050. Based on this, it proposes scenarios that describe potential impact of climate change, and issues recommendations for adaptation to avoid the worst case future scenario. It also describes the expected outcomes and results, and prioritized activities that communities identified during the course of the assessment.

The study projects the changes in climate for each township, to a 25 kilometer spatial resolution. Projections generally show an increase in temperatures by as much as 2.7 °C in 2050, with up to 17 more hot days per year. Rainfall patterns are also projected to increase during a shorter rainy season, meaning more frequent heavy rainfall events, as erosion and run-off are the most likely consequences. Strong winds and cyclones are also expected to increase. The heavier rainfall event is likely to increase the potential for flooding, which is already experienced frequently by communities living close to the Ayeyawady River and seasonal streams.

Labutta Township has a deltaic environment, a flat topography, and suffered a great loss of damage and lives during the devastated Cyclone Nargis in 2008. It is still struggling and has not reached a good recovery stage. The assessment projects up to 41 centimeters of sea-level rise by 2050, which will increase the area of salt infiltration, and cause more frequent and more intense inundations and floods. The assessment shows that decision-makers in Labutta Township will need to plan for increased coastal flooding, warmer temperatures, more frequent extreme heat days, greater amounts of rain within a shorter monsoon season, and unknown rainfall changes during other seasons. Agriculture is affected by salinity, higher average temperatures, heat waves, floods, inundation, and strong rains. As most people do not have alternative livelihoods, migration is high.

In the case of Pakokku Township, the assessment shows that decision-makers will need to plan for variable rain, with increases concentrated in the monsoon season, less groundwater availability in dry areas, greater flood risks near the Ayeyarwady, and more frequent and more severe extreme heat events. The effects will be seen through more frequent loss of assets and potentially lives, lower incomes that will drive poverty, increased migration, worse outcomes for women and a declining public health situation. Housing and basic service conditions, especially in access to water, will also worsen, driven by changes in the climate and degraded ecosystems.

Similarly, the assessment concludes that current vulnerability of Hakha Township is high. The decision makers will need to plan for increased flash floods and landslides, strong winds, warm temperatures, erratic rainfall with greater amounts of rain within a shorter monsoon season.

These findings demonstrated that all the study townships are currently vulnerable to present climate conditions, and their vulnerability will increase greatly because of the projected future changes in climate if no adaptation actions are taken under the future climate change scenarios. This is mainly due to the current socio-economic, infrastructure and ecological system conditions, and the expected impacts of climate change on these systems. Overall, without adaptation measures, climate change will be a barrier to socio-economic development for Myanmar as the three representative townships of different agro-ecology zones are found to be poorly resilient at present.

1.4 Sector Selection

1.4.1 An overview of expected climate change and its impacts in sectors vulnerable to climate change

1.4.1.1 Myanmar's climate change scenarios

According to the Myanmar INC Report, 2012, climate change was predicted to increase the frequency and level of impact of climate related hazards i.e. hydro-meteorological hazards such as floods, droughts, cyclones, etc. The "Model for the Assessment of Greenhouse gas Induced Climate Change / SCENario GENerator" MAGICC/SCENGEN model results on climate scenario for 2021 -2050 were shown as below.

Climate scenario for 2021-2050

The temperature scenario shows 1.4 – 1.7°C increase in June – November in the whole country. The north, west, central and eastern parts of the regions are 2.3 – 2.8 °C warmer during December- May. In the case of precipitation, 45 to 80% below normal conditions are projected during the cool season from December to February in the whole country except the lower Myanmar regions and the southern part. In the remaining months there is an indication of about 10 % increase of precipitation in the whole country. It means that Myanmar is going to be warmer with more rain than in 2001–2020.

The following were extreme weather events commonly happened over the previous years: i) cyclones/ strong winds; ii) flood/storm surge; iii) intense rains; iii) extreme high temperatures; and v) drought. In addition, recent climate models predicted further sustained impacts from climate change in future, which will further expose Myanmar to the negative impacts of climate change (INDC, 2015).

Climate change related phenomena include unusual fluctuations in rainfall patterns and temperatures, as well as their associated impacts on water availability, pests, disease, and extreme weather events. These environmental stresses affect the processes that underpin the various socio-economic sectors such as, agriculture, water, energy, industry, public health and etc. Myanmar is highly vulnerable to hydro-climate extremes, a quarter of the country facing flood risk (threatening 36% of the coastal population) and many areas experiencing droughts, particularly in the Dry Zone. Average temperatures are expected to rise 1- 4 ºC by the end of the century and rainfall is project to increase around 10% (mostly concentrated in fewer rainfall days and more extreme events (LIFT, 2012).

1.4.1.2 Climate change impacts in Myanmar

The Global Climate Risk Index 2018 described that Myanmar ranked the third most vulnerable country in the world to extreme weather events over the last 20 years. The Index analysed to what extent countries affected by the impacts of weather-related loss events (storms, floods, heat waves etc.). Based on the "Weather-related loss events for the period from 1998 to 2017", Puerto Rico, Honduras, and Myanmar ranked highest (Eckstein, et.al, 2019).

Myanmar first experienced with the most devastating natural disaster in its history in May 2008, when the Cyclone Nargis hardest hit the Ayeyarwaddy delta area of Myanmar. With heavy rains and winds reaching over 200 km/h, 140,000 people perished and about 800,000 people were displaced. The floods submerged more than 783,000 hectares of rice fields; many were damaged by intrusion of sea water and sand. Over 85% of rice seeds were lost and 50% of total draft animals (about 150,000 numbers) died in the affected area (PONJA, 2008). Since then, Myanmar people have awakened to the danger of climate change disaster. People began to recognize the value of environmental conservation, mangroves forest etc. To date, after a decade of this Cyclone disaster, economy still remained depressed and livelihood security was far from stabilities in the affected

areas, although the government agencies, local and international NGOs and donors provided support.

It was evident that extreme high temperatures were creating negative impacts on agricultural production and food security in all regions, most seriously in the Dry Zone. As an example, severe droughts occurred in 2009 and 2010, resulted in huge failure of major cash crops across the country. In 2010 summer season, 1,482 heat-related disorders were reported and 260 heat-related deaths occurred across Myanmar. In addition, the decrease of fresh water sources resulted in communities without safe drinking water, increasing dehydration risks and further exacerbating diarrheal diseases (NAPA, 2012).

Besides the drought, late onset and early withdrawal of monsoon period resulted in large quantities of rain falling over short periods, leading to flooding in some places and drought in others. The floods not only damaged the properties and livelihoods but also disturbed waterways and water resources, and created coastal and bank erosion, severe soil erosion and sedimentation. These days, Myanmar has experienced several times of seasonal floods and landslides in various parts of the country. A severe historical flash flood occurred in Dry Zone in October 2011 due to an impact of a tropical cyclone. The mountain torrents swept away the villages along the riverbank and hundreds of people were killed. The villages in Magway, Mandalay and Sagaing Regions were severely affected. A number of dams, reservoirs and bridges were damaged in these areas.

Moreover, the Cyclone Komen made a landfall in Bangladesh, which resulted in widespread flooding across (12) of the (14) States and Regions of Myanmar in 2015. Because of huge damage and destruction, Chin State, Rakhine State, Magway and Sagaing Regions were declared as natural disaster zones. Again, Ayeyarwaddy, Bago and Mandalay, Magway and Sagaing Regions and Kayin State were affected by floods in July, 2017 due to continuous heavy rains. According to the Government of Myanmar's Relief and Resettlement Department (RRD), more than 91,000 people across 29 townships were temporarily evacuated. RRD built evacuation sites with support from civil society organizations (Reliefweb, 2017).

Furthermore, a surge of water inundated the rural flat land in Bago Region after the Swar Chaung dam spillway collapsed on 29th August, 2018 due to heavy seasonal rains. The flooding water breached the dam causing damage to about four hundred houses in the villages of Swar Township and the bridge of Yangon – Nay Pyi Taw Highway was broken, disturbed the transport for several days. There were more than 14,000 households and some 63,000 people affected by the floods; more than 12,600 people were evacuated (New Straits Times, 2018). Hundreds of houses were damaged or destroyed, and more than 60,000 acres of farmland were flooded. Emergency response actions were conducted by the government agencies, local and international NGOs, UN organizations and etc. Post disaster rehabilitation programs were carried out – such as repair of collapsed houses, construction work of collapsed spillway, de-silting on flooded areas, supporting the displaced households, rehabilitation of farm lands, etc. (ADSP, 2018).

In addition to the floods, many regions of the country struggled against the prolonged droughts and erratic rainfall, inadequate water for drinking, household use, and cattle feed. Crop loss and yield reduction were prevalent during the past decades. Similarly, climate disasters affected the livestock sector severely which brought fatalities and losses. The livestock sector is generally a secondary source of rural livelihoods. Traditionally, most households own some livestock, usually a combination of cattle, sheep, goats, pigs and poultry. Extreme high temperatures and continuous rainy days led to pests and disease outbreaks to the crops. Moreover, it favored diseases to livestock, such as foot and mouth disease. Livestock yields were impacted directly through temperature effects on annual growth, milk and meat production and reproduction. They were also affected indirectly by decrease in animal feed - quantity and quality of pasture, forage, and grasses.

Due to the climate related disasters the low rural incomes often generated food insecurity in several areas of the country. The food shortages of rural households in the Dry Zone were estimated for over two months in the drought year of 2010 (UNDP, 2019). The burden of finding animal feeds

and water during drought was significant for poor and landless households. Many farmers sold out their animals as a coping strategy. Farmers were reluctant to keep cattle and they tended to substitute with small farm machines in their farming. Since the cattle manures are valuable natural fertilizers, declining cattle number in these days would create land degradation problem in near future.

Besides agriculture sector, the extreme climate variability also affected several key socio-economic sectors such as energy, industry, transport, natural resources, infrastructure etc. Food prices increased because of decreased production, creating socio-economic constraints to urban and rural people alike. Crop failures enforced the rural people abandon farming and out-migration to search for other income opportunities. Out- migration is a common phenomenon these days for young people in rural villages, creating labor scarcity in farming. As stated above, Myanmar is extremely exposed to high risk of natural disasters so that the emergency preparedness remains a big challenge. There is a continued need for climate change adaptation, disaster risk reduction and activities which aim at strengthening national capacity to fight against the ongoing and upcoming climate change impacts.

Climate change will exacerbate poverty and food insecurity for the poorest smallholder farmers in the foreseeable future. Moreover, climate change impacts are unequally distributed as men and women living in the most fragile environments, such as dry lands, mountainous areas, and coastal zones which are more exposed to environmental shocks and stresses. The studies on gender vulnerabilities to climate change generally found that women were more disadvantaged than men. The policies that support growth and development among vulnerable communities will be the key factor for addressing these multiple challenges.

In Myanmar, observed and future effects of climate change heighten the risks of rapid onset of disasters – such as floods and cyclones – with recurrent loss of lives and economic set-backs. They also bring silent, deep changes, such as erratic rainfall patterns and higher temperatures that are already reducing agricultural productivity in the Central Dry Zone area as well as sea level rise and soil salinization that erode human settlements and infrastructure, already driving many to seek alternative livelihoods in urban areas or abroad, thus affecting Myanmar's society and economy (GoM, 2019 (c)).

Acknowledging these challenges, Myanmar has made significant progress to equip itself with the institutional and policy instruments required to address climate change at national level. It has formulated and adopted the Myanmar Climate Change Policy (MCCP), a crucial document that mandates climate change adaptation and mitigation considerations are integrated into national priorities across all sectors, in the decades ahead.

To increase Myanmar's adaptive capacity and maximize opportunities from low-carbon development, the Myanmar Climate Change Master Plan (MCCMP) (2018-2030) clearly defines a series of high-priority activities, their respective strategic indicators, and the responsibilities of involved stakeholders across six specific action sectors prioritized in Myanmar (GoM, 2019 (d). Actions will enable the government and its development partners, private sector entities, civil society and households to invest in climate-resilient and low-carbon development in priority social and economic development sectors.

1.4.1.3 Adaptation strategies operated by the government and international projects

Approximately 14.5 million people (34% of total population of Myanmar) are residing in the Dry Zone. About 43% of households live in poverty and it is one of the most food insecure areas in the country (JICA, 2015). The Dry Zone has characteristics of very low (mean annual rainfall of 500-1000 mm) and erratic rainfall over time and space so that it is the most water stressed region of the country. The extreme variability of rainfall such as high intensities, scarce rainfalls are the major constraints to rural livelihoods, contributing to food insecurity in the Dry Zone.

To overcome scarce water availability, village ponds, small reservoirs and earth dams were constructed and renovated by the government and with the support of local and international NGOs. Farmers commonly apply various irrigation means of canal irrigation, pumped irrigation, ground water extraction and river pumping. In many villages, deep and shallow tube wells are used for drinking, domestic use water and irrigation. However, there are a number of villages encountering insufficient drinking water in summer season.

To reduce deforestation and for climate change adaptation, the Dry Zone Greening Department (DZGD) was formed under MOECAF in 1997. To reduce the reliance on the forest for fuel wood, a total of 0.4 million of fuel-efficient cook stoves and 67.8 million of fuel briquettes were distributed by the department. In addition, it provided a total of (1,420) small pond, 86 artesian wells and (1249) small dams constructed to supply water (Annual Report, DZGD, 2010). In various regions of Myanmar, several NGOs and INGOs provided efficient cook stoves, which will reduce the drudgery firewood collection, particularly by rural women. Moreover, it will eventually contribute to lessen the deforestation.

In addition, several development projects have been implemented in the Dry Zone focusing on the better water availability. The examples are - "Sustainable management of water to improve food security and livelihoods in the Dry zone" by LIFT in 2013-15. In addition, the project for development of "Water saving agriculture technology in the central Dry zone (WSAT)" was implemented by JICA and the MOALI during 2013 – 2017.

A UNDP project on "Addressing climate change risks on water resources and food security in the Dry Zone of Myanmar" has been implemented in five most vulnerable townships of Myanmar's Dry Zone (2015-2019). The project outcome will reduce the risks and effects from recurring droughts, floods and erosion through an integrated water management, crop and livestock adaptation program. It seeks to reduce the vulnerability of farmers to increasing drought and rainfall variability, as well as enhance their capacity to respond to future climate change impacts on food security. Project collaborated with the grassroots organizations such as farmer groups, community forest user groups, community-based organizations and local NGOs for the local empowerment. It was anticipated that the project would reduce food insecurity and losses from extreme climate events in (42,000) households. The project tackled the following components:

(1) "Respond to the climate-induced reduction of freshwater supply",
(2) "Climate-resilient flood and livestock production systems established and promoted",
(3) "Improve communal climate risk information and monitoring".

Moreover, climate change resilience in agriculture was one of the focus areas of the UN Food and Agriculture Organisation (FAO), to support Myanmar's effort to attain food security in the next five years of Myanmar (FAO, 2017). FAO has helped Myanmar to strengthen the governance and sustainable management of land, forest and natural resources; and enhancement of more resilience of rural communities, also local farmers' resilience in climate change as well as trans-boundary animal diseases. The FAO, in collaboration with Myanmar Aerospace Engineering University have conducted the post-disaster damage assessment in Myanmar since 2016. With the aim of enhancing disaster preparedness and response activities, the disaster risk reduction (DRR) task force and drone mapping unit were established in 2018 (FAO, 2017). In addition, FAO collaborated with the Ministry of Social Welfare, Relief and Resettlement and MOALI to map out flooded areas in Magway Region. The information was used to better understand flood vulnerability and to locate the affected communities.

It is essential for farmers to have access to credible money lenders for the improving their climate change resilience and all-round rural development of the country. MADB (Myanmar Agriculture Development Bank) is the only one government's organization for disbursing loans on an individual basis. It disburses "Seasonal Crop Production Loan" which is designed to cover the working capital needs of smallholder farmers at the beginning of the agriculture season. Loans are divided into three categories: monsoon, winter, and pre-monsoon loans and entitled crops are paddy,

groundnut, sesame, beans, long staple cotton, corn, and mustard. When a farmer successfully pays off his loans, he can apply for a fresh loan at interest rates of 8 per cent per month. The bank provides Kyats (Ks) 150,000 per acre of rice plantation and Ks 50,000 per acre of other crops. These loan amounts used by MADB generally cover about the half of the total cost of crop production. In general, the formal institutions cannot adequately offer banking services to farmers and it made them borrow from informs money lenders with high-interest rates. A few private banks and investments have started working for microfinance but not fully operationalized (Shwe et. al., 2018). These credit systems should provide the required capital of farmers and micro-enterprises to support their farming and micro business activities that will contribute to the rural development and increase the farmers' resilience to climate change.

1.4.1.4 National Adaptation Programme of Action (NAPA) Project

For several decades, Myanmar has followed a conventional economic development path without any concerns of environmental safeguards. Consequently, the country is currently confronting with its negative environmental impacts. To address these issues, Myanmar mapped out a National Adaptation Program of Action (NAPA) in 2010 – 2012. The goal of the NAPA was to identify and communicate immediate and urgent adaptation needs (Priority Adaptation Projects) for implementation in Myanmar that will enable the country to adapt to the impacts of climate change and build resilience of vulnerable communities. It covered eight sectors, namely: 1) agriculture, 2) early warning systems, 3) forests, 4) public health; 5) water resources, 6) coastal zones, 7) energy and industry, and 8) biodiversity. The preparation process followed the guidelines outlined by the UNFCCC - Least Developed Countries (LDC) Expert Group.

The "Priority adaptation project" was nominated in the NAPA target areas where communities were considered most vulnerable to climate change. Priority projects were identified using existing research on the impacts of climate change as well as in-country Participatory Rural Appraisals (PRA). Furthermore, they were prioritized using a set of fifteen (15) weighted selection criteria from a list of seventy-seven (77) Adaptation Options identified for the country. The NAPA target audience was broad and included individuals from government institutions, international agencies, NGOs, and the private sector. Priority Adaptation Projects as well as sectors were prioritized using participatory discussions and analyses including expert opinion as well as community and cultural/traditional knowledge. NAPA specified thirty-two (32) priority activities for effective climate change adaptation for eight (8) main sectors/themes (i.e. four Project Options per sector/theme). In the NAPA Report, Myanmar identified short, medium and long-term priority actions in various sectors. The four (4) priority level sectors were established to promote the climate change resilience of the people and to protect the environment (Table 5).

Table 5. The four priority level sectors established in NAPA Report

Priority Level	Sector
First priority level	Agriculture, Early Warning Systems and Forest
Second priority level	Public Health and Water Resources
Third priority level	Coastal Zone
Fourth priority level	Energy and Industry, and Biodiversity

The NAPA report stated that "agriculture" and "water resource management" sectors stood as first and second priority level, respectively. It implied that these sectors were important to give priority for climate change adaptation. By improving crop and livestock production, higher food security and farmer income will strengthen the resilience capacity of farmers to climate change, contributing to a sustainable development. Similarly, improved water management sector will boost the

agriculture production and help people's health and wellbeing, contributing to better living standards. To address these immediate needs for building climate change resilience, NAPA report also described the "Priority Adaptation Projects" as shown in Table 6.

Table 6. Priority adaptation projects for implementation in Myanmar to address immediate needs for building climate change resilience of vulnerable communities

Sector/Theme	Priority Adaptation Project Title	US$ (million)
AGRICULTURE	**First priority:** Reduced climate change vulnerability of rural and subsistencefarmers through locally relevant technologies, climate-resilient rice varieties, and ex/in-situ conservation of plant genetic resources.	US$ 1.5
	Second priority: Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.	US$ 1.5
	Third priority: Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.	US$ 1.5
	Fourth priority: Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-resilient rice varieties.	US$ 1.5
WATER RESOURCES	**First priority:** Assessing the status of dams for providing sustainable water supplies and withstanding flood risks under future climate change.	US$ 1.5
	Second priority: Constructing small-scale water impoundments in Nay Pyi Taw for flood control and increasing water supplies for local communities.	US$ 3.56
	Third priority: Protecting human life and property against climate extremes in the Ayeyarwaddy river system through channel improvement and adaptation structures.	US$ 0.6
	Fourth priority: Estimating regional rainfall-runoff relationships for supporting the development of flood early warning systems and ensuring sustainable water management.	US$ 1

Source: Myanmar NAPA, 2012

1.4.1.5 Gender roles in rural development and climate change adaptation

Agriculture plays a central role in Myanmar's economy, providing livelihoods for at least 5.4 million households of which rice is grown by 2.1 million households. The majority of farm

households (Approx. 76 %) are smallholders, with less than 5 acres (2 ha) of farmland (FAO, 2016). In most households, women traditionally take primary responsibilities in basic tasks such as child care, preparing food and bear the household chores and managing the family budget. However, their contribution is often less recognized. Generally, both men and women actively participate in various forms of agricultural activities for their daily rural livelihoods. Nevertheless, women are traditionally excluded and limited to participate in decision making, economic activities and etc., in their communities. Myanmar women have experienced the discrimination and constraints in accessing land, participating in consultations and decision-making processes regarding land, and in utilizing dispute mechanisms and etc. The reasons may lie in social or cultural inequality, limited education, skills and abilities, and etc.

In Myanmar's tradition, men are recognized as heads of households and they are dominant in decision making. Since agriculture is the mainstay of the country's economy and about 70% are residing in the rural areas, the gender roles in rural households' decision making were discussed here. A survey research showed that men mostly took a lead role in the agriculture work but the respondents mentioned that the men listened to the women's opinions and in many cases decisions were jointly made. In farm households, the proportion of women's participation in decision making was also high in almost all activities. Women's decision making power in livestock raising, growing crops for household food consumption, growing crops for sale, and non-farm economic activities were 77%, 75%, and 72%, 41% respectively. Comparing with "farm households" and "Non-farm households", women decision making power was the highest in "livestock husbandry" for farm households while the power was highest in "non-farm economic activities". Moreover, the study also showed that women's involvements were high in both households when major decisions regarding the household's economic activities were made. Therefore, women's active involvement in decision making should be considered essential for the economic development of rural households (Win and Myint, 2018).

The World Bank (2017) stated that more than 50 % and nearly 50 % of female population in Ayeyarwaddy and Bago Regions of Myanmar performed in Agriculture sector. Despite their participation, women are generally disadvantaged in such important issues as access to land, education, information and resource productivity. According to national statistics, 11 percent of women are illiterate while only 4 percent of men are illiterate.

Socio-economic characteristics of male and female-headed households were studied in Maubin (Ayeyarwaddy Region) and Daik U Townships (Bago Region) in 2015. The average educational status was found to be highly significantly different between the genders. More female household heads attended monastery and primary school level compared to their male counterparts. In addition, the percentage of high school level of male household heads was higher than female household heads (Win, et al., 2018).

A new "Farmland Law" was introduced in Myanmar in 2012, amended in 2018. It was a land registration program which issued "Land Use Certificates", the permission of right to use the farmland. Farmers will have the right to sell, pawn, lease, exchange, or donate, in whole or in part of the right for farming in accord with prescribed disciplines. However, it was noted that, women cannot fully enjoy with the right for farming of the law. It was noted that the wives' names were not mentioned in the certificates. The law was written with less consideration to gender issues, and did not extend adequate protection for women's land rights.

Like in many countries around the world, the climate change impacts women and men differently in Myanmar as a result of existing inequalities, responsibilities, roles and etc. These differences are mainly attributed to unequal in land and tenure rights, natural resources and assets; access to basic education, capital, training, and technologies, and etc. During disaster time, women suffered worse than men. Although the official data were not published, many more women were perished than men during the cyclone Nargis disaster in 2008. It was also noted that after extreme climatic events the ability to reconstruct their lives and capacity to adapt to climate change were lower than men.

Regarding these, women should be encouraged and empowered to engage more in education, social and income generation activities in order to reduce rural poverty. The integration of gender considerations in rural development and climate change adaptation plans is crucial for the long-term sustainability and effectiveness of such actions. Addressing gender-based vulnerability can strengthen the capacity, resilience, health and development of the society. Accordingly, in the Myanmar Climate Change Strategy and Master Plan (MCCSMP), 2018-2030 and Myanmar Climate Change Policy (MCCP), gender-responsive action points were included, such as mainstreaming gender issues in climate change related policies of agriculture, fisheries and livestock and irrigation sectors.

1.4.2 Process and results of sector selection

As a first activity of TNA project of Myanmar, a scoping mission workshop was organized on 27 Sept. 2018 at the ECD office in the presence of the UNEP DTU Partnership (UDP) scoping mission of TNA project. The Deputy Director of ECD, Ms. Thin Thuzar Win made a presentation for the introduction of TNA project. As a complementary project, she explained the current status of preparation of Myanmar INDC which was successfully submitted to UNFCCC in 2015. Dr. Subash Dhar Regional Coordinator of TNA - Asia and Pacific and Prof. S. Kumar of AIT explained TNA project: project background, the processes, steps to follow, and the role of stakeholders in the project. They advised Myanmar to select two main sectors for each of adaptation and mitigation to climate change. The mission contributed key suggestions to achieve the successful TNA project. The ECD of MONREC acted as a national contracting entity of TNA project, facilitating the inputs from other line ministries. Since TNA project is based on country driven project, all stakeholders were encouraged to participate in all steps of TNA process. The stakeholders who attended the scoping workshop belonged to the various categories - governments, institutions, industries, suppliers, organizations local and international NGO, private sectors, community based organizations etc. The list of stakeholders of Scoping Mission Workshop was described in Annex II. It was noted that the total numbers of participants were (38) of which (18) were female and (20) were male participants. The "Sector selection" needed to depend entirely on a country decision and therefore, all stakeholders who joined the workshop participated in decision making.

Seven numbers of tentative priority sectors for climate change adaptation were listed, which were the same as those in Myanmar INDC, 2015. They were namely "Agriculture, Early warning system, Public health, Water resource management, Coastal zone protection, Energy and industry, and Biodiversity preservation". The TNA process followed the guidelines and procedures, recommended by UDP /UNFCCC Handbook for conducting technology needs assessments for climate change, and organizing the national TNA process. In the process, the "Sector selection" came first; the fact taken into account was that the sector should be in line with the country's development priorities with the consideration of sustainable transfer of technologies or proper use of limited resources. The relevant sectors considered the fact that affected not only by the current climate conditions but also by future climatic changes. By doing so, the expected implications for environmental and social as well as economic impacts can be deduced. For the selection of the priority sectors, considerations also included vulnerability risks and adaptive capacity (existing technologies and coping strategies) and impact on sustainable development priorities technologies.

Agriculture sector was prioritized as the most appropriate sector for climate change adaptation of the country because (i) it plays the most important role in the country's economic development (ii) it is of high vulnerability to climate change, and (iii) the climate change adaptation technologies could raise overall standard of rural people and contribute to poverty reduction of the country. Myanmar is an agriculture-based country, highly dominated by agriculture; its economy is currently at the developing and transition stage to a market-oriented one. Accordingly, the objective of MOALI is **"***To assure development of agriculture as the base and all-round development of other sectors of the economy as well*" (DAP, 2017). When we considered the possible climate change impact with regard to climate vulnerability in Myanmar, there has been increasing

evidence of adverse impacts of disasters and climate vulnerability to the agriculture sector. Seasonal floods, cyclones, landslides, and droughts frequently hit the country during the last decades. Many regions of the country are highly vulnerable to climate change impacts because of their exposure to recurring extreme disasters. Medium- and large-scale natural disasters have damaged the agricultural production, agriculture-sector growth, and food value chain and it in turn constrained farmers' adaptive capacities. The impacts are so intense that farmers cannot cope with these climate change impacts without the external support. Accordingly, "Agriculture sector" was selected as a priority sector for Myanmar TNA project.

Additionally, agriculture sector is the highest user of the country's water resources. In other words, the "Water resource management sector" is a supporting sector to successful agricultural production. Not only this, the livelihoods of rural people, including the water access of drinking and household use, and the country's hydropower mainly rely on natural water resources of the country. Moreover, the evidences have showed that the "Water resource management sector" was highly vulnerable to climate change impacts during the last decades. Myanmar often suffered from damages caused by seasonal floods and droughts which were more significant than other sectors. The flood impacts were not only agricultural production losses, but also damage to people's properties and lives. Similarly, the occurrence of drought, a hidden disaster, resulted in poor growth in agriculture and water related sectors, such as transport, energy, industry, health and etc., hindering the overall development of the country. Taking these into consideration and after comprehensive discussions, the stakeholders confirmed that "Agriculture" and "Water resource management" sectors were the most suitable sectors for climate change adaptation in Myanmar TNA process.

CHAPTER 2: Institutional Arrangement for the TNA and the Stakeholder Involvement

The MONREC is the main ministry to coordinate with other line ministries to implement the task relating with climate and environment, and make sure to consolidate the concerns of climate change into the development of national and sectoral plans and programs. The Environmental Conservation Department (ECD), a focal point for climate change, communicates with international organization. The main duty is to negotiate with and report to UNFCCC, and to implement national level by transforming global-level decision that is including the endorsement of projects from different climate change funds to support the country. Like other climate change related projects, ECD acted as an executing agency for TNA project. The project has followed the guidelines provided in the guide notes: Organizing the National TNA process: An Explanatory Note, 2010-16, and the guidelines proposed by the UDP/UNFCCC Handbook; TNA Guidebook Series: Technologies for Climate Change Adaptation – The Agriculture Sector and The Water Sector, UNEP, 2011: http://tech-action.org/. Following these guidance, ECD formed institutional arrangements for the successful implementation of the TNA project. The following initial steps were undertaken:

- Appointment of the TNA coordinator and national consultants,
- Identification of relevant stakeholder agencies for the TNA Committee,
- Formation of National TNA Project Steering Committee
- Define a process for stakeholder consultation by establishing the TNA committee and Technical Sectoral Stakeholder Working Groups for all the priority sectors

2.1 Organizational Structure for a TNA Process

Figure 3 shows the Organizational structure for the TNA process. The various elements in the country's structure was broken down and explained in the following sub-sections.

2.1.1 National TNA team

The Myanmar National TNA team was organized by following the step-by-step guide note of TNA. The national TNA team was made up of 1) the national coordinator; 2) the TNA committee; 3) National consultants (mitigation and adaptation); and 4) sectoral working groups. Their main roles and responsibilities were described below.

2.1.1.1 The national TNA coordinator

The national coordinator was assigned to Mr. Kyaw San Naing, Director of Climate Change Division, Environmental Conservation Department. He was familiar with the broader issues of climate change and the role of technologies in mitigating and adapting to climate change. His job was to provide day-to-day leadership and vision for the TNA process, responsible for the overall management of the TNA. He was a focal point to manage of the overall TNA process such as vision and leadership for the overall effort, facilitating in communication between the national TNA committee members, national consultants and stakeholder groups. He also provided the formation of networks, information acquisition, and coordination and communication of all work products. He is also the official contact point for the country, communicating progress and/or any queries directly with the Country Coordinators at UDP and the Regional Centers.

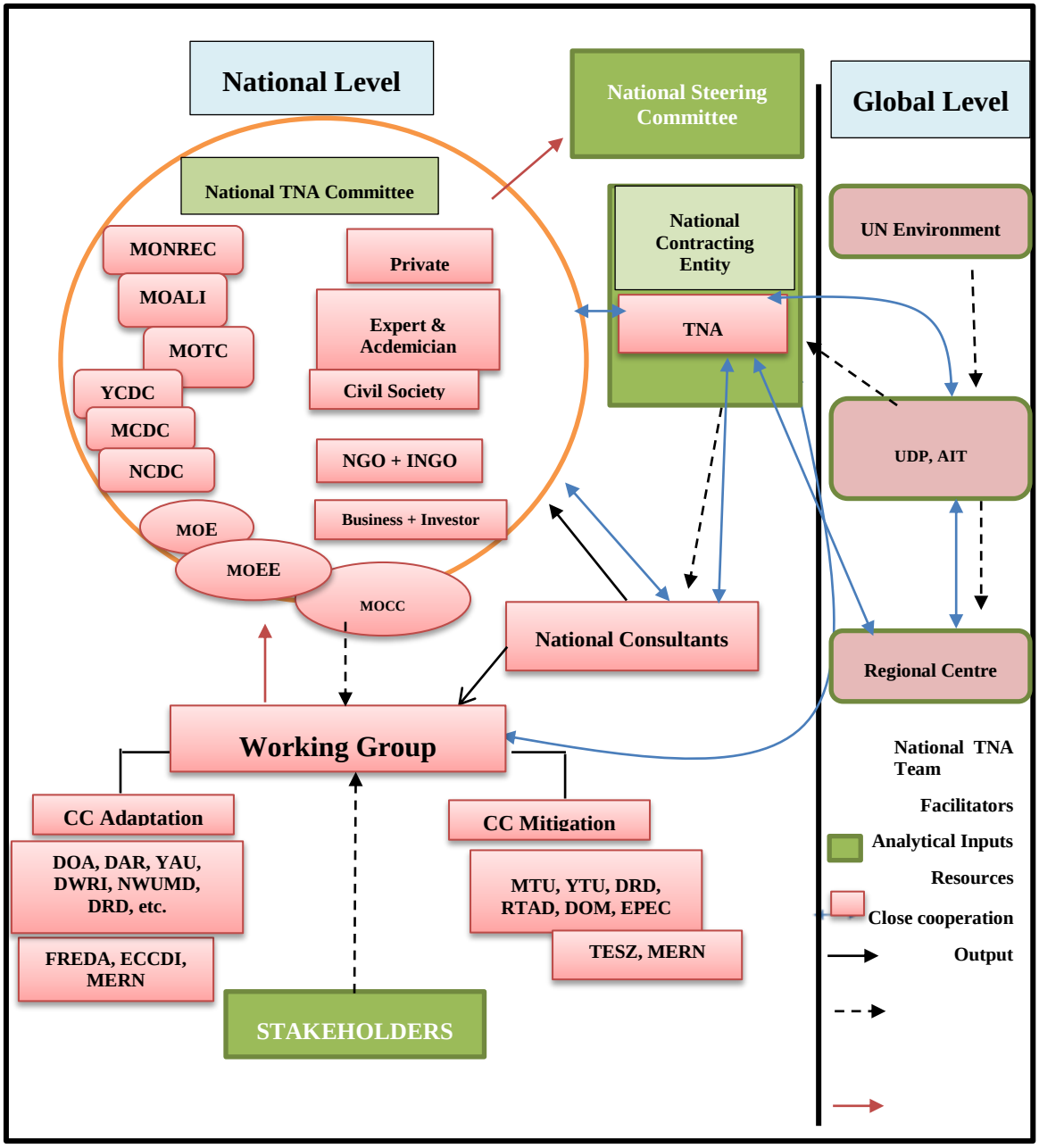

Figure 3. Organizational structure for the TNA process of Myanmar

2.1.1.2 The TNA committee

The committee was the core decision-making group in which the representatives were responsible for implementing policies. It was composed of representatives from relevant ministries, civil society (NGOs), the private sector and experts or academics. Generally, the members were familiar with national development objectives, sector policies, climate change science, the potential climate change impacts for the country, and adaptation needs. The role of the National TNA committee was to provide leadership to the project in association with the TNA coordinator. Specific responsibilities were:

- Provide leadership to the project in association with the TNA coordinator,
- Identify national development priority sectors,
- Decide the constitution of sectoral/technological workgroups,
- Approve technologies and strategies for mitigation and adaptation recommended by sectoral workgroups,
- Provide approving the sectoral Technology Action Plan (a roadmap of policies that will be required to remove barriers, and creating the enabling environment) and

- Develop a cross cutting National Technology Action Plan for mitigation and adaptation.

2.1.1.3 National consultants

The National TNA coordinator in consultations with UDP assigned two national consultants, one responsible for mitigation and one for adaptation for the TNA project. They were responsible to identify and prioritize technologies, barrier analysis and market assessment, and drafting of project proposals for priority technologies for their respective area of expertise. Their specific responsibilities were -

- Provide process-related and technical advisory services needed for conducting TNAs, Barrier Analysis, and developing Technology Action Plans (TAPs)
- Lead and undertake activities such as research, analysis and synthesis in support of the TNA/TAP, delivering all project outputs
- Participate in capacity building workshops
- Work in close partnership with the National Coordinator to facilitate communication within the national TNA Team (consultants, sectoral working groups and the national committee), engage with stakeholders, form of networks, and coordinate and communicate all deliverables

2.1.1.4 Sectoral / technology working groups

Various stakeholders were central to the TNA process to constitute the working groups by the TNA committee to provide an active role to the stakeholders in the TNA process. In order to provide appropriate technologies for a sector, the working groups were formed on sectoral basic, and they conducted market barrier analysis and recommended an enabling framework for the sector. The composition of the sectoral working groups included representatives of government departments that have responsibility for policy formulation and/or regulation; private and public sector industry representatives; and technology experts (e.g., from universities, consultants, etc.). They contributed with technical expertise and input to the technology prioritisation, the barrier analysis and ideas/ inputs for the enabling framework for a given technology and/or sector.

The sectoral/technical workgroup members were listed in Annex III. The main purpose of the stakeholder participation was to get their involvement throughout the TNA process, technology identification and prioritization, barrier analysis, market mapping and development of enabling framework, Technology Action Plans (TAPs). Therefore, it was emphasized to get continuous and adequate involvement of stakeholders at each stage of the TNA process. The stakeholder involvement was considered very crucial to the TNA process as it reflects national response to climate change technology.

2.1.2 The National TNA project steering committee

The steering committee was composed of members from all relevant ministries responsible for policymaking, and key stakeholders from the private sector and civil societies (NGOs). Mr. Hla Maung Thein, the Director General of ECD, MONREC chaired the committee. It was formed with nineteen (19) members of whom twelve (12) men and seven (7) women were composed. The composition of the committee was described in Annex IV. Their role was to provide high-level guidance to the national TNA team and help secure political acceptance for the TAP. The specific responsibilities were –

- Coordinate the selected technologies prioritized by TNA working group and national consultants with the national development plans related with climate change,
- Provide guidance for the implementation of TNA processes of the National TNA team,
- Approve the Technology Action Plans – TAP for the climate change mitigation and adaptation, once the TAP have been finalized.

2.2 Stakeholder Engagement Process Followed in the TNA – Overall Assessment

The TNA process ensured the widest possible stakeholder participation. For the "climate change adaptation" sector, two technical stakeholder working groups were established on sectoral basis: for "Agriculture" and "Water resource management" sectors. The national TNA team organized the formation of "Sectoral Working Groups" of key stakeholders. Firstly, the most relevant government organizations, NGOs and private sectors etc. nominated a responsible person from each organization for the TNA Project. After receiving the nominees, the two working groups, namely "Agriculture sector" and "Water resource management sector", were organized depending on their relevancy. The Minister of the MONREC approved the lists of these working groups. There were fourteen members of "Agriculture sector working group" where the sex ratios of six (6) women and eight (8) men were included. The "Water resource management sector" included a total member of sixteen (16) persons of which six (6) women and ten (10) men were participated. The members of these stakeholders workgroups were the same as the lists of the participants in the Inception Workshop held at ECD, Nay Pyi Taw (Annex III).

These stakeholder working groups represented the related organizations, such as agriculture, water, fishery, livestock breeding and veterinary, rural development, inland water transport, City Development Committee and so on. They were the representatives of the Government departments, private and public sector, organizations and other relevant institutions such as universities, research organizations and relevant NGOs. They all were mandated with the responsibility of taking decisions with regard to the technologies appropriate for respective sectors, undertake barrier analysis, market assessment and enabling framework for relevant sectors, and contribute to development of TAP and project ideas. They all attended the **"**National Inception Workshop" held on 2 July, 2019 at ECD office, Nay Pyi Taw. The National TNA team organized the second sectoral/technical working group meeting with and core stakeholder groups of agriculture sector at 10 September, 2019 at ECD office. The participants of sectoral working group members of each "Agriculture" and "Water resource management sector" were presented in Annex V. Furthermore, for the technology prioritization process, the national TNA team organized a series of "bilateral meetings" during the third week of September, 2019 by visiting at government departments concerned such as DOA, IWUMD, YAU, DRD and DAR. The lists of the government officials who joined the "bilateral meetings" were described in Annex VI. The goals, objectives and working arrangements of the participatory process were explained and all sectoral stakeholder working groups members agreed with the processes. This consultation included the detail explanation of purpose of stakeholder participation and the processes of the TNA Project.

Besides the government organizations, local NGOs and private sectors were participated in all consultation workshops. The working group of "Agriculture sector" included the representatives of three local NGOs, namely MERN, FREDA and ECCDI while "Water resource manangement sector" group included NGOs and private associations such as CDDCET, Hydro-Informatics Center, Yangon and Fresh Water Resources Program Department, WWF. In addition, the representatives from the "Water and Sanitation" Section of Yangon City Development Committee (YCDC) and Mandalay City Development Committee (MCDC) and Nay Pyi Taw Development Committee (NPTDC) participated in the " Water Resource Management Sector" group**.** The Project Coordinator and the consultants facilitated these sectoral working group discussions ensuring the maximum output from the consultation.

It was observed that, among the attendees, a considerable number of stakeholders were knowledgeable about the selected sectors and they were the "most relevant" by considering their attributes relevant to the project. However, some participants have limited knowledge related with the selected sectors and they had less influence on the discussion. For example, the staffs from YAU, DAR, and DOA and the local NGOs of MERN, FREDA and ECCDI have adequate knowledge about "Agriculture sector". Similarly, the participants from DRD, IWUMD, Directorate of Water Resources and Improvement (DWRI) of River Systems, Hydro-Informatics Center and WWF, were knowledgeable and familiar with "Water resource management sector".

During the Inception Workshop (2 July 2019), the attributes of each "Key stakeholder" were discussed among all members of the group. During the first stage of the workshop, all participants conducted the exercise of "Ranking stakeholders". The last row showed to rank the stakeholders who are the "most relevant" by considering their attributes relevant to the project. The results of the "Ranking stakeholders" for "Agriculture" and "Water resource management" were described in Table 7 and Table 8, respectively. After the completion of "Stakeholder identification" and "Ranking stakeholders", the discussions among each group were conducted to define the engagement strategy.

Table 7. Stakeholder identification (Agriculture Sector)

KEY STAKEHOLDERS/ Organizations	CLASSIFY (opponents, allies, not defined)	INTEREST (institutional, political, personal)	INFLUENCE	MOST RELEVANT
A Department of Research and Innovation, MOE Department of Bio-Technology, Mandalay Technology University (MTU)	Allies Allies	Institutional Institutional	(Lowest) The participants from these government organizations who are joining the workshop have little knowledge related with the project's TFS. Therefore, some have little influence on the project activities.	(Lowest) The participants are less relevant with the project.
B Livestock Breeding and Veterinary Department (LBVD), MOALI	Allies	Institutional	(Low) Same as above	(Low) Same as above
C Environmental Conservation Department (ECD), MONREC; Dry Zone Greening Department, (DZGD), MONREC Myanmar Environmental Rehabilitation-Conservation Network (MERN), Yangon Department of Rural Development (DRD), MOALI	Allies Allies Allies Allies	Institutional Institutional Institutional, political Institutional, political	(Medium) During the discussion of the workshop, some participants showed some influence at the topic what they are discussing.	(Medium) The participants are relevant to some extent with the project. They can lead the discussion during the MCA process
D Forest Resources, Environmental Conservation and Development Association (FREDA), Yangon Ecosystem Conservation and Community Development Initiative (ECCDI), Yangon	Allies Allies	Institutional, political Institutional, political	(High) During the discussion of the workshop, some participants showed some influence at the topic what they are discussing.	(High) The participants are relevant to some extent with the project. They can lead the discussion during the MCA process

E Yezin Agricultural University (YAU), MOALI	Allies	Institutional, political, personal	(Highest) Most of the participants have well experience related with "Water Sector" of TNA project.	(Highest) The participants are most relevant with the project. They can lead the discussion during the MCA process.
Department of Agriculture Research (DAR), MOALI	Allies	Institutional, political, personal		
Department of Agriculture (DOA), MOALI	Allies	Institutional, political, personal		

Table 8. Stakeholder identification (Water Resource Management Sector)

KEY STAKEHOLDERS/ Organizations	CLASSIFY (opponents, allies, not defined)	INTEREST (institutional, political, personal)	INFLUENCE	MOST RELEVANT
A Myanmar Port Authority, Ministry of Transport and Communication (MOTC) Hydro-Informatics Center, Yangon Fresh Water Resources Program Department, WWF	Allies	Generally, the participants have interest in the TNA Project. At the time of project implementation of "Water sector", who will be the ownership of the project's selected technology?	(Lowest) The participants from these government organizations who are joining the workshop have little knowledge related with the project's TFS. Therefore, some have little influence on the project activities.	(Lowest) The participants are less relevant with the project. Moreover, some attendees were young staffs (e.g "Staff officer" at the low level position in terms of responsibility and subject matter knowledge.
B Directorate of Water Resources and Improvement of River Systems (DWRIR), MOTC; Inland Water Transport, MOTC	Allies	Same as above	(Low) Same as above	(Low) Same as above
C Department of Fishery, MOALI Environmental Conservation Department (ECD), MONREC Forest Department (FD), MONREC	Allies	Some have institutional interest and some have personal interest	(Medium) During the discussion of the workshop, some participants showed some influence at the topic what they are discussing.	(Medium) The participants are relevant to some extent with the project.
D Engineer Section (Water and Sanitation), YCDC, Engineer Section (Water and Sanitation), MCDC	Allies	Some have institutional interest and some have personal interest.	(High) During the discussion of the workshop, some participants showed some influence at the topic what they are discussing.	(High) The participants are relevant to some extent with the project. They can lead the discussion during the MCA process

IWUMD, MOALI DMH, MOTC Climate Smart Agriculture Center, YAU	Allies	Most of them said that they have all related interests - institutional, political, and personal. Myanmar needs to enforcement of the existing laws, rules and regulations which have already put in place.	(Highest) Most of the participants have well experience related with "Water Resource Management Sector" of TNA project.	(Highest) The participants are most relevant with the project. They can lead the discussion during the MCA process.

2.3 Consideration of Gender Aspects in the TNA process

Gender consideration has been included in various stages of the TNA process. The gender compositions of "sectorial working group" at the consultation workshop in Agriculture sector were six (6) females and eight (8) males while in "Water resource management sector" the composition of females and males were six (6) and ten (10), respectively. All stakeholders when deciding the technology priorities considered the gender issues. For the technology identification, the participation of female was emphasized; female should have an opportunity to participate in the implementation of the selected technologies. For selecting the "Criteria" for prioritization of technologies, it considers whether the female are directly affected or not by the impacts of the technologies. The females, like their male counterparts, should enjoy the benefits of the introduced technologies of the project. In order to tackle the gender issues, the female participation in the labor force of the selected adaptation technologies was also emphasized.

For the pursuing a gender-responsive approach, men and women are ensured to benefit equally from the actions set out in TNAs, and gender differences need to be taken into account throughout the entire TNA process and its outcomes. The gender action plans will be incorporated in the climate change adaptation policies and the TAP. Women and men will have equal opportunities in relation to the Technology Action Plans (TAPs). Similarly, when conducting the barrier analyses, this gender issue will be integrated into their TAPs and a gender-responsive TNA produced.

CHAPTER 3: Technology Prioritization for Agriculture Sector

The National TNA team tried to fulfill the objectives of TNA process. The two main objectives for the process of prioritizing sectors and adaptation technologies are: (1) to meet a country's development priorities and (2) to maximize sustainability outcomes. Myanmar TNA process followed the guidelines and procedures recommended by UDP /UNFCCC such as TNA Step by Step Guidance, Handbook for conducting technology needs assessments for climate change, organizing the national TNA process, Multi-criteria Analysis (MCA) guide notes, and etc. Since

TNA processes are participatory in nature, it is crucial to involve all the stakeholders throughout the whole process. During the consultation processes, all relevant stakeholders were encouraged to involve the various steps of the process such as the prioritization of the "sector selection" and "technology selection". Moreover, the gender inclusion in all processes was emphasized. The nominated technologies were described in TFS in a way that can be clearly understood, accepted, supported and implemented at all relevant levels of stakeholders, i.e. from government ministries, NGOs, private sectors and other organizations.

Once the agriculture was selected as a priority sector, a range of environmentally sound technologies and coping measures were identified and categorized. A list of technologies was supplied in a structure of agriculture sector, their availability in the short or medium to long term and their applicability on a small or large scale. Stakeholder inputs were applied at all stages in these all steps. It was emphasized that the technologies required to reduce the vulnerability risks, contributed to sustainable development priorities and to be clearly in line with countries' development priorities and needs. For prioritization of portfolios of technologies and measures for adaptation, the TNA team and stakeholders applied a Multi-criteria Analysis (MCA). It facilitated to take a decision by analyzing how well different options for the decision score on a set of criteria, which was followed by a discussion among the stakeholders on the relative importance of different criteria. In total of ten (10) technologies were nominated and three (3) technologies were identified as most preferred technologies for Agriculture sector.

3.1 Key Climate Change Vulnerability in Agriculture Sector

Agriculture sector was prioritized as the most appropriate sector for climate change adaptation of the country because (i) it plays the most important role in the country's economic development (ii) high vulnerability to climate change, and (iii) the climate change adaptation technologies could raise overall standard of rural people and contribute to poverty reduction. Myanmar is an agriculture-based country, highly dominated by agriculture; its economy is currently at the developing and transition stage to a market‐oriented one. Accordingly, the objective of MOALI is **"**to assure development of agriculture as the base and all-round development of other sectors of the economy as well" (DAP, 2017). Thus, the adverse climate impacts will surely undermine all-round development of socio-economic sectors of the country.

When we considered the possible climate change impact and with regard to climate vulnerability in Myanmar, there has been increasing evidence of adverse impacts of disasters and climate vulnerability to the agriculture sector. Seasonal floods, cyclones, landslides, and droughts frequently hit the country during the last decades. Many regions of the country are highly vulnerable to climate change impacts because of their exposure to recurring extreme disasters. Medium- and large-scale natural disasters have damaged the agricultural production, agriculture-sector growth, and food value chain and it in turn constrained farmers' adaptive capacities. The impacts are so intense that farmers cannot cope with these climate change impacts without external support (such as national and international supports). In this regard, the applicable adaptation technologies for Myanmar farmers are immediate requirement.

Due to the rainfall variability and erratic and record-breaking intense rainfall, there were very often increased flooding and storm surge across Myanmar. The observed past, on-going and future climate changes have significant consequences in almost all sectors like agriculture, livestock and food security, natural resources and biodiversity; human settlements, public health and etc. The future climate projection simulated by PRECIS climate model showed that Myanmar tends to be warmer with longer summer time and heavier rainfall during rainy season in some areas with higher annual total precipitation (DMH, 2014).

3.2 Decision Context

For the efficient and effective application of technologies, the TNA technology selection was emphasized to comply with the current status of agriculture production and the policies, strategies and frameworks laid down by the MOALI and other concerned ministries. Under the NSDS, 2009, the government set the three goals such as (i) Sustainable management of natural resources; (ii) Integrated economic development; and (iii) Sustainable social development. Therefore, the sustainable concept was one of the priorities given when the technologies were considered (NCEA, 2009).

MCCSMP, (2018-2030) also identifies priority actions in key development sectors to build the adaptive capacity of communities and to promote low carbon development. Among the sectoral outcomes, it mentions that the agriculture, fisheries and livestock sectors will adopt climate-resilient and environmentally sound adaptation technologies and climate-smart management practices (MONREC, 2017 (b)). Thus, the TNA technology selection process mainly emphasized the technologies related with sustainability and conservation of natural resources. For example, the technologies of the development of CSA villages, conservation agriculture practices and soil and water conservation are included in pre-selected options.

Agriculture sector is contributing about 30% of the country's gross domestic product (GDP), providing employment to about 60% of the population. Thus, the impacts of climate change on agriculture have influenced on the livelihoods, food production and the overall economy of Myanmar. In this context, MCSA, 2015 developed by the MOALI aims to achieve food security and nutrition and climate resiliency, with a globally competitive agriculture sector attaining high productivity by 2030 (MOALI, 2015). Myanmar has been applying CSA and good agricultural practices (GAP), contributing to higher living standard, especially in rural areas. To comply with this CSA concept, the technology of establishing Climate Smart Villages was considered as a potential adaption option.

Vulnerability to climate change is a function of exposure, sensitivity, and adaptive capacity. A combination of indicator values representing exposure (change in temperature and precipitation), sensitivity (share of labor in agriculture), and adaptive capacity (poverty) identifies Myanmar as one of the seven most vulnerable countries to climate change in Asia and the Pacific (ADB, 2009). The studies in the INC report, 2012 also revealed that all parts of Myanmar's society and economy, and all areas of the country, notably the Dry Zone and the Ayeyarwaddy delta are vulnerable to climate change.

Myanmar is considerably a large country with diverse agro-ecosystems. The country is generally categorized into three main regions, namely Central Dry Zone, Hilly, and Delta and Coastal Zones. The climate change impacts on these ecosystems vary with their different topography and geographical setting, and accordingly climate change adaptation technologies will differ. Therefore, the adaptation technologies selection considered the country's region-wise requirement. The pre-selected technologies were focused on the suitability to various regions, namely Dry Zone, Hilly, Delta and Coastal Zones.

The observed and projected changes in climate include a general increase in temperature, variation in rainfall and an increased occurrence and severity of extreme weather events such as cyclones, floods, droughts, intense rains and extreme high temperatures. The country is also experiencing a decrease in duration of the southwest monsoon season due to its late onset and early retreat. Current patterns of socioeconomic development rely on climate-sensitive sectors and on its particular location.

MCCS, 2019 also described that Myanmar's population and economic activities are concentrated in disaster risk-prone areas such as the delta, coastal and central Dry zones, which are highly exposed to hazards and have both high poverty levels and low response capacity. Coastal regions are particularly at risk from sea level rise and cyclones, while the lowlands and central Dry zone are vulnerable to the impacts of floods and droughts, respectively. Communities and businesses located in at-risk regions and reliant on climate-sensitive economic activities are particularly vulnerable to

the impacts of climate change. Therefore, in the "Decision context" of the priority technologies included the technologies related with central Dry Zone and Ayeyawady Delta Areas.

MRSDS of MOALI targets production growth that satisfies both domestic and export requirements. By 2030, rice production must reach at least 19.40 million metric tons, about 60% of which is for local food consumption and 40% for international trade. (MOALI, 2015(a)). Strategically and politically, paddy is designated as the main crop of the country for self-consumption and earning foreign exchange. Thus, priority was given to paddy crop in considering the climate change adaptation technologies. The three rice technologies were included in the list of pre-selected technologies, such as the development of paddy dryers and the stress tolerant rice varieties to submergence and salinity.

3.3 Overview of Existing Technologies in Agriculture Sector

Currently, Myanmar's economy is in a positive trend; economic growth is expected to rise to 6.5 percent in 2018-19 due to its economic and political reforms, infrastructure development, investment in and liberalization of sectors like wholesale and retail, insurance and banking and etc., (WB, 2019). Along with this, the agricultural production has been boosting with intensive farming systems with high inputs of chemical fertilizers and pesticides. The injudicious use of these agrochemicals will create negative impacts on the environment as well as on the farm community. The most significant impact is land degradation – which is noticeably reducing the soil fertility. Moreover, commercial mono-cropping (i.e., rice, maize, and pulses) in a large area in successive years will favor the high infestation of pests and diseases, and expose highly susceptible to the climate shock and climate variability. These unsustainable practices within the agriculture sector are happening now and likely to worsen in the near future, unless the environmental concerns are incorporated in the agricultural strategies. Therefore, for the medium and long-term perspectives of climate resilience agriculture, the institutional arrangement, policies and work plans should focus on a sustainable agriculture production system.

To adapt the harsh climate and poor ecosystem, Dry Zone farmers have been using indigenous or traditional farming technologies. To reduce the total crop loss, farmers generally diversify their crops. They practice multiple cropping systems: intercropping and mix-cropping (3-4 crops in a same plot). Under the unreliable rains, the risk-averse farmers could harvest one crop or another for their subsistence level. Most farmers follow the double crop and relay crop whenever they think that they can access the adequate water availability. As an adaptation technology, farmers generally apply technologies such as use of local or indigenous varieties, shift of sowing time, change of crop or variety, use of shorter duration varieties, zero tillage and etc. (Swe and Ando, 2015).

Majority of farmers have small or marginal landholdings. Under the climate related disasters, farmers use a variety of coping mechanisms, such as selling cattle; shifting to other types of livelihood options; change to daily laborers; and seasonal migration, and etc. However, these options are temporary coping measures, not preparing for the future climate problems. Farmers do not use options that improve long-term adaptive capacity due to the various constraints, including the poor knowledge and technology, and limited supports from the government and other funding organizations. In general, farmers access very scarce institutional credits, inadequate resistant and improved crop varieties and lack of crop insurance system. To fight against the climate change, farmers' responses are use of their traditional cultivation practices which they think to match with the changing climate. The practices are crop diversification, local and indigenous stress-tolerant varieties, and short duration varieties, adjusting the planting date, change of crops varieties and cropping pattern, and etc. In general, farmers follow intercropping, mix-cropping, double cropping and relay cropping wherever the water availability exist. These risk-averse farmers have to harvest what is left on their lands at their subsistence level.

The MOALI recommends the farmers to carry out climate-change related measures, such as adjusting cropping systems, using stress-tolerant plant varieties and maximizing water use efficiency. The MCSA Strategy, 2016 focuses on adapting crop varieties and corresponding

farming practices and managing the risk of disaster and loss of crops and income. The extensively driven strategies by the Ministry are use of hybrid rice, Systematic Rice Intensification (SRI), alternate wetting and drying irrigation technique (AWD), and Good Agriculture Practice (GAP) for rice production and other crops (MOALI, 2015). The following are some examples of technologies applied in agriculture sector at present.

- Plant breeding for crop improvement programs of important crops such as rice, maize, sesame, peanut, pulses, etc.,
- Promoting quality seeds (rice, sesame, peanut, pulses, etc.)
- Development and improvement of post-harvest technologies
- Integrated Pest Management
- Promotion of organic and bio-fertilizers
- Soil and water conservation
- Irrigation and water management
- Promotion of aqua culture
- Good Agriculturial Practices (GAP) for rice, other crops and vegetables
- Systematic Rice Intensification (SRI)
- Alternate Wet and Dry (AWD) in rice cultivation technology

MOALI has introduced several advanced technologies mainly focused on increased production, many of which directly or indirectly related to adaptation to climate change. The examples were CSA, Systematic rice intensification (SRI), Alternate Wet and Dry method (AWD) in rice production. Concerning with status of new technologies encouraged by the MOALI, their application were constrained by farmers' financing capacity, in general. In addition, many farmers are reluctant to invest in new technologies because they have often experienced with high risk of unreliable market prices and climate change impacts. In general, farmers did not utilize many technologies to their full potential due to various operational and/ or institutional constraints (i.e.). Similarly, some technologies are proven and readily available, but cannot be fully applied at present because they are costly (i.e. development of stress tolerance varieties, drip irrigation, hydroponic vegetable production etc.).

3.4 Adaptation Technology Options for Agriculture Sector and their Main Adaptation Benefits

The MOALI has been making efforts to increase crop productivity and improve all-round development of the agriculture sector. The main objectives of agriculture sector are (i) To improve the current level of food productivity ensuring national food security, and (ii) To alleviate poverty while enhancing rural incomes. To fulfill the production targets of various major crops, farmers are encouraged to apply high input technologies, farm mechanization, intensive and commercial farming. These high input technologies of commercial farming will negatively affect the environment unless farmers do not consider the necessary counter measures. To address these issues, the process in TNA technology prioritization mainly focused on the sustainable production technologies.

Most of the nominated technologies of TNA project considered the sustainable approach, which conforms to the Myanmar Agenda 21, 1997. The Myanmar Agenda 21 covers the three broad dimensions of sustainable development – the social, economic and environmental dimensions. One of the two strategic areas identified by Agenda 21 was to "Promote sustainable agriculture, livestock and fisheries development". National Sustainable Development Strategy (NSDS) of Myanmar mainly based on Agenda 21 and Myanmar Millennium Development Goals. (NCEA, 2009). To be in line with these national development policies and strategies, the sustainable development was put forward in prioritizing the adaptation technologies under the agriculture sector.

The TNA project aimed to enhance the resilience of vulnerable farmers against unavoidable impacts of climate change by increasing their adaptive capacities and their livelihoods. Although many are not applied in a large scale for the time being, there exist technologies related with climate change adaptation. The underlying reasons are undeveloped markets and lack of credits and supports to the farming industries and etc. Most adaptation technologies require a considerable amount of financing, and not all the technologies are possible to apply at the same time. In the TNA technology selection process, therefore, the most suitable technologies were prioritized to match with the country's current institutional, social and political context.

The following ten agriculture technologies that were highly relevant and applicable to climate change adaptation were taken into consideration in the TNA process.

(1) Establishment of Climate Smart Agriculture Villages (CSV) for sustainable agricultural production in Myanmar
(2) Conservation Agriculture (CA) technology for sustainable agriculture lands in Myanmar
(3) Improvement of "Salinity tolerance rice varieties" in coastal and inland salinity areas
(4) Development of paddy dryers as a community based adaptation technology
(5) Dissemination of solar dryer technology for high valued crops as an adaptation option
(6) Development of submergence tolerance rice varieties in river basins
(7) Introduction of a weather index-based crop insurance system
(8) Solar powered drip irrigation technologies in cash crop production and plantation
(9) Hydroponic vegetable production technology
(10) Integrated soil and water conservation technology for resilient agricultural production in hilly regions

It was found that most of the nominated technologies could hold three categories of benefits: adaptation, food production and mitigation co-benefits. The technologies such as "Climate Smart Agriculture Villages (CSV)", "Conservation Agriculture (CA) technology", "Integrated soil and water conservation technology" were introduced in the TNA selection process. They all have potentials to contribute to climate change adaptation i.e., increase crop resilience, better soil fertility and water-holding capacity and reduced yield variability, leading to sustainability. They will also contribute to climate change mitigation (mitigation co-benefits) by improving soil quality - i.e., increase soil carbon storage, nitrification, and carbon sequestration, and reduce use of nitrogen fertilizers. The development of CSV that includes CSA practices will have potential synergies and co-benefits resulting from adaptation, mitigation, and food production practices. CSV practices will offer increased economic opportunities for farmers resulting from crop and livestock production. This integrated farming system under the CSV will be more productive compared to standalone mitigation and adaptation practices.

In the case of delta and coastal regions of Myanmar, rice productions significantly declined due to the saline water intrusion. With more frequency and intensity of cyclones and sea level rise under the climate change, the saline affected areas are increasing year after year. As a coping strategy, farmers traditionally use saline tolerant local rice varieties saved on their own for several decades. However, these varieties gave low yields since they were degenerated because of the lack of crop improvement programs. Therefore, improvement of "salinity tolerance" rice varieties in coastal and inland salinity areas was proposed. The technology will provide farmers to adapt the saline condition and to increase yields and food security. Similarly, at the flood-prone areas like deltas and river basins, seasonal floods destroy a huge acreage of rice crops almost every year. The technology of submergence tolerance rice varieties in river basins was described as an adaptation technology these specific areas.

In agriculture production, one of the challenges is the high rate of rice postharvest loss during its drying process. Summer paddy area generally covers about 2 million ha with a yield of 5 t/ha which

contributes one fourth of annual total production of the country (DAP, 2017). Harvesting times of summer paddy coincide with the start of monsoon season. Farmers' conventional practice is "sun dry" for 3 - 4 days before storage or selling. In this method the grains are spread on plastic sheets or paved floors, and street drying is very common. Due to lack of drying facilities, farmers suffer high rate of post-harvest loss, slow drying rate and rains disturbance. With poor grain quality, paddy price significantly reduced. Under such condition, paddy dryers will offer a good compromise between drying (dryer) cost and benefits in terms of higher quality and weather risk avoidance. Although not all are well functioning, about 1500 low cost -paddy dryers are currently operating in Myanmar. Currently, there are only a few new types of improved paddy dryers which can dry rice seeds evenly with precise moisture. Therefore, a technology, namely the "Development of paddy dryers**",** was proposed to scale up as a community-based adaptation technology in the face of climate change.

In recent decades, climate induced disasters and extreme weather events have been affecting the country. Although these impacts directly and adversely affected agricultural production, an insurance system for farmers has not yet been realized. For the protection of farmers against these risks, crop insurance is one of the most effective ways in managing risk. Since it is the right time to introduce a "weather index-based crop insurance system", the technology was recommended in the technology selection process. The insurance system will serve an adaptation tool to reduce the vulnerability of farmers due to climate variability and extreme weather.

Rice is a staple food crop which covers approximately 50% of the annual total sown area of the country. Since the rain fed monsoon rice amounted for more than 80% of total rice area, rice production is highly vulnerable to climate change. Comparing with other cash crops, it requires much more water. More droughts and warmer temperatures are expected in future climate scenario. Therefore, the adaptation technologies were considered to grow high valued cash crops and vegetables which have less water requirement, as an alternative to rice crop. Besides, the water saving technologies such as solar powered drip irrigation, and hydroponic system, and soil and water conservation technology were nominated.

3.5 Criteria and Process of Technology Prioritization for Agriculture sector

For the technology familiarisation, the Technology Fact Sheets (TFS) of nominated ten climate change adaptation technologies/ options for agriculture sector were circulated one week before the stakeholder consultation workshop. The TFS included: brief technology description, costs of the technology, application potential in the country, gender aspects, adaptation and social, economic, and environmental benefits. In addition, estimated initial cost and maintenance cost for the technologies were described based on site visits and focus group discussions of with user farmers. During the consultation workshop held at 2 July 2019, the National TNA team introduced the TNA project and MCA methodology to prioritize the adaptation technologies. The participants were the core stakeholder groups and wider stakeholder groups from concerned government departments, private sectors and local NGOs. They were encouraged to participate and all stages of the process ensured the participation of all stakeholders. Moreover, emphasis was given to the gender integration to involve in all steps of TNA processes, such as gender analysis of the technology, inclusion of gender criterion to assess each technology, gender sensitive stakeholder engagement in decision-making process etc. Based on their experiences and knowledge related with adaptation technologies, the stakeholders gave feedbacks to the TFS. After the thorough discussion, the technologies were prioritized with the use of MCA methodology.

The second technical working group meeting was held at 10 September by the National TNA team and core stakeholder groups of agriculture sector. The national consultant gave an explanation on TFS and MCA, as a continuation of previous consultation meeting. The participants provided some modifications and inputs to the TFS. They ensured that these technologies should comply with the existing national and local priorities, plans, and on-going projects in the context where the technologies are going to be transferred and diffused. They also took account of technologies that

had eco-friendliness, and applicability to the farmers' existing conditions. Moreover, the enhancement and participation of gender aspects was a requisite of a technology. Applying MCA, the national TNA team and stakeholders thoroughly discussed, evaluated and prioritized the pre-selected ten (10) technologies mentioned in the TFS, and achieved the final result of technology prioritization.

As a third activity of the technology prioritization process, the national TNA team organized a series of bilateral meetings during the third week of September 2019. The national TNA team visited at several government departments concerned with the pre-selected technologies such as DOA, IWUMD, YAU, and DRD etc. The responsible and interested persons with different levels, i.e., Director General, Deputy Director General and Directors and other staff, were present at the meeting as the core stakeholder groups and wider stakeholder groups. They all enthusiastically participated in the discussion and gave suggestions on selected technologies of the project.

The MCA technology prioritization exercise involved the steps such as identifying options, identifying criteria, scoring, weighting, and sensitivity analysis.

3.5.1 Identifying options

Before organizing stakeholder consultations, the national consultant conducted the desk study. The sectoral working groups and the consultant undertook a review of existing development planning documents (INC, NAPA, INDC, Agriculture and water sector development plans and framework, etc.). Then the consultant prepared technology factsheets (TFS) and other information for input into the MCA template. Relevant sources of information referred to the Climate Techwiki and guidebooks published by UNEP DTU water and agriculture (for adaptation). As an output, a list of ten (10) technologies including TFS for Agriculture sector was produced to be analyzed. They were distributed to the stakeholders one week in advance of the stakeholder meeting.

3.5.2 Identifying criteria

The different technology options need to be compared to find out which technologies are better or more appropriate than another, and more worthy of implementation. To help assess this, criteria for evaluating each technology option were defined. The final selection of criteria also depended on the national context and priorities. The consultant working together with TNA coordinator suggested criteria that reflect country's development priorities, and the sectoral working groups validated them after a thorough discussion. A list of criteria was produced for assessing adaptation technologies which will be inputted to the MCA template.

3.5.3 Scoring

Technology options were evaluated based on the selected criteria. Firstly, a performance matrix was constructed, in which the scale of evaluation can be different for each criterion. Secondly, the performance matrix was converted to a scoring matrix, in which the scales for all criteria are the same: 0-100. The most preferred option was assigned a score of 100, while the least preferred is given a score of 0. The scores for the remaining options should reflect differences in the strength of preference. Then they were normalized with respect to the best and worst performing options.

After summarizing the stakeholder views, the consultant filled in the performance matrix and built the scoring matrix. The stakeholders provided their views and opinions on the technology options performance and suggested scores for discussion.

A performance matrix in which each row describes a technology option and each column describes the performance score of the options against each criterion was developed.

The scores were determined following a thorough discussion among all the stakeholder groups. The criteria were chosen for evaluating the technologies based on the "decision context". Generally, the expert group discussed the importance of each criterion and then reached a consensus on the score for each technology. Scoring options of Agriculture sector were presented in Annex VII.

Due to the constraints in information resources and limited time, costs and benefits of several proposed technologies could not be valued in monetary terms, and their cost benefit analysis. It was impossible to collect information on the cost of implementation, since some proposed technologies were not fully utilized in the country at this moment. Therefore, assumptions for capital cost, operation and maintenance cost and economic return were based on the expert judgment. They discussed the cost to set up and operate the technology, and maintenance per year and economic benefit and agreed in the following range. There were five classes identified for the capital cost, operation and maintenance, and economic benefits (income) as follows:

Level	Score
Very low:	0-20
Low:	21-40
Medium:	41-60
High:	61-80
Very high:	81-100

Similarly, five levels of social and environmental benefits of the technology were classified for the scoring process as follows:

Level	Score
Very low:	1
Low:	2
Medium:	3
High:	4
Very high:	5

For the criteria (Social and environmental benefits, etc.) technology options were scored on a scale anchored at 1 (lowest score) and 5 (highest score) based on the expected merits of the technology. Table 9 showed the criteria for economic, social and environmental benefits for MCA for prioritization.

Table 9. Criteria for MCA for prioritization of adaptation technologies in Agriculture Sector

Criteria category	Criteria / Indicator	Scoring Scale
Public financing needs	Capital cost: to set up (infrastructure, resources, etc)	Very low: 0-20, Low: 21-40; Medium: 41-60; High: 61-80; Very high: 81-100
	Operation and maintenance cost: To operate and maintenance the technology	Very low: 0-20, Low: 21-40; Medium: 41-60; High: 61-80; Very high: 81-100
Economic benefit	Income increase: By applying this particular technology, how much income / profit will be provided	Very low: 0-20, Low: 21-40; Medium: 41-60; High: 61-80; Very high: 81-100
Social benefit	The technology will contribute to the community / society in terms of (1) Job creation: More jobs will be created	Very low: 1; Low: 2, Medium: 3, High: 4, Very high: 5
	(2) Health: The community can enjoy the better health	Very low: 1; Low: 2, Medium: 3, High: 4,; Very high: 5

Criteria category	Criteria / Indicator	Scoring Scale
	(3) Gender participation: The technology will provide jobs opportunities to female workers/ farmers	Very low: 1; Low: 2, Medium: 3, High: 4; Very high: 5
Environmental benefit	The technology will protect and sustain the ecosystem services in terms of (1) Reduction in chemical use: the technology will use less agro-chemicals, which have negative impacts on environment	Very low: 1; Low: 2, Medium: 3, High: 4, Very high: 5
	(2) Ecosystem protection: reduce erosion	Very low: 1; Low: 2, Medium: 3, High: 4; Very high: 5
Climate related benefit	Resilience to climate change; mitigation co-benefit;	Very low: 1; Low: 2, Medium: 3, High: 4; Very high: 5

3.5.4 **Weighting**

When all technology options were scored against all criteria, the scores still could not be compared because preference of one criterion does not necessarily equal the preference on another criterion. Therefore, each criterion was assigned a weight to reflect the weight of importance that stakeholders assign to each of the specific criterion. When the criteria were weighted, the scores against all criteria could be compared. The expert judgments were sought from members of stakeholder groups to assign a weight to each criteria to reflect their relative importance in the decision making process. The cumulative sum of weights across all criteria was equal to 1.0. According to their order of relative importance, each criterion was assigned a weight between 0.1 and 1.0.

In the context of the TNA process, it was essential that the weights reflected the views and priorities of stakeholders. Accordingly, weights were best determined by participatory methods. The stakeholders considered how important each of the criteria is for a given objective (development, adaptation potential, etc.), and assigned weights to them so that they reflect the relative importance of the criteria. The consultant facilitated discussion to obtain decision on weights and helped to create a consensus among the experts on a score for each criterion. This information was inputted into the MCA template. Then, the decision matrix was expanded including the weighted scores. The criterion decided and weightings by all stakeholders (Option 1 and Option 2) were provided in Table 10.

Table 10. Criteria and weight values (Option 1 and Option 2) of Agriculture Sector

Category	Criteria	Weight Factor	
		Option 1	Option 2
Cost	Cost	25%	20%
	Capital Cost	0.18	0.12
	Operation and Maintenance Cost	0.07	0.08

Benefits	Economic	30%	20%
	Income	0.30	0.2
	Social	23%	30%
	Health improvement	0.08	0.1
	Job creation	0.12	0.15
	Gender participation	0.03	0.05
	Environmental	12%	18%
	Less pollution/ less GHG	0.06	0.08
	Ecosystem protection	0.06	0.1
Others	Climate related	10%	12%
	Resilience to climate change	0.1	0.12
TOTAL		100%	100%

3.5.5 Scoring Matrix

All the weights and scores for each of the options are combined to derive an overall value. The total weighted score of each technology option are calculated for each technology by multiplying its relative score for each criterion by the corresponding weight given to that criterion. As described in the MCA Manual, the Scoring Performance Matrix was constructed based on the above criteria and weight factors. The Scoring Performance Matrix was shown in Table 11. The Normalized score (Option 1 result) of Agriculture Sector was established and described in Table 12.

Table 11. Scoring Performance Matrix of Agriculture Sector

Technology	Costs	Benefits			Others	Total Score
		Economic	Social	Environmental	Climate related	

	Capital	Operation & Maintenance	Income	Health	Job Creation	Enhanced Gender Participation	Less pollution/ less GHG	Ecosystem protection	Resilience to CC	
(1) CSA villages	0	0	10.87	33.33	50	50	66.66	66.66	100	377.53
(2)Conservation Agriculture	42.85	20	65.21	66.67	100	100	100	100	100	694.74
(3) Salinity tolerance rice	100	80	69.56	33.33	50	50	33.33	33.33	50	499.56
(4)Paddy dryers	42.85	48	8.69	0	0	0	0	0	0	99.55
(5) Solar dryer for cash crops	42.85	60	17.39	66.67	100	50	66.67	33.33	50	486.95
(6) Submergence tolerance rice	57.14	60	54.34	0	0	0	0	33.33	50	254.82
(7) Weather index crop insurance	14.28	88	0	0	0	0	0	0	50	152.28
(8) Solar drip irrigation	71.42	88	100	100	100	100	100	100	100	859.42
(9) Hydroponic	28.57	52	52.17	66.67	50	50	66.67	66.67	50	482.75
(10) SWC in hilly regions	0	100	58.70	33.33	50	50	33.33	66.67	0	392.03

Note: In all Tables, the names of technologies were used in short form due to the limited space.

Table 12. Normalized score (Option 1 result) of Agriculture Sector

Technology	Costs	Benefits			Others	Total Score
		Economic	Social	Environmental	Climate related	

	Capital	Operation & Maintenance	Income	Health	Job Creation	Enhanced Gender Participation	Less pollution/ less GHG	Ecosystem protection	Resilience to CC	
(1) CSA villages	0	0	3.26	2.67	6	1.5	4	4	10	31.4
(2) Conservation Agriculture	7.71	1.4	19.56	5.33	12	3	6	6	10	71.01
(3) Salinity tolerance rice	18	5.6	20.87	2.67	6	1.5	2	2	5	63.64
(4) Paddy dryers	7.71	3.36	2.61	0	0	0	0	0	0	13.68
(5) Solar dryer for cash crops	7.71	4.2	5.22	5.33	12	1.5	4	2	5	46.97
(6) Submergence tolerance rice	10.29	4.2	16.30	0	0	0	0	2	5	37.79
(7) Weather index crop insurance	2.57	6.16	0	0	0	0	0	0	5	13.73
(8) Solar drip irrigation	12.86	6.16	30	8	12	3	6	6	10	94.02
(9) Hydroponic	5.14	3.64	15.65	5.33	6	1.5	4	4	5	50.27
(10) SWC in hilly regions	0	7	17.61	2.67	6	1.5	2	4	0	40.78

3.5.6 Results and sensitivity analysis

All the information and views collected in the previous steps were then consolidated, with a few technologies selected for further detailed analysis. Calculating the total scores for these options was performed using the MCA template provided by UDP. The technology options were then ordered according to their total score, and the three best-scoring technologies can be selected for further analysis.

The process resulted in a list of ranked technologies prioritized according to their scoring against the criteria and weights given to each criterion, as identified by the national TNA team and stakeholders. The highest total relative weighted score was ranked as the most preferred technology, whereas the one with the lowest relative score was ranked as the least preferred option.

Sensitivity analysis can help assess whether, and how much, the ordering of the options will change depending on the chosen weights, or the preference allocation. This can be very helpful for consensus building. Since there were no disagreements on scoring process between the stakeholder members, the process of "Sensitivity to changing scores" was not conducted. However, there was some different preference between working group members regarding the importance of criteria, and so the "Sensitivity to changing weights" was performed. The final results of MCA for technology prioritization of agriculture sector was described in Table 13 below.

Table 13. Final result of MCA of Agriculture Sector

Technology	Normalized value/ Total Score		Ranking	
	Weighted Option 1	Weighted Option 2	Weighted Option 1	Weighted Option 2
(1) CSA villages	31.43	39.51	8	7
(2) Conservation Agriculture	71.01	76.45	2	2
(3) Salinity tolerance rice	63.64	57.65	3	3
(4) Paddy dryers	13.68	10.72	10	10
(5) Solar dryer for cash crops	46.97	52.25	5	5
(6) Submergence tolerance rice	37.79	31.86	7	8
(7) Weather index crop insurance	13.73	14.75	9	9
(8) Solar drip irrigation	94.02	95.61	1	1
(9) Hydroponic	50.27	52.69	4	4
(10) SWC in hilly regions	40.78	42.41	6	6

3.6 Results of Technology Prioritization for Agriculture Sector

Based on the results of the MCA, the top three ranking of technological options were given below:

(1) Solar powered drip irrigation technologies in cash crop production and plantation
(2) Conservation Agriculture (CA) technology for sustainable agriculture lands in Myanmar
(3) Improvement of "Salinity tolerance rice varieties" in coastal and inland salinity areas

It was observed that, despite their high potential of reducing vulnerability effects from climate change, the results of the MCA analysis showed that the relatively high cost technologies were not favored by the ranking of MCA. They were "Establishment of Climate Smart Agriculture Villages (CSV) for sustainable agricultural production in Myanmar, "Introduction of a weather index-based crop insurance system" and "Integrated soil and water conservation technology for resilient agricultural production in hilly regions".

Since there were no disagreements on scoring process among stakeholder members, the process of "Sensitivity to changing scores" was not conducted. However, there was some different preference between working group members regarding the importance of criteria so that the "Sensitivity to changing weights" was performed. Considering the tendency to disfavor high cost interventions, and to verify the robustness of results, a sensitivity analysis was carried out by lowering the weights assigned to cost and economic benefits of technologies by 25% to 20%, and by 30% to 20%, respectively and other benefits increased by that amount. The analysis did not alter the results in a significant manner. Moreover, Normalized scores (Option 2 result) of Agriculture Sector was shown in Annex VIII.

CHAPTER 4: Technology Prioritization for Water Resource Management Sector

Myanmar is blessed with vast of water resources. The internal total renewable water resources are estimated to be about 1000 km^3 per year. It contains surface water (four major rivers and five river basins) and groundwater. The actual utilization is stated as only 5% of the available fresh water (IWRM, 2014). It means that the country has ample water availability so that there may be no concerns while the demand for water use is expected to grow with economic development and increased population these days. Myanmar is rich in renewable fresh water resources and the value was the second highest value after Indonesia among the ASEAN countries. The sectoral withdrawal

was recorded as domestic 7%, industry 3% and agriculture 70%. Being an agricultural country, irrigation is the largest water use category (ASEAN SoE 2000).

With regard to fresh water resources, the four major rivers, namely Ayeyarwaddy, Chindwin, Thanlwin, and Sittaung Rivers, running from north to south, are the main arteries of the country. They not only serve as important sources for navigation and irrigation water, but also the country's hydropower production. Although only 46330.55 MW has been currently developed from the country's rivers, the hydropower potential is estimated to be more than 100,000 megawatts (FAO 2014).

4.1 Key Climate Change Vulnerabilities in Water Resource Management Sector

Since the "Water resource management sector" plays a vital role of the country's natural resources, it was selected as a priority sector of climate change adaptation of Myanmar's TNA project, in addition to the "Agriculture" sector. The selection was also in line with the country's development plans, strategies and policies. In Myanmar NAPA report (2012), "agriculture" and "water resource management sector" was identified as the first and second priority level sector of national climate change adaptation plans, respectively. Moreover, in the Myanmar's National Sustainable Development Strategies (NSDS) published in 2009, the sustainable freshwater resource management was described among eleven areas of sustainable management of natural resources of the country (NSDS, 2009).

Myanmar Agenda 21 also stated to "Strengthen integrated water resources policy, planning and management systems" and "Improve water supply and environmental sanitation (NCEA, 2006). Therefore, the prioritization of "Water resource management sector" complies with the country's current and future development plans and strategies, ensuring the sector more efficient and effective implementation and sustainability.

The climate change impacts differ depending on their particular locations and contexts; the adaptation technologies may vary accordingly. For example, the Central Dry Zone is the most water -stressed regions in Myanmar; with very low and erratic rainfall patterns, people encounter seasonal water shortages. Since the livelihoods are largely dependent on the southwest monsoon, availability and access of water resources are key determinants of rural poverty.

In the case of the deltas and floodplains of lower Myanmar, flood risks are prevalent. Fresh water availability and salinization are main water resources management issues for agriculture, aquaculture and drinking water. In these areas, rainwater harvesting in open ponds and wells is the most typical traditional method for drinking water supply either individually or communally.

Nationally, about 45% of people draw their drinking water from protected or unprotected dug wells, and another third from tube wells (IWMI, 2015). However, it requires careful attention on its potentials since overexploitation can cause the depletion of water resources and land subsidence.

Moreover, groundwater irrigation often creates the soil salinity problem. The saline affected fields became degraded and yields were reduced so that farmers gave up the groundwater irrigation. Many areas of central dry zone have shown inland salinity or irrigation salinity problem caused by surface water or underground water irrigation.

4.2 Decision Context

Regarding with access to basic services of water of the country, overall access to safe drinking water increased from 63% to 69% from 2005–2010. There exist wide variations across the country's state and regions, as well as rural and urban areas. 81% of the urban population had access to safe drinking water while only 65% of rural dwellers in 2010. The access to water supply in rural areas was 60.6% improved while the household access to sanitation in rural areas: 67.3% improved (GoM, 2016(a)). To solve the problem, Myanmar has launched the first National Strategy and Investment Plan (2016-2030) for rural water, sanitation and hygiene in 2017, with the support

of UNICEF. The ”National Strategy” and ”Investment Plan” for Rural Water Supply, Sanitation and Hygiene (WASH), in schools and WASH in health facilities 2016 – 2030 were released in 2016. The strategy covered safe water supply, sanitation and hygiene services in rural communities, schools, and health facilities including responses in emergency and humanitarian settings, achieving the targets of Myanmar SDG 6.

For the effective conservation of water resources, National Water Resources Committee (NWRC) was formed in 2013. The NWRC adopted the National Water Framework Directive (NWFD) in 2014. The NWFD presents seven principles for achieving good ecological status for the water quality elements in Myanmar water bodies and river basins. Principle (1) of NWFD stated that *"*Good status for all ground water and surface water: The Directive aims for 'good status, i.e. clean and sufficiently stored' for all ground water and surface water (rivers, lakes, transitional waters, and coastal waters) in Myanmar*."* (Norwegian Institute for Water Research, 2017 IWRM in Myanmar). The National Water Policy (NWP) was approved by the Cabinet in 2015. The vision of the NWP was adopted as the long-term vision for the IWRM Strategy development. The vision stated: *By 2020 Myanmar has become a water efficient nation with well-developed and sustainable water resources based on fully functional integrated water resources management system* (GoM, 2014).

Although Myanmar has huge water resources and consideable rainfalls, water shortages exist, especially throughout the Dry Zone Area. Myanmar also recognizes the degradation of its ecosystems which ultimately affects water quality and quantity, and therefore investments will be enhanced in conservation and in water-related infrastructure (MSDP, 2018). Regarding with water resource management, the action plans of MSDP also described *"to enhance irrigation and drainage services, and support more efficient and sustainable water management systems with the outcome of increased productivity and farmers' income"*. In addition, it mentioned that water resources are managed to support access to effective, efficient and affordable services for improved water supply.

MOALI launched "Agricultural Sector Policies and Thrusts for Second Five Year Short Term Plan" in 2016. Among the policies and thrusts, water use and management policy highlights the point to ensure accessible irrigation water that can be efficiently utilized by farmers when needed for crops and also indicates the point to explore the possibility of exploiting underground water for agriculture/ livestock/ fishery and related activities without adversely affecting natural environment and water sources (MOALI, 2016).

4.3 Overview of Existing Technologies in Water Resource Management Sector

To incrase the crop production, the Government has made huge investment to expand irrigation by constructing irrigation schemes (dams, reservoirs, weirs and etc.) across the country since 1988. A total area of ca. 18,400 km^2 (about 20% of the total sown area) is irrigated in Myanmar, mainly in the Central Dry Zone. In 2014, the total number of 240 dams, 327 river pumping stations and (12,258) groundwater irrigation facilities were completed (FAO 2014).

In the central dry zone areas, approximately half of agriculture production is rain-fed while 31 % of irrigation water is supplied by canals, 11 % by tanks, 4 % by tube wells and 8 % by other irrigation methods. However, in many cases, the irrigation schemes are performing far below their potential, which is mainly attributed to inappropriate design and poor operation and maintenance systems. Increased water use efficiencies can be achieved through improving the performance of these irrigation schemes. The IWUMD has been currently working on the improvement and rehabilitation of over twenty irrigation schemes in several regions of the country with the international loans from WB and ADB and etc.

Where the surface water sources were unavailable, farmers tried to get the underground water access to increase their production. Small and medium -scale groundwater extraction has been widely utilized since last decade. In the plains and upland areas of Myanmar, farmers generally practiced rain-fed production and drought is a major risk. Farmers' indigenous adaptation

technologies include rainwater harvesting ponds, soil and water conservation techniques, crop management practices, and etc. In addition, the physical structures for rainwater harvesting (such as small earth dams, tanks, hand-dug shallow wells, runoff harvesting) are their crucial adaptive measures to resilient to their climatic conditions.

With the international funding, UNDP, NGOs, INGOs and local CBOs have provided drinking water purification facilities in delta and coastal areas of Ayeyarwaddy Region during last ten years. Many facilities are still operating and villagers share the diesel cost and manage the operation. Because of the increasing saline intrusion, many villages in coastal areas are encountering difficulties for the fresh drinking water. In 2018, Forest Resource Environment Conservation and Development Association (FREDA) distributed the medium scaled solar desalinization facilities to ten coastal villages in Ayeyarwaddy Region.

There are ten water related ministries such as MOALI, MOE, MOTC, Ministry of Social Welfare, Relief and Resettlement (MOSWRR) and etc., and three major City Development Committees, namely Yangon, Mandalay and Nay Pyi Taw Development Committee. For the water resource management, the technologies are crucial to increase the water productivity (e.g., agriculture) and / or to decrease the water-related risks. They also provide production benefits as well as the environmental and social benefits. The technologies are not stand-alone but rather based on the integrated approach. Therefore, improved and integrated solutions for sustainable management of water resources have become an absolute necessity to meet the country's development needs.

To fulfill the SDG 6 "*to ensure availability and sustainable management of water and sanitation for all*", the Myanmar government together with the cooperation of local and international NGOs have carried out the water supply infrastructure improvements. It includes, among others, the following -

(i) Rehabilitation of community ponds, dug wells, drilled wells

(ii) Provision of new drilled wells for communities and for schools and health centers

(iii) Small pipe water supply systems; and household rain water tanks

In recent years, Myanmar suffers severe monsoon flooding almost every year and the flood management is an urgent necessary action. The WB is working on river basin management and upgrading Myanmar's water flow forecasting and systems, as well as strengthening communities against future floods, upgrading irrigation systems, monitoring dam safety and etc. For an early warning system for natural disasters, the JICA and the DMH have been working on the establishment of weather radar towers since 2013. Under the climate change impact, rivers bank erosion, emergence of sand bars, sedimentation and river flow pattern changes are worsening. The concerned government departments such as DMH, DRR, Department of Irrigation (ID), and DWIR, are working the necessary measures collaboratively and cooperatively (GOM, 2014).

The existing flood management and DRR activities and programs in delta areas are -

- The construction of polders provided with embankments, dykes, polders sluice gates, and drainage systems
- Strengthening and rehabilitation of flood protection works of structural structures
- Bank erosion protection work
- Tidal river management
- Integrated Water Resources Management (IWRM)

For reducing the water-related disasters and strengthening the resilience of coastal ecosystems, Myanmar has conducted the following measures.

Efforts have been made to integrate MAPDRR into national development programme aiming to pursue sustainable development. Relief and Resettlement Department (RRD) is now collaborating with DMH, General Administration Department (GAD) and JICA for setting up end – to–end Early

Warning System (EWS) in some of the disaster prone townships of Ayeyarwaddy Region and Rakhine State.

4.4 Adaptation Technology Options for Water Sector and Their Main Adaptation Benefits

Although Myanmar has plenty of physical water resources, the access to water for drinking as well as for irrigation is difficult for rural people in many States and Regions because of the lack of infrastructure. Moreover, the common constraint in crop production across Myanmar is the crop failures caused by drought and flood. To address these issues, the following nine technologies in "Water resource management" sector were proposed for the TNA prioritization process.

(1) Renovation and improvement in village ponds and tube wells for better livelihoods in Myanmar Dry Zone
(2) Improvement in rooftop rainwater harvesting for adaptive delta management in Myanmar
(3) Solar-powered desalination and purification technology in coastal areas in Myanmar
(4) Water purifying technology in remote villages of Myanmar
(5) Solar powered water extraction in central Myanmar
(6) Rural water supply with gravity flow system in hilly regions of Myanmar
(7) Rainwater collection from ground surfaces for land rehabilitation and water conservation in central dry zone
(8) Renovation and upgrading the existing irrigation schemes for the efficient use of irrigation water
(9) Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar In Myanmar, village ponds, tube wells were reliable water resources in rural livelihoods over the last decades. In recent years, however, the reliability of these facilities is declining and many villages are encountering insufficient water during summer season. To cope with these issues, the technology, namely "Renovation and improvement in village ponds and tube wells" was proposed for better livelihoods in Myanmar Dry Zone. The technology will be applied to recharge the dried up bore wells and open wells and to rejuvenate and increase the ground water level. The technology includes renovation of village ponds and installation of "Recharge Pit". It will provide sufficient and better drinking water access. Moreover, villagers can establish home garden; small scale vegetable production will partly contribute to food security, better health and sanitation and improve village economy.

In the delta region, which covers large parts of Ayeyarwady, Yangon and Bago Regions the water quality from the streams, rivers and wells has high turbidity and generally saline affected. Because of its poor quality, the water cannot be drinkable. The delta area receives sufficient annual rainfalls (about 2000 mm) so that people traditionally rely on the rainwater collected through their rooftops. They keep the water in large jars for storage which can sustain 3- 4 months after the rainy season. Roofs of many poor households are made of thatch and palm leafs which are difficult to provide clean runoff water. In addition, the containers are so small that they cannot maintain water more than one month. In this regard, the technology of "Improvement in rooftop rainwater harvesting" was described as an adaptation technology in the delta region. It will include infrastructure improvement of existing rooftops, provision of household rain water containers, and the capacity development trainings on water quality to ensure safe drinking water access.

Similarly, drinking water demands in coastal area of Myanmar has been growing due to the drought occurrence and salinity intrusion. The coastal zones (about 5200 km^2) are below high spring tide level with coastal length of about 2,832 km. Under the climate change, fluctuated rains are leading to severe water shortages, and at the same time saline affected areas are extending with higher intensity. Therefore, "Solar-powered desalination and purification technology" was proposed as a climate adaptation technology in coastal areas. The technology will provide a reliable and clean drinking water from seawater. Solar energy will overcome the usually high-energy operating costs as well as greenhouse gas emissions .

Moreover, there are many rural remote villages across the country where the drinking water is insufficient from their existing facilities. Because of poor management in operation and maintenance, water quality is poor and often contaminated. Many are using water from unimproved and unclean sources. Villagers often suffer diarrhea and other water borne diseases in rural villages. In this regard, the technology of "Water purifying technology in remote villages" will be introduced to improve the health and quality of life through sustainable access to safe drinking water. Installation of filter machines for targeted villages is a way to ensure people enjoy tasting safe and clean water.

Similarly, in the context of climate change, decreasing freshwater supplies is common, especially in central Myanmar. The UNDP –ICDP project provided to several villages with the water pump stations for underground water extraction about three decades ago. The medium scale or large scale diesel engines were used for drinking and household uses for the village community. Moreover, increasing demand of irrigation water for higher crop production encouraged the farmers to use the water engine pumps for groundwater extraction or pumping from a nearby water sources. Water pumping was achieved by the use of diesel engines by medium and large farmers but high diesel and electricity costs are unaffordable for the small holders. Therefore, the use of "Solar powered water extraction" technology was recommended for community use for the resilience to current and future climate. Solar energy is a promising alternative to conventional electricity and diesel-based pumping systems so that it will provide mitigation co-benefits.

The natural springs are freshwater sources for rural villages of hilly regions where the ethnic minorities are residing (e.g Shan , Kachin and Chin States). With their indigenous knowledge, these people have well conserved and maintained the springs in hilly and mountainous areas for centuries. Traditionally, they use bamboo pipes to collect the water from these springs to their houses. In this regard, "Rural water supply with gravity flow system (piped water)" will be one of the options to provide these communities with safe and clean water. The improvement at the collection point of the spring and concrete tanks will be made for community use. The maintenance of the water supply, such as cleaning tanks, repair pipes will be done by the communities. They will access readily cleaner water for drinking and household use, which will in turn make the rural community healthier and more enjoyable.

In addition, the Dry Zone is characterized with poor sandy soil with low fertility and low moisture holding capacity. It is compounded by its intense rains causing serious soil erosion problem. With their indigenous knowledge, farmers apply a range of traditional soil and water conservation (SWC) practices, such as overflow bunds, gully plugging, strip cropping, and etc. However, most practices are not in a well function. Regarding this, "Rainwater collection from ground surfaces for land rehabilitation and water conservation" was nominated for Central Dry Zone. The technology will include the collection of runoff of rainwater from various sources of ground surface catchment to farm ponds and storage tanks.

For irrigation, MOALI has constructed considerable numbers of irrigation infrastructure across Myanmar, particularly in the Dry Zone. However, the performance of these irrigation schemes was suboptimal. The improvement and upgrading of the physical infrastructure and management of these irrigation and drainage systems are essential for enhancing farm productivity. Therefore, the "Renovation and upgrading the existing irrigation schemes for the efficient use of irrigation water" will be a relevant option as an adaptation technology under the TNA project. Existing irrigation infrastructure, such as canal structures and water courses will be rehabilitated. The technology will help better irrigation water access to the farmers but also mitigate floods in low land areas. It also comply with the priority projects described in NAPA (2012) which focused on the status of dams for providing sustainable water supplies and constructing small-scale water impoundments for flood control and increasing water supplies.

Generally, Myanmar is experiencing recurrent seasonal floods in monsoon season every year. The lowlands and flat terrains situated in the river basins are obviously exposed to inundation and often

severely damaged by floods. In July and August, 2019 several States and Regions in the country were hit by heavy monsoon rainfall and flooding. Therefore, a technology package on "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar" was nominated as a climate change adaptation technology. For the flood risk management in river basin and coastal areas of Myanmar, renovation and repair work of existing dikes and protection of river banks erosion will be conducted. New embankments, dikes and polders will be constructed and extended in the necessary areas.

During the TNA process, the National TNA team made efforts to apply the participatory approach to involve all the core stakeholder groups and wider stakeholder groups from the early stages of the process and continued till the end. The stakeholder groups participated in the TNA processes were concerned governmental authorities (national and local), NGO's, Community based organizations (CBO) and private sectors. Based on their knowledge, experiences and information, the technologies were evaluated and prioritized for the most suitable technologies by applying the method of MCA. The TNA technology prioritization processes for "Water resource management sector" were conducted as the same procedure as for the "Agriculture sector". Both sectors were carried out in separate sessions. For the technology prioritization of Water resource management sector", nine (9) technologies were preselected and described in the TFS. After the considerable discussion among the stakeholders, three (3) technologies were successfully prioritized.

4.5 Criteria and Process of Technology Prioritization for Water Sector

The TNA technology prioritization processes for "Water resources management sector" were similar to those conducted in "Agriculture sector". The process also followed the guidelines and procedures recommended by UDP /UNFCCC Handbook for conducting technology needs assessments for climate change, organizing the national TNA process, Multi- criteria Analysis (MCA) guide notes, and etc. Being the process in participatory approach, all relevant stakeholders from government departments, NGOs, private sectors and other organizations were encouraged to involve the various steps of the process. It was also ensured the gender inclusion in all steps of the processes, starting from the Step 1 (Identification and categorization of technologies) to the Step 3 (Decision-making process).

The MCA prioritization exercises (identifying options, identifying criteria, scoring, weighting, and sensitivity analysis) were conducted in a same way as in "Agriculture sector". The five classes identified for the capital cost, operation and maintenance, and economic benefits (income) are the same as in "Agriculture sector". As described in the MCA Manual, the Scoring Matrix was constructed based on the selected criteria and weight factors. The criteria for economic, social and environmental benefits were the same as described in Table 9 in the previous Chapter. The Scoring options of water sector were described in Annex IX.

The national consultant acted as MCA facilitator and helped to create a consensus among the experts on a score for each criterion. Then, the decision matrix was expanded including the weighted scores. The criterion decided and weightings were described in Table 14. Accordingly, the Scoring Performance Matrix of Water sector was presented in Table 15.

Table 14. Criteria and weight values (Option 1 and Option 2) of Water Sector

Category	Criteria	Weight Factor	
		Option 1	Option 2
Cost	Cost	25%	23%
	Capital Cost	0.2	0.15

	O&M Cost	0.05	0.08
Benefits	Economic	30%	27%
	Income	0.3	0.27
	Social	20%	23%
	Health improvement	0.1	0.1
	Job creation	0.08	0.08
	Gender participation	0.02	0.05
	Environmental	15%	17%
	Water saving	0.08	0.1
	Reduction GHG/ erosion	0.07	0.07
Others	Climate related	10%	10%
	Resilience to climate change	0.1	0.1
TOTAL		100%	100%

Then, all the weights and scores for each of the options are combined to derive an overall value. The total weighted score of each technology option are calculated for each technology by multiplying its relative score for each criterion by the corresponding weight given to that criterion.

Table **15.** Scoring Performance Matrix of Water Sector

Technology	Costs	Benefits	Others	Total

			Economic	Social			Environmental		Climate related	score
	Capital	O & M cost	Income	Health	Job Creation	Enhanced Gender Participation	Reduced Chemical use	Ecosystem protection	Resilience to CC	
(1) Renovation village ponds & tube wells	54.05	100	77.78	100	100	100	100	100	100	831.83
(2) Rooftop rainwater harvesting	100	88.89	0	66.67	0	0	0	50	50	355.56
(3) Desalination in coastal areas	94.60	22.22	11.11	66.67	33.33	0	0	0	50	277.93
(4) Water purifying technology	94.60	88.89	28.89	100	33.33	100	0	50	50	545.71
(5) Solar powered water pumping	40.54	88.89	24.44	33.33	33.33	0	0	50	50	320.54
(6) Water supply with gravity flow	13.51	55.56	11.11	33.33	33.33	0	50	50	0	246.85
(7) Rainwater collection from ground surfaces	5.41	22.22	66.67	0	33.33	100	50	100	50	427.63
(8) Renovating irrigation schemes	0	0	77.78	33.33	66.67	0	50	100	50	377.78
(9) Technology for flood disaster risk reduction in Ayeyarwady delta	32.43	44.44	100	66.67	100	100	100	100	100	743.54

Note: In all Tables, the names of technologies were used in short form due to the limited space.

The process resulted in a list of ranked technologies prioritized according to their scoring against the criteria and weights given to each criterion, as identified by the national TNA team and stakeholders. The Normalized scores of (Option 1 result) were presented in Table 16. The highest total relative weighted score was ranked as the most preferred technology, whereas the one with the lowest relative score was ranked as the least preferred option. The final results of technology prioritization of water sector were described in Table 17.

Table 16. Normalized score (Option 1 result) of Water Sector

Technology	Costs		Benefits						Others	Total score
			Economic	Social			Environmental		Climate related	
	Capital	O & M cost	Income	Health	Job Creation	Enhanced Gender Participation	Reduced Chemical use	Ecosystem protection	Resilience to CC	
(1) Renovation village ponds & tube wells	10.81	5	23.33	10	8	2	8	7	10	84.14
(2) Rooftop rainwater harvesting	20	4.44	0	6.67	0	0	0	3.5	5	39.61
(3) Desalination in coastal areas	18.92	1.11	3.33	6.67	2.67	0	0	0	5	37.7
(4) Water purifying technology	18.92	4.44	8.67	10	2.67	2	0	3.5	5	55.20
(5) Solar powered water pump	8.11	4.44	7.33	3.33	2.67	0	0	3.5	5	34.39
(6) Water supply with gravity flow	2.70	2.78	3.33	3.33	2.67	0	4	3.5	0	22.31
(7) Rainwater collection from ground surfaces	1.08	1.11	20	0	2.67	2	4	7	5	42.86
(8) Renovating irrigation schemes	0	0	23.33	3.33	5.33	0	4	7	5	48
(9) Technology for flood disaster risk reduction in Ayeyarwady delta	6.49	2.22	30	6.67	8	2	8	7	10	80.38

Table 17. Final result of MCA of Water Resource Management Sector

Technology	Normalized value Total Score		Normalized value Ranking	
	Option 1	Option 2	Option 1	Option 2
(1) Renovation village ponds & tube wells	84.14	87.11	1	1
(2) Rooftop rainwater harvesting	39.61	37.28	6	6
(3) Desalination in coastal areas	37.70	33.30	7	8
(4) Water purifying technology	55.20	55.27	3	3
(5) Solar powered water pumping	34.39	34.29	8	7
(6) Water supply with gravity flow	22.31	23.97	9	9
(7) Rainwater collection from ground surfaces	42.86	45.26	5	5
(8) Renovating irrigation schemes	48	46.67	4	4
(9) Technology for flood disaster risk reduction in Ayeyarwady delta	80.38	82.09	2	2

4.6 Results of Technology Prioritization for Water sector

The technologies were selected based on their potential to reduce vulnerability to climate change, and social, economic, and environmental benefits. Based on the results of the Multi-criteria Analysis the top three ranking of technological options were given below:

(1) Renovation and improvement in village ponds and tube wells for better livelihoods in Myanmar Dry Zone

(2) Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar

(3) Water purifying technology in remote villages of Myanmar

Despite their high potential of reducing vulnerability effects from climate change, the results of the MCA analysis showed that the relatively high cost technologies, such as "Renovation and upgrading the existing irrigation schemes for the efficient use of irrigation water", "Rainwater collection from ground surfaces for land rehabilitation and water conservation in Central Dry Zone" and "Rural water supply with gravity flow system in hilly regions of Myanmar" were not favored by the ranking of MCA.

Since there were no disagreements on scoring process between the stakeholder members, the process of "Sensitivity to changing scores" was not conducted. However, there was some different preference between working group members regarding the importance of criteria so that the

“Sensitivity to changing weights” was performed. Considering the tendency to disfavor high cost interventions, and to verify the robustness of results, a sensitivity analysis was carried out by lowering the weights assigned to cost and economic benefits of technologies by 25% to 23%, and by 30% to 27%, respectively and other benefits increased by that amount. The analysis did not alter the results in a significant manner. The Normalized scores of weighted option 2 result of Water Resource Management Sector were presented in Appendix X.

CHAPTER 5: Summary and Conclusions

Myanmar farmers have been applying traditional adaptation technologies to fight against the climate change for decades, such as use of short duration crop varieties, resistant varieties, change of crops and cropping patterns, sowing time, and etc. However, it was observed that the climate variability in recent decades was so intense that farmers could not withstand with their traditional technologies. It is, therefore, an urgent need to help farmers to build resilience to the climate change impacts. There are several improved and advanced technologies which can be applied in the process of adapting to climatic variability and climate change. Due to the constraints of financing and timeframe, it is impossible to apply all the suitable technologies at the same time. The main objective of TNA is to prioritize the most relevant technology application in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to climate change impacts.

In line with the Myanmar Sustainable Development Plan (2018 – 2030), the Government of Myanmar is committed to the achievement of the Sustainable Development Goals (SDGs) with the objective of ensuring balance between developments in the economic, social and environment spheres. Being a developing country, agriculture and water resources are crucial for Myanmar's economic development and livelihoods. Accordingly, "Agriculture" and "Water resource management" sectors were prioritized in the TNA's sector selection process. For the technology selection processes, there are broadly two sets of criteria, one related to the benefits and the other related to costs. It is important to ensure that the selected criteria should include all relevant aspects; they are well-defined and not redundant. The criteria used for the technology priority selection for both sectors were much related with the possible outcome of the technology, mainly focused in economic (increased income or productivity), social (more jobs creation, better health condition, gender inclusion) and environmental factors (resilience to climate change impact).

There were ten (10) pre-selected technologies for "Agriculture" sector while nine (10) technologies were pre-selected for "Water resource management" sector. After a long deliberation, the stakeholders, by applying the MCA methodology, decided to select three (3) technologies from each sector. They were identified as follows:

The technologies selected for "Agriculture" sector:

Priority 1: Solar powered drip irrigation technologies in cash crop production and plantation

Priority 2: Conservation Agriculture (CA) technology for sustainable agriculture lands in Myanmar

Priority 3: Improvement of "Salinity tolerance rice varieties" in coastal and inland salinity areas

The technologies selected for "Water Resource Management" sector:

Priority 1: Renovation and improvement in village ponds and tube wells for better livelihoods in Myanmar Dry Zone

Priority 2: Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar

Priority 3: Water purifying technology in remote villages of Myanmar

In Myanmar, there are many existing technologies in agriculture and water sector which are directly or indirectly related to climate change adaptation. Most of them are based on the farmers' traditional technologies. In addition, several improved and modernized ones were often introduced during last decades but they were not fully utilized. Because of the significant adverse impacts of climate change, Myanmar farmers and authorities concerned well recognized that adaptation technologies are the only option for the resilience of the current and future climate change. The concerned government departments have integrated these adaptation issues into the country's development plans and strategies. It is a good time and a great opportunity for Myanmar to participate in the TNA project. The Technology Action Plan (TAP), an output of the project, will be successfully adopted and disseminated in near future.

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Annex I: (a) Technology Factsheets for Selected Technologies (Agriculture Sector)

Priority Technology (1)

Solar powered drip irrigation technology

Introduction

Water management is a big challenge to Myanmar farmers because more than 80% of crop production is rain fed agriculture. As a consequent, crop production was highly affected by flood, drought and water scarcity. The canal irrigation methods only covers less than 20% of the total cultivated areas, and the rest are vulnerable to climate variability. In this regard, low- pressure and solar powered drip irrigation technologies will be pursued for vegetable production and orchard plantation. Drip irrigation is a type of micro-irrigation system allowing water to drip slowly and directly into the root zone and minimizes evaporation. The plant gets the exact amount of water and fertilizers it needs, resulting higher production. The system fits well with net house system, which makes less use of pesticides and herbicides. It can provide higher cropping intensity (2-3 crops per season) and higher income from the sale of products. The technology can produce crops in the off-season. It can also produce improved product quality, and earlier maturity, which can catch higher prices.

Technology characteristics

The system requires an appropriate design of hardware. The initial cost is high, and it needs a careful maintenance of relatively clean water, and the tendency of emitters to clog with contaminants. It is also important to disseminate the technological knowledge to farmer education and on-farm demonstration.

The barrier for the technology was the farmers' perception; they think that the drip would not supply sufficient water and complexity of drip systems; the tubes and pipes are also occasionally damaged by rodents or other animals. Seasonal removal and disposal of used drip laterals and plastic mulch was also a problem for vegetable growers.

Country specific applicability and potential

Barriers to adoption include high initial costs, the need for relatively clean water, and the tendency of emitters to clog with contaminants. Practical, hands-on technology can improve the productivity and sustainability of farmland. To promote the wider adoption of a drip irrigation system, it needs both easy-to-use and affordable to small scale and commercial scale vegetable growers. Drip irrigation products should be reliable and durable. The following supports are necessary to scale up the technology.

- Strengthen existing capacity of key ministerial departments,
- Enhance awareness of local water users,
- Capacity development through Training-of-trainer

The timeframe for the project implementation: medium to long-term

Status of technology in country

The low-cost gravity-fed drip systems were introduced in Myanmar in 2006 but it was soon abandoned because of the technical problem, high management requirements and expense. Moreover, the drip-sets were in poor quality. Iron clogging and ‘‘drip kits’’ were expensive and did not suite to local horticultural crop production; due to the lack of flow over time from the gravity tanks and resultant poor plant growth.

At present, some NGOs have financed small sprinkler systems and drip irrigation, and some private companies and better-off farmers are using this technology. Due to their technical complexity and the high investment required, most farmers are still reluctant to try such technologies. However, consumers ‘choice are becoming more priority to safer foods these days,

the demand of the quality products from drip irrigation system will be greater. Commercial production of water melon with drip irrigation has been common since 3-4 years ago in Mandalay, Bago and Yangon Regions.

Climate change mitigation/adaptation benefits

In the face of climate change in Myanmar, more droughts and heat stresses are expected. Less water requirement and timely application of this technology will contribute to reduce vulnerability to climate change impacts, especially drought conditions.

Benefits to economic, social and environmental development

Economic benefit:

- Higher yields – since the plant gets the exact amount of water and fertilizers, resulting higher production; higher income, some available in the off-season production with a higher price; increased cropping intensity and high annual income
- Improved product quality, and earlier maturity (more marketable products in City Marts and safer foods and better quality products)
- Due to reducing the time and drudgery of manual watering, farmers are able to diversify the crops and focus on higher value crops, leading to improved productivity and higher incomes.

Social benefit:

- Employment opportunities: Reduce the time of manual watering the plants, farmers have more time for other employment. More available time will make the household members to enjoin social and education activities; more job opportunities to others options.
- Health benefit: With easy application of nutrient management and integrated pest management (IPM) practices, the use of chemical fertilizers and pesticides are reduced. It gives low health risk to the farmers as well as to consumers. Drip irrigation fits well with the net house facilities which can easily protect the disease and pest infestation with less application of pesticides.
- Gender inclusion: Women will have the same opportunity as men to get jobs. With more household income, women can enjoy better livelihoods. Women can operate easily since the system needs less energy and time; they can enjoy more other activities; more nutritious food in their daily diet; more income and more social well beings.

Environmental benefit:

- Reduce pollution: the technology reduces pollution of environment (air, soil, water) due to the less use of harmful chemical pesticides and herbicides. Reductions in GHG emissions and ecosystem degradation: less weeds grow because the irrigated area is small. There is less humidity around the plants that favors less occurrences of plant diseases and pests; less chemicals use would less impact on the underground water quality and soil quality.
- Saving fertilizers: reduced chemical fertilizer use – apply soluble fertilizers by fertilization through the irrigation pipes and the drips (better nutrient use efficiency). More efficient use of chemical fertilizers will reduce leaching to the soil and less soil pollution.
- Sustain soil health and quality: more favorable due to practices which help to conserve soil and water, and increase biodiversity.
- Saving water: it needs only about half amount of water of conventional irrigation (higher water use efficiently) and it has water application uniformity;
- Saving energy: using less energy for water extraction, such as underground water.

Financial requirements and costs

The technology generally serves small and medium scale beneficiaries; commercial productions are also possible. For 1 acre (0.4 ha) of a farm, a full irrigation set can cost 100 US$; Low-cost solar pumps: 350 US$; and Net house: 100 US$

Priority Technology (2)

Conservation Agriculture (CA) technology for sustainable agriculture lands in Myanmar

Introduction

Soil erosion and degradation and the impacts of climate change, particularly drought and floods are the long-term major challenges of Myanmar. It calls for a need for greater environmental management in agriculture for the sustainable production. As an agro-ecosystems management approach, the "Conservation Agriculture (CA) technology" will be an adaptation technology to be applied. It aimed at improving and sustaining agricultural productivity. Under the expected future climate scenario, soil erosion and degradation will continue to occur, and so sustainable rain fed agricultural lands should be taken into consideration, before the situations become worse.

Technology characteristics

CA is comprised of three interrelated principles -

- No or minimum mechanical soil disturbance: no-tillage and sowing or broadcasting of crop seeds, and direct placing of planting material in the soil
- Maintenance of a permanent organic soil mulch cover: especially by crop residues, crops and cover crops; organic mulch soil cover, and crop species diversification
- Diversification of crop species: grown in sequence or associations through rotations; in case of perennial crops, such as orchard or plantation of mango, pomalo banana, etc., including a balanced mix of legume and non-legume crops. The technology is a long-term-ecosystem conservation; taking care during the operation period is a key factor. It includes the following activities or programs:
    - External inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally; minimum soil disturbance to soil;
    - Manual weed control during initial years while soil mulch cover and integrated weed management practice is being established.
    - Suitable crop rotations or associations, and on the amount of the biomass from the production system that is retained as surface mulch and being incorporated or sequestered into the soil.

Country specific applicability and potential

Main barriers to the adoption of CA practices are -know how, tradition, inadequate policies, unavailability of appropriate equipment and machines, and of suitable herbicides and alternative management strategies. Area-specific constraints may occur in the semi-arid areas which have initial low supply of crop residues and vegetation biomass for soil mulch cover development; competition for crop residue as livestock feed. However, there are places of enough rains or irrigated conditions and the soil fertility are good for crop production, where is relevant to introduce the CA technology. Moreover, the hilly regions, such as Shan States and coastal areas of Ayeyarwady and Bago Regions also need to fertility improvement and suitable to apply the CA technology.

In general, the policy makers and department heads show no much interest in environmental conservation and long term development activities. Limited policy experience and expertise to assist in the transformation of conventional tillage-based systems to CA systems for small and large farmers in different ecological zones should be solved. Actually, the number of countries

where CA has been adopted and it has increased to 55 countries in 2013 with some 155 million hectares worldwide on both large and small farms since 2008- 09.

The Timeframe of the project implementation: long -term

Status of technology in country

The CA technology has been applied in a small scale in some areas but the official data was not available. Orchard crops and plantation tree crops such as oil palm, rubber, citr**u**s, and coconut were managed under CA.

Similar to CA technology, a traditional technology namely "Khoke-phone" / Relay cropping has been well established in lower Myanmar (Yangon, Bago, and Ayeyarwaddy Regions) since several decades ago. Just before or soon after the monsoon rice harvest, pulses (black gram) seeds were broadcast into the rice stubbles. Then the rice stubbles were cut by a large machete/ knife to cover the black gram as a mulching purpose.

To increase in a wider adoption CA, the following programs are necessary;

- Incentives to farmers
- Participatory learning approaches such as farmer field schools (FFS) to strengthen farmers' understanding of the principles of CA, will target to smallholder farmers;
- A need for effective national and regional policy and institutional support - Technical and financial support from governments, donor agencies and international organizations for CA research and development- bilateral and multi-lateral donors support for CA
- Government departments, policy-makers, institutional leaders and others need to be aware of long term benefits of CA and policy and institutional support is crucial for the introduction and accelerated adoption of CA. The technology is coherent with the Myanmar's existing policies, such as Myanmar's Agenda 21 (MA 21), 1997 and Myanmar SDGs

Climate change mitigation/adaptation benefits

With minimum disturbance to soil, CA enhances biodiversity and natural biological processes above and below the ground; Because of the better soil health and moisture holding capacity, the crops can adapt to climate variability, such as drought and floods, to a considerable extent. CA provides not only the climate adaptation potential but also mitigation co-benefits due to the less use of agro-chemicals.

Benefits to economic/ social and environmental development

Economic benefit:

Yields are comparable with and even higher than those under conventional intensive tillage systems;

Better farm income (reduction of costs of machinery/ land preparation and fuel; and time-saving that permit the activities of other agricultural and nonagricultural aspects; Reduced fuel and machinery costs; Crop diversification (rotation, relay cropping) provides more income;

Social benefit:
Labour requirements are generally reduced by about 50%, which allows farmers to save time for other social and job activities; Women will have less shock under the long-term sustainable agricultural system.

Environmental benefits

- The ecosystem will be conserved and improved and the community can enjoy the ecosystem services. CA complies with ecological sustainability as follows.

- Increased system diversity and the stimulation of biological processes in the soil and above the surface as well as due to reduced erosion and leaching, the use of chemical fertilizer, pesticides, herbicides is reduced in the long term. Ground water resources are replenished through better water infiltration and reduced surface run off;
- Utilizing crop diversification and cover crops instead of a fallow period, it improves productivity and soil quality. Cover crops encourage the soil carbon sequestration and climate change mitigation, exhibiting superior performance compared to tillage-based farming;
- Soil protection against water and wind erosion; greater soil health and nutrient efficiency; and better water use efficiency in dry land areas. The areas where the severe water erosion occurs and combined with poor profit margins of crop production will have long-term benefit by adoption of CA.

Financial Requirements and Costs

- Capital, operating costs – Not available

Priority Technology (3)

Improvement of "Salinity tolerance rice varieties" in coastal and inland salinity areas

Introduction

Being an agrarian country, Myanmar has been experiencing the negative impacts of climate change. Among them, salinity is becoming a striking issue detrimental to crop production. The salt affected areas in delta region were increased year after year and recorded as 56,027 ha in 2009 (DOA, 2003). The contributing factors were complex impacts of climate change - seasonal sea water intrusion, sea level rise, cropping system management, and etc. In the monsoon season (May to September) the upper part is fresh water. The saline water intrudes into the southern part of delta from October to April. People traditionally scheduled their farming and fishing activities in accordance with the brackish water condition of their particular area. Water salinity is high during dry season, during high tide and the area near the sea. The meteorological data predicted that sea-level rise will be continuing; due to the severe storms, tidal waves of about 1.5 - 3 m inundate in low-lying coastal areas. In spite of lack of comprehensive research study, farmers witnessed that substantial rice areas were affected with sea water intrusion, particularly after the Cyclone Nargis in 2008. Cyclone Nargis damaged many polders, resulting in the uncontrolled entry of salt water and, thus, reducing rice yield. The fields once with good fertile soils were gradually degraded and less productive. Presently, several villages are encountering significant economy decline; many rice fields abandoned.

As a coping strategy, farmers traditionally use saline tolerant local rice varieties, namely, Annawar Bo, Kunni and Kunwah, etc. All were adopted since several decades ago and the seeds were highly degenerated with less purity and low performance. Farmers are using their saline land since the good fertile lands are scare but rice yields are often decreased with increasing salinity, especially when experienced in the early development stages. Climate change vulnerability of subsistence farmers can be reduced through the use of locally relevant technologies, improved climate-resilient rice varieties, and ex/in-situ conservation of genetic resources.

Technology characteristics

The saline tolerant varieties currently used in coastal areas are the local varieties or landraces. Key strengths of this seed system are that the varieties are well adapted to the farmers' production system, and the seed is affordable due to the existence of local exchange and dissemination mechanisms. However, the limitations are that not all varieties are high yielding, that there is seed storage problems associated with seed disease and pest incidences. Further, purity problems can arise due to mixtures of seed lots after harvest, caused by inadequate seed cleaning equipment. More than 80 % of farmers use self-saved seed for paddy production in the delta regions.

The technology includes –

- Promote variety improvement program - cultivation of "traditional rice varieties" with natural tolerance to salinity: develop seed systems to conserve, multiply, and promote sharing and exchange of traditional varieties to remote areas;
- Introduce and promote higher-yielding and improved salt tolerant rice varieties appropriate to farmer preferences;
- Community-based seed systems will be established to promote seed exchange and encourage farmers to plant traditional and modern varieties
- Protocols for the selection and purification of these varieties, and the collection and storage of the seeds will be developed and taught to farmers.
- Coordination between the MOALI and the DMH will be strengthened to facilitate the timely delivery of information on weather and of early warning on weather disturbances.

Country specific applicability and potential

Opportunities: infrastructure development has been improved in delta region, such as road access, agriculture machines, and mobile phones

Recently, the private sector had been active in generating and promoting technologies which need to be adapted to local conditions to make them more suitable to specific conditions in the various rice-growing areas;

Farmers are accustomed to use their traditional salt-tolerant rice varieties many decades ago. They want to improve these varieties because the yields were very low. They are eager to adopt the new varieties of salinity tolerance varieties; these rice varieties have a good market because the communities of these areas consume them;

Constraints: Limited communication and collaboration between DAR, Seed Division and Extension Division of DOA. It leads to inefficiencies in the performance of the seed chain and quality assurance system. In turn, this reduces the amount of quality seed of in-demand varieties reaching farmers and the overall seed quality.

The timeframe for the project implementation: medium to long- term

Status of technology in country

Under the variety improvement program of Rice Division of DAR in Nay Pyi Taw – Yezin, the salinity tolerance rice varieties have been produced. Some were tested for their suitability and adaptability in delta areas. As a component of the technology, the selection of farmer's traditional varieties was also conducted. The seeds of selected traditional varieties will be multiplied under the certified seed program and distributed again to the salt-affected areas. The field inspection is extremely important to distinguish whether they are off-type plants, weed or disease infected plant contaminate the field Certified Seed . The training program was designed in accordance with the growth stage of rice and held five (5) times from sowing seeds to harvesting in a season.

However, the technology was not well developed, probably because of weak in technology, human resource and financing mechanism. Project activities should be conducted in close collaboration with DAR, and Seed Division & Extension Division of Department of Agriculture (DOA).

The following are recommended for a successful adoption of the technology:

- A participatory and inclusive approach is necessary, Strengthen research and extension linkage
- To strengthen the extension network and delivery system of rice seed sector
- Conduct training activities on participatory approaches in working with farmers, women and men,

- Conduct awareness campaigns and education
- Apply farmer field school (FFS) approach and locational demonstration plots.

Climate change mitigation/adaptation benefits

The use of improved salinity tolerance rice varieties will build resilience of local farmers in saline affected areas, with sustainable rice production.

Benefits to economic, social and environmental development

Economic benefit:

Quality and high yielding seeds will be available to farmers and increase rice production; it provides employment and income and provides the farmers of Myanmar with quality rice seed;

The adaptation of rice farming to the impacts of climate change will be improved and farmers' capacity to cope with associated risks will be enhanced. Moreover, the environmental impacts of rice farming will be minimized while conserving the diversity and richness of rice ecosystems

Social benefit:

More job opportunities; along with the production increase and all round improvement in community level will encourage the women's role in social and economic status.

Financial Requirements and Costs

- Capital, operating costs – Not available

Priority Technology (4)

Development of paddy dryers as a community based adaptation technology

Introduction

There are significant losses along the rice value chain process starting from field to market. Lack of drying facility of rice grains is a big challenge for farmers and rice millers at the harvest. Summer rice area covers about 2 million ha with a yield of 5 t/ha which contributes one fourth of annual total production of the country. Harvesting times for summer rice coincide with the start of rainy / season, and often face with monsoon rains (March - May in Lower Myanmar and June - August in Upper Myanmar). In the current years, unusual or unseasonal rains also affected the monsoon rice (mostly in Nov. - Dec.). Farmers normally practice sun dry for 3-4 days before storage or selling. The moisture content of cereals has to be brought down to 14 % or less for safe storage. In this method the grain is spread on plastic sheets or paved floors and allowed to dry for two to three days. Several disadvantages are high rate of loss, slow drying rate and longer drying time, rains disturbance. Farmers suffer high crop loss due to lack of drying facilities; rice quality deterioration; the paddy price was significantly reduced by 50%. The mechanical dryer, where heated air is blown through the grain mass has the following advantages: continuous process; drying under controlled conditions; shorter drying time; and drying during adverse weather.

Technology characteristics

It is important to dry rice grain as soon as possible after harvesting ideally within 24 hours. Delays in drying, incomplete drying or ineffective drying will reduce grain quality and result in losses. Paddy drying methods include traditional and mechanical systems; at the rural level the flatbed-type batch dryer would be suitable because of its simple design and operation, fast installation and assembly, and uniform low fuel consumption. It has a minimum capacity to dry two (2) tons of paddy in four hours from an initial moisture content of 20 % to 14 % using paddy husk or any other agricultural waste for thermal energy power.

It can dry rice grains to a moisture content level of 10 % to 13 %, depending on whether the weather is dry or wet. A typical recirculating batch dryer, for example, requires at least 10 tons of rice in just one drying operation. Because it needs electricity to run the dryer and fuel for the air heater at the same time, the investment and operating cost for such a dryer is higher.

Hardware: Dryer, components, construction service;

Software: Technical training, economic aspect, efficient operation and maintenance to the owners;

Flatbed paddy dryer (fixed type, batch dryer), low cost dryer for farmers will be introduced. Technology/ know-how and management related issues can be addressed through capacity building measures;

Country specific applicability and potential

The technology still have limitation for farmers (for low cost small scale dryers) due to shortage in electricity supply to the village level; it need proper consensus among community if the dryer is intended for community ownership of farmers or millers.

Proper training (for owner and operators) on drying technology, and dryer operation/maintenance is
key to have the sustainability; The availability and easiness of sun drying as a simple and very inexpensive alternative to the mechanical dryers.

For choosing the right technology options, to change the mindset of local farmers, the knowledge dissemination is required; to understand the technology, there needs demonstration and awareness talk to see the advantages; Careful handling and operation are necessary; improper maintenance and weakness in operation will cause the negative impact (e.g., very high temperature to the grain will reduce the rice quality)

Status of technology in country

First dryer was constructed in Feb 2006 in Myanmar. Dryer ownership was rice millers, private seed farm, farmer community – association, Co-operative, Government Seed Farm, and etc. Currently, there are about 1500 dryers (small and medium scale) in operation. A considerable number of users accept the technology. Dryers offer a good compromise between drying cost and benefits in terms of higher quality and weather risk avoidance.

Mechanical paddy dryers are widely used across the Southeast Asian nations, and technical improvements are being made, particularly in Vietnam, India and China.

The timeframe of project implementation: long- term

Climate change mitigation/adaptation benefits

Use of mechanical drying systems offers so many advantages over sun drying like maintenance of paddy quality, safe drying during rain and at night, easy control of drying parameters and the potential for saving on labor cost; Reduce the postharvest loss significantly; more often farmers suffer a great loss due to the irregular rains when drying the paddy.

Benefits to economic, social and environmental development

Economic benefit: Advantages of dryer:

- Less breakage of paddy leads to less broken percentage
- 10% higher in head -rice recovery than sun dried paddy
- High milling output per hour than ordinary paddy
- 5% higher in market price

Social benefit:

Reduce labor and time consuming for drying paddy grains; more time for second crop preparation; No need to worry about drying of their grains in bad weather. No negative impact to environment; Reduce the tedious work of drying paddy under sun; all with manual labors and the heat of sun exaggerated the poor health; By mechanical drying processes, women can feel relaxed; Use of free time in another useful way

Reduce the tedious work of sun-drying processes which are still common in Myanmar, such as Bund drying after harvest, Highway Drying**, etc.**

Financial Requirements and Costs

High initial cost, individual farmers cannot afford on their own; The cost of such a dryer is approximately 400, 000 kyats or US$ 400 (inclusive of fan).

Priority Technology (5)

Dissemination of solar dryer technology for high valued crops as an adaptation option

Introduction

Much of the drying of crop produce, such as chili pepper and sesame, is done in the open air, under the direct sunlight, often on the ground or a mat. A large amount is eaten by pests like rodents and insects, while rain and wind also ruins the crops' quality. Since this conventional method takes a longer time and the produce are highly exposed to the damage by rains. As a consequence, it will create the high Aflatoxin content and a poor quality. In 2016, FDA (Food and Drug Administration) Myanmar approved that almost all chili powders in local markets are contaminated with Aflatoxion and not safe for consumption. Aflatoxion can lead cancerous health problem, especially it develops into a liver cancer. Lots of liver cancerous health problems are found in Myanmar these days. It was noted that the Aflatoxion is a result of the improper postharvest technology. With improvement of postharvest technology, at least at drying stage, the risk of Aflatoxion in high value crops, like sesame, chili pepper, peanut, seed maize and etc., will be eliminated. The newly introduced solar dryers for several cash crops have mitigation potential, since they use only solar energy and leaving no carbon footprint.

Technology characteristics

Since 2016, Solar Dryer Dome (SDD) technology was introduced to Myanmar as a demonstration scale. It is an advance postharvest technology which has a climate change adaptation potential. Comparing with the conventional method the drying period is shortened by 50% while the spoilage and loss are significantly reduced. The drying process is done under a shelter dome with a quick period and it can avoid the adverse impact of unexpected rains and winds. In addition, the color of the produce dried inside the SDD gives more vibrant and brighter than conventional one. The main advantages of SDD are better product quality (color, skin, taste) with high hygienic standards (no dust, no pollution, no fungus,), and better prices.

It provides a greenhouse-like shelter to dry the agricultural produce, allowing sunlight through while keeping away rain and pests. It is made from super-durable polycarbonates and it protects the dried items from contamination of elements while utilizing the maximum power of the sun, enabling high quality food with longer shelf life. Solar Dryers in Parabolic Domes allows water to run along the walls (no contamination of goods by water).

Country specific applicability and potential

Since Myanmar farmers are engaging with more export opportunities in recent years, they are interested in solar dryers to improve their products. For example, the high value crops (such as chili, elephant foot yam, tea leaves, ginger, and pulses) are required to dry to meet quality

requirement of foreign market. Several export items such as sesame, peanut, seed maize and chili pepper should be free from Aflatoxin, which need to be dried properly after the harvest. With the introduction of "Open market economy" in Myanmar in 1990s, the commercial production of export items of high value crops have been taken place. Due to the high export demand and economic return, Myanmar agricultural businesses have been advancing.

Sesame seeds are year-round produced in Myanmar. Japan, Taiwan and China are the main importers of Myanmar's sesame. Myanmar exported 25 thousand MT of sesame seeds, including the black sesame to Japan in 2007. The trade of sesame seeds across the world is over 800 thousand MT, in which Myanmar shares 15% of global sesame trade.

Status of technology in country

Inclusive Business of Covestro and Natural Farm Fresh Myanmar (NFFM), a social enterprise installed several mid-size SDDs (8m x 12m) during 2016 -2017. Most of them are used by SME owners for drying gingers and vegetables in Yangon, and for processing safe, clean, and hygienic chili in central Myanmar. UV protection of solar dryers maintains colors and nutrients of fruits and vegetables.

There are about 800,000 acres of tea plantations in Myanmar. Myanmar's dried tea leaf is exported to Thailand, China, Germany and other European countries. Some tea growers and dealers in Southern Shan State have adopted solar tea leaf dryer, instead of firewood, to improve product quality.

Climate change mitigation/adaptation benefits

Since the impacts of natural disasters are expected to increase in future it is important to take the systematic DRR management measures. The Government developed the Myanmar Action Plan on Disaster Risk Reduction (MAPDRR) in 2017. Myanmar is committed to disaster risk reduction and it has systems and procedures at National, State/Region, District, Township, Wards and Village Tracts levels for disaster management.

The solar dryer technology has mitigation potential, since it avoids the use of diesel engine power and electricity and use only the solar energy and leaving no carbon footprint.

Benefits to economic / social and environmental development

With the use of SDD, the productivity increases in terms of labor and energy cost saving. Due to its green-house effect, the products will have higher durability and transparency over a long time. The better quality products with a good hygiene can earn a better price. Since the products are free from dust and Aflatoxin, it promotes the consumers' health.

Financial requirements and costs

One SDD (medium size): US$ 150,000

Priority Technology (6)

Development of submergence tolerance rice varieties in Myanmar

Introduction

Myanmar stands the world's sixth-largest rice-producing country. Rice is the staple food in Myanmar and the country's economy highly depends on its export. Rice is grown on over 8 million ha, which covers more than half of the country's arable land. Rice yield rose to 4.1 t/ha in 2010.. In the face of climate change, Myanmar is forecast to be affected with more weather extremes such as frequent and intense of drought, flood, and heat stress. With tropical cyclones and rising sea levels, flooding risks in coastal areas and deltas are increasing in recent years. Therefore, the farmers who live in low lying areas are most severely hit by floods.

Flood-tolerant rice varieties will be an effective adaptation option under such hazardous circumstances of intense flooding events. Submergence of either short-term (flash floods) or long-term (stagnant flooding) can affect rice crops at any stage, and the chances of survival are extremely low and rice yields are severely affected. Myanmar traditional varieties, locally known as deep water rice varieties can withstand flooding condition. During flooding, the rice plant elongates its leaves and stems to escape submergence and able to survive. The high-yielding modern varieties cannot do so and if floods last for more than a few days, they are unable to recover and rice fields are severely damaged or totally destroyed.

Natural disasters can destroy the valuable genetic resources. For example, in 2008, Cyclone Nargis damaged 122,782 hectares of deep water rice in Myanmar. Some of the precious stress tolerant genes might be lost by such disasters. The national rice breeding program of conservation of submergence tolerance genes should be initiated for the future use of regional or global rice improvement program.

Technology characteristics

The technology will introduce a genetic breeding method to Myanmar to develop submergence tolerant rice varieties. This technology will support the development of promising lines at the research farms located in rain-fed lowland of delta and coastal areas. As a result of the technology, new rice varieties tolerant to flash floods and having high yields will be developed. It will improve the production level and income of rice farmers in flood affected regions.

(1) The project will employ DNA marker-assisted selection techniques in rice breeding and improve those varieties with the efficient addition of the useful traits of resistance to flooding. The use of marker-assisted breeding helps breeders incorporate specific desirable traits into new varieties with more accuracy and speed. Evaluation of existing rice genetic resources, verification of useful genes, introduction of backcrossing and high-capacity genotyping, development and evaluation of promising rice lines that can adapt to flooded prone areas. Rice breeding system is strengthened to develop promising lines adapting to natural and social environment in Myanmar.

(2) At the same time, the indigenous rice varieties (deep water rice and floating rice) planted in the flood prone areas will be selected and tested in locational demonstration plots. The seeds of these selected traditional varieties will be multiplied under the certified seed program and they will be distributed to the flood prone areas.

Country specific applicability and potential

The technology complies with the Myanmar Rice Sector Development Strategy (MOALI, 2015), which states to "promote the cultivation of "special traditional rice varieties" with natural tolerance for deep water, prolonged flooding, or drought.

Under the cooperation of DAR and DOA, agricultural extension workers will test these breeding lines in different locations of flood prone areas, including evaluating their performance on farmers' fields. The selected lines which survive under the flood -stress and retain desirable grain qualities are either released directly or bred into widely grown and popular local varieties. Along with improved crop management, proper use of technology through extension work and the support of national institutions are key factors for the development of adaptable varieties in particular localities.

Status of technology in country

Since several years ago, DAR introduced submergence tolerance varieties from IRRI, tested in several locations for their suitability, under the national plant breeding program. An adaptation research on "submergence tolerant rice varieties" has been conducted in Rice Division of DAR. The breeding lines of submergence tolerance, namely Swarna Sub1, Samba Mahsuri, IR64-Sub1) were introduced from IRRI, Bangladesh and India and they were tested in varietal trial programs

of DAR. They were known to have a yield advantage of 1–3 tons following flooding for 10–15 days. These research programs will be extended.

Under the collaboration between Myanmar and Japan International Cooperation Agency (JICA), a technical cooperation project on "Development of participatory multiplication and distribution system of quality rice seed" was implemented during 2011 – 2016. The purpose is to establish participatory multiplication and distribution system of quality rice seed in Ayeyarwaddy delta area. Under this project, some "Stress-tolerant rice varieties", particularly, submergence tolerance varieties were grown in trial plots and rice varieties with desirable traits were selected by farmers.

Climate change mitigation/adaptation benefits

Tropical cyclones are recurrent phenomenon in recent years. Increasing sea levels will further increase flooding risks in coastal areas and deltas. In addition to water depth, higher sea levels increase the duration of flooding which is typically the decisive feature to determine survival rate of rice plants. "Development of submergence tolerant rice varieties" will be an effective adaptive option under such intense flooding events.

The technology has mitigation potential as a co-benefit. It was noted that deep water rice emits the least methane, a Greenhouse Gas, of the wetland rice ecology, producing approximately three times less than paddy field rice.

Benefits to economic / social and environmental development

The technology is a kind of Disaster Risk Management (DRM). By adopting tolerance varieties, farmers can avoid the crop loss by the severe floods. At the time of flood disaster, the adopters of new technology can obtain significantly higher productivity than the non-adopter. Generally, farmers can obtain more profit from adopting them. However, the adoption of tolerance varieties could involve high risks and uncertainties; if farmers own enough land, they will allocate more land to such new varieties.

Time frame: Long -term

Implementing/ cooperating Agency: DAR and DOA

Financial requirements and costs

Capital, operating costs – Not available

Priority Technology (7)

Introduction of a weather index-based crop insurance system

Introduction

Climate induced disasters and extreme weather events are affecting Myanmar, such as flood, drought, cyclone, and storm surge and salinity intrusion. They directly and adversely affected agricultural production, and are threatening to have more intense and frequent occurrence. In addition, localized calamities such as hailstorms, landslides, cyclones and floods led to extensive crop damage. For the protection of farmers against these risks, crop insurance is important in managing risk on the farm level. A weather index-based crop insurance system is an adaptation tool to reduce the vulnerability of agriculture sector due to climate variability and extreme weather. Compensation is based on weather indexing (e.g., rainfall, temperature, etc.). Once weather conditions match the predefined parameters, payments are issued without loss investigation.

Technology characteristics

It needs technical assistance from foreign organizations and cooperates with the DMH and the MOALI. It will be implemented in cooperation with an international insurance firm, Myanmar Agricultural Development Bank (MADB) and Myanma Insurance Enterprise.

Crop insurance pays for liabilities, depending on the rate that both parties agreed to when they bought the insurance. To set the premium rating, the insured amount (maximum amount payable) is calculated on risk factors such as the amount of rainfall, moisture content and the speed of the wind, which is measured by satellite, and issued by the DMH. The system will cover the farmers who have a land-use right certificate (Form 7); Agricultural advisory service to farmers by experts, ensuring continual interaction. It will use the most suitable monitoring tools for quality assurance. The use of ICT is to quicken compilation of data, verification and faster settlement of claim.

The premium rates vary from 1.5 % to 3.5 %; picture-based insurance product connects technology with weather index based insurance. Survey will include an inspection of the weather conditions in each region, crop varieties, previous climate-related hazards and the number of farmers interested in availing crop insurance; the premium rating will depend on the data procured after the joint survey. The liability rate may vary depending on the climate conditions of each region as the weather index differs in each place.

It needs to conduct a feasibility study and farmer risk assessment, Launch field implementation and farmer socialization; It needs to secure accurate satellite data to create more effective weather indexing systems; A holistic approach is important to risk management, rather than relying exclusively on insurance system. Crop insurance is one of the most quoted tools for risk management. It can only play a limited role in managing the risks related with farming. In practice, agricultural insurance is almost invariably complementary to a whole set of risk management measures of which adequate farm management practices constitute an important element.

Country specific applicability and potential

It requires awareness campaign / workshop to let the farmers thoroughly understand the system. An Android-based mobile application records and transmits the data using smartphones. This data is transferred to the central crop insurance portal, making it available in real time to government officials and insurance companies. The smartphone data contains vital information, such as photos and videos of the particular area, geo-tagging, probable harvest date, the yield, etc.

Opportunities: availability of low-cost internet and rising use of smartphones

Challenges: The system is challenging in raising awareness on the importance of risk management on the farm level due to impediments which include cost, the scattering of plots across vast rural areas, unreliable data and the lack of human resources capacity.

Barriers: the premium rate is to be calculated on the market price of paddy across one acre of farmland; and the amount of rainfall varies across Myanmar, rice varieties, time of sowing, topography of particular farmland and their resistance to floods / drought are also different. For this reason, the criteria used to decide eligibility and compensation are expected to differ across regions.

The timeframe for project implementation: long term

Status of technology in country

A national consultation workshop on challenges and opportunities of crop insurance for Myanmar was held in Nov., 2018. Some pilot projects started conducting joint surveys in five areas / regions of Myanmar. The Ministry of Planning and Finance (MOPF) announced on 2nd January 2019, that the country is now officially open for foreign companies in order to develop the Myanmar insurance sector;

Crop Insurance Law will establish the framework through which the government and private sector can further develop; the system is a kind of risk mitigation; and preparedness action relevant with MAPDRR of 2017;

Crop insurance is available in neighboring Thailand, India and China, Bangladesh, and India. Myanmar is at the beginning stage. The farmers are keen to avail of the crop insurance system, as it can cover possible losses.

Climate change mitigation/adaptation benefits

As a climate change adaptation technology, the insurance scheme is to protect farmers against crop damage to a considerable extent. The system helps in mitigating the looming threats of climate change to which the farming communities are very vulnerable. It will reduce risk of climate change especially impacting small farm households. Affected farmers will get quicker recovery. Mitigating risk in the agricultural sector has a direct implication for agricultural productivity and farmer welfare.

Benefits to economic / social and environmental development

The agricultural insurance system will mitigate the financial impact of natural disasters. If there is a reliable and sound crop insurance system, the impact will be reduced to affected farmers. They can recover from the climate change disaster sooner and can make efforts for their livelihoods. There are no environmental negative impacts.

Financial Requirements and Costs

- Capital, operating costs – Not available

Priority Technology (8)

Establishment of Climate Smart Agriculture Villages (CSV) for sustainable agricultural production in Myanmar

Introduction

Myanmar has an agriculture-based economy, relying on its agriculture sector. Agricultural production and food security is a major challenge under the adverse impact of climate change; a substantially adaptive agricultural system is an urgent necessity. More than 80% of crop production is under the rain-fed agriculture system, which is extremely vulnerable to the climate change. In addition, a large portion of GHG emission came from the agriculture sector, as documented in Myanmar INC Report in 2012. Therefore, apart from the climate change adaptation needs, agriculture sector has a great potential for reducing the GHG emission (climate change mitigation). To address these challenges, the Climate-Smart Village (CSV) approach will be pursued. The technology of Climate Smart Agriculture (CSA) has three main characteristics, such as (1) sustainably increasing productivity (2) building resilience to climate change; and (3) reducing GHG emissions. Therefore, CSV technology is a community-based approach to climate-resilient and sustainable agricultural development of the country.

Technology characteristics

The technology includes the following activities and programs.

- Production infrastructure development - such as farm roads, farm to market roads which facilitate marketing, good water management practices, such as canal irrigation or rain fed- water conservation; mechanized land leveling, drainage irrigation facilities which can provide stable water for crops,
- Integrated nutrient management (INM); biomass recycling and soil health, conservation tillage; crop residue management; appropriate use of chemical fertilizers;

Integrated Pest Management (IPM); Modified water management strategies - water saving technologies (such as, alternate wet and dry technology (AWD))

- Integrated farming system (livelihood diversification): Small scale of cow, goat, pig chicken, duck raising, fish ponds; Crop diversification: mixed, inter, relay cropping - proper Cropping System management, Post-harvest management
- To reduce GHG emission from rice fields, the following initiatives will be conducted: Off-season application of rice stem residue, No rice straw burning,
- Capacity building and knowledge transfer is highly required to disseminate the CSA technology.
- Supportive measures are – Policy engagement, institutional arrangements, climate information advisory services, gender and social inclusion

Country specific applicability and potential

The Myanmar CSA Strategy (2015) stated that - By 2030, Myanmar will be a climate-resilient, food – and- nutrition- secure country, with high productivity and competitiveness in global markets, through CSA villages. Capacity building and knowledge transfer is highly required to disseminate the CSA technology. The followings are the supportive measures for the technology adoption - policy engagement, institutional arrangements, climate information advisory services, gender and social inclusion.

.The timeframe for project implementation: long term

Status of technology in country

The technology is political -coherent with national development policies and priority. Myanmar National Adaptation Programs of Action (NAPA), 2012 proposed priority projects in agriculture sector include the use of climate-resilient rice varieties, crop diversification, and CSA approaches to reduce climate change vulnerability of subsistence farmers. There are four key adaptation policy areas on CSA which can be integrated with current agricultural policies: 1) encouraging adaptive crop development and farming practices; 2) irrigation and water resource management; 3) disaster risk management and 4) crop and income loss risk management.

CSA technology was introduced in 2014 in Myanmar. It still needs to be developed at the community level. A National CSA Center was established at Yezin Agriculture University (YAU), in 2018, which is a focal point for the advancement of knowledge, monitoring of impacts, and adoption of CSA and sustainable land management practices. A National CSA Technical Support Group (TSG) was also formed at YAU, which is responsible for the technology development of CSA in Myanmar.

Climate change mitigation/adaptation benefits

The technology will contribute to reduce vulnerability to climate change impacts by enhancing crop resilience against climate change; its contribution to the sustainable development and benefit to society, the community will have more resilience at the time of climate change related disasters. The technology provides not only adaptation but also mitigation co-benefits.

Benefits to economic / social and environmental development

Economic benefit:

Higher income from the sale of quality crop products with a premium price,

Social benefit:
Employment opportunities: The technology needs more labor and the participation of the whole community.

Health benefit: The limited application of chemical fertilizers and pesticides, therefore, the technology gives low risk on health of the farmers as well as for consumers due to the reduced use of agro-chemicals.

Gender inclusion: Women will have the same opportunity as men to get jobs. With the economic and rural development, village women can enjoy better livelihoods. The women will have more job security in the agriculture sector and SME in the village level.

Environmental benefit:

Better soil health: With the use of INM practices, less use of farmers apply reduced chemical fertilizers and more organic manures crop residues. It improves soil organic matter, fertility and better soil health leading to the soil carbon retention, CO_2 sequestration (Mitigation potential).

Reduce pollution: The application of IPM technology also reduces pollution of environment (air, soil, water) due to the less of harmful chemical pesticides and more use of natural pesticides.

Soil erosion control: Managing the soil organic matter for soil carbon sequestration, mulching, cover crops for moisture conservation, will create lower irrigation needs as well as soil erosion

Sustain ecosystem services: more favorable due to practices helped to conserve soil and water, and increase biodiversity. Good contribution of the technology from the view of ecosystem protection

Financial requirements and costs

- About USD 0.6 million for formulating and implementing CSVs (2 villages each in 3 different agro-ecological zones: central dry zone, delta region, hilly region)
- USD 0.1 million for capacity building programs (Demonstration plots, Farmer Field School/Participatory approach, Farmer to farmer technology dissemination).

Priority Technology (9)

Hydroponic vegetable production technology

Introduction

Vegetable are widely grown across Myanmar, especially in monsoon season and post monsoon season. Larger vegetable grown areas are found in Sagaing, Ayeyarwaddy, Bago, Magway, and Mandalay Regions and Southern Shan State. Such vegetables as lettuce, mustard, water melon, bitter gourd can also be well produced in lowland areas of the country. For the commercial production, the main constraints are labour intensive and it need much water to supply regularly. Hydroponic farming, an ideal advanced technology, can save water and labor. With more water scarcity in future climate change scenario, the hydroponic technology will help the growers more adapt to the adverse impacts. Production adjustment can also be made to stabilize sales income from hydroponic farming. Moreover, its intensive and sustainable production will promote the high value quality products in the market.

Technology characteristics

Hydroponics is a method of growing plants without soil by using mineral nutrient solutions in a water solvent. Terrestrial plants are grown with only their roots exposed to the nutritious liquid, or the roots may be physically supported by an inert medium such as coconut coir, rice husks, wood fiber, gravel, brick shards, etc. Appropriate hydroponic solutions are necessary for plant nutrition; Adjustment of nutrients is done weekly to balance the nutrient requirement. Containers should exclude light to prevent algae and fungal growth in nutrient solution. Care should be taken during operation time and regular maintenance is necessary.

(1) Static solution culture: plants are grown in containers of nutrient solution plastic buckets, tubs, or tanks; a hole is cut in the lid of the reservoir for each plant, with aeration provided by an aquarium pump; nutrient solution is changed either on a schedule,

(2) Continuous-flow solution culture: the nutrient solution constantly flows past the roots, water containing all the dissolved nutrients required for plant growth is re-circulated past the bare roots of plants in a watertight thick root mat - one liter plastic bottles can be used as containers

Country specific applicability and potential

The technology is at the beginning stage in Myanmar. A few private companies in Yangon are using this technology for vegetable production. DAR, Nay Pyi Taw set up a section for hydroponic farm, and it is at its initial and experimental stage. Therefore, the private and government sector showed interest in hydroponic technology. The technology will support the government policy of "Millennium Development Goal 1" – to reduce the number of people living in poverty and hunger by half to raise their incomes, improve their nutrition and food security, provide opportunities for sustainable growth.

The timeframe for implementation project: medium and long term

Status of technology in country

As a commercial scale, only a few are in a starting stage although the technology is attractive to the farmers as well as consumers. These days, there are more concerns of consumers over pesticides and freshness. Myanmar's middle class mostly depends on local markets of fresh fruit and vegetables, but the country's biggest retailer, City Mart Holdings, is now trying to change this. Since last year, supermarket operator City Mart Holdings has been offering fresh, direct-from-farm produce in Yangon, Nay Pyi Taw and Mandalay.

Terre des Hommes (TdH) Italy has set up the technology in 45 villages, with funding from LIFT since 2013 in the Dry Zone of Mandalay and Magway Regions. Leafy vegetables such as mustard leaves, morning glory and lettuce, and etc. were grown for an extra income of the small households.

Uni Vege, a Japanese-owned hydroponics farm in Yangon, that sells packaged vegetables grown at an indoor facility in - boutique micro-green and traditional salads for sale, distributed in a series of City Mart through refrigerated distribution. The products were sold at City Mart outlets and it sold well to the health-conscious consumers.

Climate change mitigation/adaptation benefits

Water is becoming scare year after year, and water resources are often limited in agriculture production. Hydroponic system is a water-saving technology: the plants take only the required amount. It promotes the livelihoods of the most vulnerable groups in rural areas to become healthier and to adapt to climate and environmental shocks. When witnessing the success stories, farmers –to farmers' technology distribution will be achieved. Replication in other areas – peri-urban situations, where there hydroponic systems can operate on small plots, and access to markets is easier than rural areas to minimize food insecurity.

With improved nutrition, strong and healthy people have more adaptive capacity to environmental shocks. It reduces the vulnerability of farmers to extreme flooding and drought events. Improve food security; providing nutritious vegetables for home consumption and extra for sale.

Benefits to economic / social and environmental development

Economic benefit:

The technology can be applied as a small scale for home consumption, and the extra production can be sold; interested households can develop a commercial scale production. Plants commonly grown hydroponically include tomatoes, peppers, cucumbers, lettuces, mustard, etc. Villagers can save money and earn more.

Health benefits:

Fresh, pesticide-free vegetables are easily accessed for home consumption; improve nutrition; consuming vegetables by villagers are generally about two - three times a week; when hydroponic production by several households (in a village), people will have easy access to eat them almost daily.

Social benefit: There will be more social network - buying and selling or giving presents/ sincere tokens – leading to a healthier and more enjoyable society.

Time and labor saving: Through labor saving, women and men can work for other activities; reduce drudgery from tiresome of watering the plants; Women can do operating/ taking care of the plants in rural areas as well as in peri-urban areas; Women are traditionally key players in agriculture who participate in crop production and manage livestock production. They have key responsibility for food security in the family. Women were strongly encouraged to participate in the training for technical knowledge on hydroponic vegetable planting. Women's organizations are also included to ensure that new technology reached both women and men.

Environmental benefit:

Saving precious water resource; reducing pump water will save the energy use in crop production; it can tackle both immediate natural disasters and the more gradual impacts of climate change; the system goes well with net house and reduces the use of pesticides, and herbicides, less pollutants in the environment.

Financial Requirements and Costs

- 2,000 US$ (3 meter x 6 meter of a plot size can maintain more than 400 plants)

Priority Technology (10)

Integrated soil and water conservation technology for resilient agricultural production in hilly regions

Introduction

About 10 % of total cultivated land in Myanmar is estimated to be highly vulnerable to soil erosion. With the rolling topography and high elevation, the Shan State and Chin State are the most affected areas by soil erosion and land degradation. The main causes were high deforestation, poor agricultural practices and shifting cultivation in upland areas. As a traditional technology of soil and water conservation (SWC), an indigenous "swidden/ shifting cultivation system was practiced over centuries. However, due to the urbanization and population increase and intensive cash crops production interrupted the traditional system, the traditional SWC technologies could not be maintained at farmer's level. Although SWC measures were implemented in several regions of Myanmar in 1990s encouraged by the government and donor organizations, the success was limited due to the insufficient expertise and funding. Farmers recognized that their soil fertilities are reducing and it is required to use high input of chemical fertilizers. Using high dose of chemicals will destroy the soil structure and exacerbate the soil erosion process.

Technology characteristics

The technology includes the following programs:

1) Physical conservation works: bench terraces, soil sedimentation bunds and check dams to protect village range land and farmland; rain water harvesting through gully plug and contour bund, planting trees on communal land to cover the ground quickly; to encourage villagers is essential to participate in conservation activities; Cash-for-work program (include the poorest members of a community and women given priority),

2) Vegetative methods: cover crop planting, contour planting, strip cropping, relay cropping; contour bunds, hillside terraces, planting trees, grasses and shrubs can help to stabilize the erosive velocity of flowing rain water. Degraded sloping cropland will be cultivated with permanent cover of fodder grasses and legumes (Hairy vet); Cover crop system can build soil carbon and soil organic matter (SOM), which improve the soil physical, chemical and biological characteristics. It is important for enhancing soil health, thereby sustainable production.

3) Hedgerow cultivation: not only control soil erosion but also help restore soil structure and fertility; nitrogen-fixing hedgerows (*Leucaena, gliricidia*) grown between contoured rows of cash crops; cut when it reaches 1-2 m to serve as mulch for conserving moisture and organic fertilizer (green manure).

4) Agroforestry: rows of permanent crops such as coffee, orange, citrus and banana dispersed throughout the farm plot, with cereals or other crops and legumes (e.g., mung bean, lentil, soybean, peanut, lemon grass, etc.)

5) Community-based adaptive agricultural practices and off-farm income generation (duck, poultry, pig rearing), etc.

With technology assistance, farmers should be fully involved in all stages of development of contour bunds and ridges, but the cost should be partly supported and access to credits. Follow-up in maintenance will be done regularly; stakeholders/ community participation plays an important role.

Country specific applicability and potential

Demonstrating of promoting diversified and adaptive agricultural practices were conducted. However, only a few farmers followed the technology. The constraints for the technology are – high initial cost and weak community participation.

Adoption of SLAT (Sloping Land Agricultural Technology) is still poor, since the government allocated budget is inadequate. No immediate results will discourage the community's active participation. For the community level watershed approach, the legal and policy frameworks are required to promote sustainable planning and management in a water catchment area. Trainings and workshops such as trainings on resilient farming for the sustainable high land ecosystem (e.g. integrated farming systems) will also be conducted.

The timeframe of project implementation: long term.

Status of technology in country

Under the UNDP /FAO project (1997 – 2000) in Myanmar, the SWC was implemented as a component of food security and livelihood. It covered three townships in Dry zone (namely, Chaung-u, Kyaukpadaung, and Magway) and three townships in Shan State (namely, Ywangan, Kalaw, and Pindaya). A community level watershed approach was taken to erosion control and more water harvesting activities (contour bund, check dam, sedimentation dam), providing training for these activities. It improved crop production potential and sustainable agriculture development. However, the technology was sustained in a few areas after the project terminated.

Climate change mitigation/adaptation benefits

There is a likelihood of more frequent intense rainfall: increase in flooding and severe drought across the country under the future climate change, soil erosion will badly damage hilly area

agricultural lands unless the countermeasures are well in place before the condition become serious. The SWC technology will reduce vulnerabilities to climate change impacts relating to agricultural production and food security. The technology aims to increase production over the long term, while eliminating erosion and land degradation. Diversify crops and livelihood options can reduce the climate change risks.

The technology has mitigation potential as co-benefit, since the cover crops and mulching practices encourage the soil carbon sequestration.

Benefits to economic, social and environmental development

More fruitful production and more family income; sustainable ecosystem will provide all round improvement at village level as well as community level; farmers will involve in all stages of development of contour bunds and ridges, more jobs for income; benefit to the whole watershed conservation, reduce the land degradation and soil erosion process; improve ecology of the area by increase in vegetation cover; women's life will be improved in the long term; Increase agricultural production, reduce poverty, and improve livelihoods

Financial requirements and costs

Capital, operating costs- not available; Costs are very rough at this stage

Annex I: (b) Technology Factsheets for Selected Technologies (Water Resource Management Sector)

Priority Technology (1)

Renovation and improvement of village ponds and tube wells for better livelihoods in Myanmar Dry Zone

Introduction

Since long time ago, village ponds and hand dug wells were traditional reliable water resources for drinking and household use in rural villages for all seasons. Around early 1990s, tube wells have been widely installed in areas with good water quality and aquifer. However, the reliability of these facilities is declining these days in the face of climate change. Many villages, especially in the central Dry Zone are encountering insufficient water access during the summer season. To address these issues, the renovation and improvement are required for sufficient water supply to the rural villages.

Ponds and small reservoirs for rainwater harvesting emerge as a critical role for improving water supplies for villages in the Dry Zone. In many cases, however, they only provide a seasonal resource for 7-8 months a year and dry up during the dry season. Most villages had more than one pond. Village ponds are usually formed by earthen structure and provide for multiple uses including domestic, livestock, small-scale irrigation, and other uses. The viability of ponds often declines due to siltation or because embankments collapse during floods. Renovating, managing and maintaining village ponds and their catchments will provide income opportunities for poor and landless people.

Technology characteristics

Rain water harvesting is the only way to recharge the dried up bore wells and open wells and to rejuvenate and increase the ground water level. The technology includes: "Recharge Pits" are constructed with the use of coarse sand, boulders, and gravels, which act as natural filters; artificial recharge to ground water is a process by which the ground water reservoir is augmented at a rate exceeding that under natural conditions of replenishment.

Rain water harvesting through "Recharge Shaft" in village ponds, bore well and open wells; Digging of water absorbing pits, building recharge structures for bore well and open wells, and etc.,
Renovation of village ponds, installation of small scale cost-effective earth filled dams,

Intensive care will be taken for implementation as well as in maintenance. Training courses and workshops are necessary not only to the operators/ responsible persons of management and maintenance; village youth including women will be included in the training.

Country specific applicability and potential

The technology is in line with the National Water Policy (NWP) of Myanmar, 2014, which is the first integrated water policy for the watersheds, rivers, lakes and reservoirs, groundwater aquifers and coastal and marine waters. Myanmar Water Vision' states that "By the year 2030, the country will have an attainment of sustainability of water resources to ensure sufficient water quantity of acceptable quality to meet the needs of people of the country in terms of health, food security, economy and environment".

The timeframe for the project implementation: long-term

Status of technology in country

The investment cost of the technology is so high that local community generally cannot afford themselves. During the last decades, some INGO and NGOs, government organizations and other funding agencies such as JICA have been implementing similar projects in several areas of the country but it did not cover all the necessary areas of the country.

Village ponds are usually managed by Irrigation Department (ID) and collaboratively with the community. Unless the community commits to maintaining the structures, investments will be lost. Water management groups will be set up within villages to maintain rainwater harvesting storage infrastructure. ID provides technical assistance for constructing ponds, in 2012, ID helped to renovate or construct 200 ponds in the Mandalay Region, while the NGO -Proximity renovated the 260 ponds during the same year.

Climate change adaptation benefits:

Myanmar is one of the most vulnerable countries to climate change. It was estimated that there will be more droughts, irregular and fluctuated rains and high temperature of future climate forecast. Rising water ground level of in bore wells and much more water capacity of village ponds will serve the community with sustainable water during the prolong drought. This technology will reduce the negative impacts of climate change and make more resilience to the community.

Benefits to economic, social and environmental development

Economic benefit:

Increase productivity and income, through sufficient water from ponds and bore wells, village people can establish home garden; some village ponds can be also used for supplementary irrigation and small scale vegetable production, which will partly contribute to food security; sufficient water for cattle and livestock and better production , better village economy;

Social benefit:

Creation of job opportunity for landless people; Provide drinking water to livestock and cattle which gives the secondary income, producing livestock products; More income generation works such as development of SME when the village has enough water access.

Health benefit:

Individual household will access sufficient water, particularly during summer months; Improve sanitation and drinking water quality; reduced water borne disease and better health condition. Domestic and community water supply will be good.

Gender participation:

Reduce the drudgery of women to fetch the water away from home; more water availability condition in the village promotes the women's roles in daily life. They can extend their participation to the community level. They can do more jobs related with water availability.

Environmental benefit:

Village ponds act as rain rainwater harvesting and it has a potential for alleviating storm-water runoff and more recharge of groundwater. It will conserve more rain water and also provide supplementary irrigation water at the time of drought.

Protect soil erosion and increasing its fertility; conserving soil and water, natural properties of land, helping to improve the quality of groundwater, raising its level, and preventing wells and tube wells from drying up, ground water recharging grow crops including homestead gardens, maintain the biodiversity;

Financial requirements and costs

It is estimated that one village pond and five tube wells will be repaired and renovated; the "Recharge Shaft" will also be installed wherever possible. The project site will be at 5 villages each in Myinchan and Nwahtogyi Townships. Total villages for project site are for 2 Townships (20 villages in total.)
The estimated budget for a village pond is 1 Million Kyats while for bore wells/ tube wells for each village is 1 Million Kyats.
Total estimated cost for one village: 2 Million Kyats

Total cost for 20 villages (2 Townships): 20 Million Kyats
The beneficiaries: 20,000 households

Priority Technology (2)

Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar

Introduction

Climate change is perceived as a key factor behind the changing pattern of rainfall event in terms of their intensity, frequency and timing. Rise in the number of extreme floods resultant losses and damages to lives and property across the nation is an indicator of changing profile of natural disasters. Among the natural hazards, majority are related to water induced disasters. It is evident that existing structural and non-structural measures of flood risk management are insufficient to cope with new kinds of extreme events.

Coastal areas may be flooded by storm surges combining with high tides and large wave events at sea, resulting in waves over-topping flood defences or in severe cases by tsunami or tropical cyclones. A storm surge, from either a tropical cyclone or an extra-tropical cyclone, falls within this category. Slow-rising floods most commonly occur in large rivers basins. The increase in flow may be the result of sustained rainfall, rapid snow melt, monsoons, or tropical cyclones. Rapid flooding events, including flash floods, more often occur on smaller rivers, rivers with steep valleys, rivers that flow for much of their length over impermeable terrain, or normally-dry channels. The cause may be localized convective precipitation (intense thunderstorms) or sudden release from an upstream impoundment created behind a dam, landslide, or glacier.

Generally, Myanmar experienced flood twice a year. Monthly flood percentage at deltaic area is noted as 45% in August and 25% in September. Even Myanmar has to face with multiple flood problems, existing flood mitigation structures are found largely ineffective or out-dated in the face of climate induced extreme flood events. The basic problem for planning appropriate flood mitigation measures is the lack of a reliable assessment of the risks. The current challenges with regards to flood risk assessment are multi-dimensional and needs to account for a variety of new possibilities that were less relevant in the past.

Seasonal monsoons have brought strong winds and heavy rains across Myanmar, which further intensified with depressions and low-pressure areas over the Bay of Bengal, causing increased water levels in major rivers and flooding. Myanmar is often encountering recurrent seasonal floods in monsoon. In July and August 2019, several states and regions in the country were hit by heavy monsoon rainfall and flooding. More than 89,000 people were displaced across nine states and regions. At least 41 people have died after heavy rain triggered a massive landslide in Paung Township, Mon State.

Technology characteristics

Coastal dikes were constructed in coastal regions in Rakhine State, Ayeyarwaddy and Sittaung delta, Mon State and Tanintharyi Region for flood management. There are altogether 225 dykes in 3980 km, among which 97 are for flood protection, 7 are for urban protection and the others are sea water protection dikes.

In the current condition, there are several challenges for the maintenance of existing dykes. The possibility of overtopping of embankment increases due to heavy deposition in the river. Continuous and gradual rising of river bed level would entail the raising of dikes. There is limited funding of the government organizations for strengthening, rehabilitation and maintenance of embankments. The condition is exaggerated by the occurrence of floods and cyclone with more intensity and frequency under the climate change. These conditions necessitate both raising and strengthening of the embankments in an urgent manner.

For the flood protection, investigation is needed to determine the weak portions of the dikes for rehabilitations and appropriate maintenance measures. Dikes inspection is usually conducted three times, such as, before monsoon, during monsoon and post monsoon. Protection work to prevent bank erosion will be done before the flood season. For the flood risk management in river basin areas of Ayeyarwady delta, renovation and repair work of existing dikes will be conducted. The following activities will involve as the technology approach.

- Repairing of water level gauge
- Re-sectioning and strengthening of dikes
- Clearing bushes and grass at the land side of dike slope
- Construction of dike or levee to control flood waters
- Upgrading of monitoring and managing the dike systems
- Planting forests in upstream areas and mangrove trees at river banks

The other supportive activities are

- Dissemination of flood warning to local levels in time
- Enhancing the community awareness of flood preparation and avoidance
- Encouraging public participation in monitoring, management and resolution of flooding

Country specific applicability and potential

The proposed technology complies with the MAPDRR, 2012" which sets the goal for Disaster Risk Reduction: to make Myanmar safer and more resilient against natural hazards, thus protecting lives, livelihood and developmental gain.

ASEAN Agreement on Disaster Management and Emergency Response (AADMER) provides a regional direction to deal with disasters through enhanced cooperation and improvement of regional capacities. Article 5.1 of AADMER asks the parties to take appropriate measures to identify disaster risks in its respective territories covering natural and human-induced hazards, risk assessment, monitoring of vulnerabilities, and disaster management capacities. Further AADMER Work Program 2016-2020 prioritizes, as one out of eight priority actions enhancing risk assessment and improves risk awareness of ASEAN Community by strengthening ASEAN's capacity in risk and vulnerability assessment, improving the availability of data and information on regional risk and vulnerability and by enhancing mechanism on risk data utilization and information sharing. IWUMD has joined AADMER Work Program and currently in the process of preparing a guideline "Integrating Climate Change Projection into flood risk assessment at the river basin level".

Status of technology in country

The IWUMD made hydrology investigation base on historic measured data and estimate inflow amount in river, flood occurrence possibility for various irrigation and drainage facilities. And IWUMD can made flood map based on current hydrological data. And so as to integrate climate change, more efficient hydrological investigation works are needing (for example- real time rainfall observation). And also capacity for application of Global Climate Model, Downscaling works need to predict the future climate condition. For now IWUMD prepared EPP (Emergency Preparedness Plan for every dams and disclosed to the local community for their awareness for flood from dams.

To integrate climate change projection into flood risk, the following steps has to be done,

- Some suitable global climate model has to be downscaled so that localized climate data.
- Use incorporate with emission scenarios
- Prepare historical rainfall data and projection for future.
- Hydraulic Analysis for flood map
- Vulnerability assessment

Climate change adaptation benefits

The technology is a kind of disaster risk management which is a vital issue for the wellbeing of the people living in the disaster prone areas.

Benefits to economic, social and environmental development

Due to the mitigation of flood impacts, the community will recover in a shorter time from the disaster and enjoy their normal livelihoods.

Financial requirements and costs

Unavailable at this moment

Priority Technology (3)

Water purifying technology in remote villages of Myanmar

Introduction

Water is critical to the survival of the people and the planet. However, in many rural remote villages, there is insufficient water from their existing facilities. The water in open wells and boreholes are usually drying up during the dry season. Villagers, especially women and children are spending a lot of time to collect water from long distance in neighboring villages. In general, the quality of water is not good due to contamination—Iron, Arsenic, Fluoride, Manganese, Nitrogen, Calcium. Due to the poor management, operation and maintenance, water borne diseases often occur, especially in monsoon seasons. Diarrhea was in the top ten leading cause of

morbidity in Myanmar and according to "Health in Myanmar 2014" published by Ministry of Health and Sports. With the poor knowledge, many rural households still use water from unimproved sources and sanitation facilities.

In these days most urban people drink bottle water while in rural remote areas people cannot afford to buy the bottle water due to the financial and transport constraints. In this regard, community based water purifying plant will be introduced to improve the health and quality of life in remote villages.

Technology characteristics

Installation of water purifier (filter machine) for targeted village is a way to ensure that people are enjoying tasting water without any contaminants. Water purification is the process of removing undesirable chemicals, biological contaminants, suspended solids, and gases from water. The water is purified and disinfected for human consumption. The methods used include physical processes such as filtration, sedimentation, and distillation; biological processes such as slow sand filters or biologically active carbon; chemical processes such as flocculation and chlorination; and the use of electromagnetic radiation such as ultraviolet light. Water purification can reduce the concentration of the particulate matter including suspended particles, parasites, bacteria, algae, viruses, and fungi as well as reduce the concentration of a range of dissolved and particulate matter.

Country specific applicability and potential

The technology goes well with the Myanmar's sustainable development Goal No.6 which not only addresses the issue relating to drinking water, sanitation and hygiene, but also the quality and sustainability of water resources.

Status of technology in country

Drinking water source of most urban people is bottle water. In recent years, many households installed the home-type water purifier machine instead of buying the bottle water daily. The large and medium scale types are commonly used in factories, schools, monasteries, health centers and etc. A water purifier plant was installed in Oak Pho Kwin Chaung village of Pyapon Township of Ayeyarwaddy Region by FREDA, a local NGO in 2014. The villagers can access the purified water with a cheap price, a share for operation cost of diesel engine.

Climate change adaptation benefits

The villages of remote areas generally have poor infrastructure, such as poor communication (road access) and very often lack of basic services – very rare access of health facilities, schools, electricity, and etc. These poor people are vulnerable to climate related disasters. With the sufficient access of safe and clean water, the community will enjoy the better health and better quality of life. It will, in turn lead to more resilience to the negative impact of climate change. The people with better health systems will be able to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress.

Benefits to economic, social and environmental development

Social benefits:

Rural populations have sustained access to water supply services. Through improved access to safe water supply, households in the project areas will realize reductions in the time and money needed to collect and buy water.

Health benefit:

The technology will protect water and sanitation related diseases and improve the health and quality of life for all village people through improved access to safe water supply. Community can enjoy clean water, contaminant-free water in their home. The machine gives many health benefits like detoxification, skin hydration and absorption of nutrients and etc.

Environmental benefit:

Under the climate change with greater severity and intensity of extreme weather events, people are confronting with changes in the spread and abundance of disease-carrying vectors such as mosquitoes, or changes to the physical environment that causes threaten livelihoods. People will have more adaptive capacity to the adverse impacts of climate change.

Gender participation:

The key role of women in the sustainable use and management of water supply systems and their interest in effective operations and maintenance needs to be acknowledged. Women will participate in all training opportunities (including technical training) and be active decision makers in Village Water Committees. The community including women will involve in key aspects of participation, responsibility, authority, control, and accountability.

Financial requirements and costs

The water purifiers will be provided to the remote areas of the regions with high poverty rate such as Chin State and Ayeyarwaddy Region.

Water purifying plant: US$ 5000

The foundation building: US$ 3000

Total cost of the project: US$ 8,000 (1.2 Million Kyats)

Priority Technology (4)

Solar-powered desalination and purification technology in coastal regions in Myanmar

Introduction

The drinking water demands in coastal and delta of Myanmar has been growing under the often drought climate condition and salinity intrusion. Besides, the fresh water from hand-dug wells and tube wells are rare availability, mostly are saline contaminated. In the coastal zone about 5200 km^2 are below high spring tide level with coastal length of about 2,832 km. These areas are subject to flooding with more or less saline water. The lack of rain under climate change is leading to severe water and food shortages in these areas, and agriculture is often failure. However, these regions have the sufficient solar irradiation, and thus the solar powered desalination will provide a sustainable solution to meeting water needs. It will provide a reliable and clean drinking water from sources such as brackish groundwater or sea water. Solar energy overcomes the usually high-energy operating costs as well as greenhouse emissions . It has the potential to bring clean water to remote communities, particularly in coastal and delta areas that do not have access to safe and clean water supply system and, far away from the national electricity grid.

Technology characteristics

Solar-powered desalination units will be installed in coastal villages. Solar energy is the most promising renewable energy source due to its ability to drive the thermal desalination systems directly through solar collectors. It drives physical and chemical desalination systems indirectly through photovoltaic cells. A solar-powered desalination unit produces potable water from saline water through direct or indirect methods of desalination powered by sunlight.

With rapid advances in solar energy technologies – both photovoltaic and solar thermal, it can couple the solar energy with desalination for improving energy efficiency. Solar powered desalination systems, photovoltaic powered reverse osmosis (PV-RO) or solar thermal powered reverse osmosis (ST-RO) can be applied. One type of solar desalination unit is a solar still, a condensation trap, is a simple way of distilling water, using the heat of the sun to drive evaporation, and ambient air to cool a condenser film. In a solar still, impure water is contained

outside the collector, where it is evaporated by sunlight shining through clear plastic. As the water evaporates, water vapor rises, condensing on the glass surface for collection. This process removes impurities, such as salts and heavy metals, and eliminates microbiological organisms. It can also remove trace contaminants such as arsenic and uranium that may cause certain health problems. The smaller system device can produce 3,500 liters of water an hour.

Disadvantages

Since the process is driven solely by solar energy, weather conditions and variable solar can negatively impact the efficiency. The intermittent nature of sunlight and its variable intensity, throughout the day and during nighttime, will make desalination challenging.

Trainings and user organization

Training for the operation and maintenance of village water supply systems users manage to undertake minor repairs. The pre-construction community mobilization and training will be organized.

Country specific applicability and potential

The technology aligns with the Myanmar's SDG 6, which states that "Ensure availability and sustainable management of water and sanitation for all" and the related targets and indicators. The project will improve the health and quality of life for tens of thousands people through improved access to safe water supply.

Status of technology in country

FREDA imported 40 numbers of desalination panels (CAROCELL 3000 FCUBED SOLAR DESALINAZATION SET) from Australia in 2018. They were installed in several villages of Bogalay, Pyapon and Mawlamyaingkyun Townships where groundwater used for drinking is too salty for the healthy consumption, especially in summer season.

Climate change adaptation benefits

The desalination technology is necessary to install in coastal areas where the concerns of sea level rise is prominent. Under the climate change, the sea water intrusion is becoming more intense in encroachment area as well as in frequency. Under this condition, the availability of desalinized water will help people adapt more to salinity problem and enjoy a healthy life.

Benefits to economic, social and environmental development

It delivers clean water with solar power. It can eliminate the operating cost of diesel fuel. If this technology is scaled up, it could help supply to more rural households. In addition, the fresh water will be used for small-scale home gardens which can contribute food security.

Because the system can run on solar power, it avoids the large carbon footprint of a typical high energy-consuming desalination plant. It's also significantly cheaper over the lifetime of the system. The system could help address the country's water challenges, and the country to prepare for a future that's likely to involve more drought as climate change worsens.

Financial requirements and costs

Two units of solar desalination sets will be installed in each village of selected 20 villages. Total cost for the project site: 40 sets (for 20 villages) will be US$ 20,000 (30 Million Kyats). The project site will be 10 coastal villages each in Yangon Region (Kunchankone and Kawhmu Townships) and Ayeyarwaddy Region (Pyapon and Daydayae Townships).

Cost: US$ 500 per unit of CAROCELL 3000 FCUBED SOLAR DESALINAZATION SET (made in Australia)

Beneficiaries: 3,000 households

Priority Technology (5)

Solar powered water extraction in central Myanmar

Introduction

In the context of changing climate, there is decreasing freshwater supplies and increasing demand for irrigation due to the need for higher crop production. In rural villages of central Myanmar, many people rely on deep tube wells for drinking water and household use and small scale farming. For the irrigation of small and large farmers, the creeks and streams are also reliable fresh water sources. Water pumping was achieved mainly by the use of diesel engines in the previous decades. However, high diesel and electricity costs are unaffordable to the small holder households. In many rural areas, grid electricity is not available in current condition. Therefore, using solar energy for water pumping is a promising alternative to conventional electricity and diesel-based pumping systems. The technology will support sustainable development of groundwater using tube wells to secure fresh water supplies and provide for small-scale supplementary irrigation.

Technology characteristics

A solar pumping system from deep or shallow tube wells will be installed for the community use. The piping system will be constructed to connect water to individual households with metering devices. Solar water pumping is based on photovoltaic (PV) technology, which converts solar energy into electrical energy to run a direct current (DC) or alternating current (AC) motor-based water pump. The key device is the electronic controller, which adapts the available power from the solar generator to the solar pump. Besides its controlling function, it provides inputs for real-time monitoring of various parameters, such as borehole water levels and storage tank levels, as well as pump speed. While the prices for PV panels, pumps and controllers are cheaper than last decades, some farm households can afford the system installation individually. The determining of an efficient system of solar generator, pump and irrigation technology varies with the specific site and uses.

A "Village Water Committee" will collect a small fee from each household once per month, based on their water consumption (an average of US$ 2-3 per month per household). The community will be self-reliant in terms of water supply. The initial investment will be shared by the community; they feel a strong sense of ownership and responsibility for the system. The piped connection (directly to the household) will have a major impact in terms of convenience.

Trainings: Provision of trainings is required for the efficient use of the technology. Awareness raising programs will include health impacts due to the drinking water and climate change. It will also focus on the participation of women in the trainings.

Country specific applicability and potential

The system goes well with the Government's strategy to reach 70 per cent of the population with piped water by 2030. Currently, it was recorded that only 8 per cent of the population in Myanmar have piped water access.

Status of technology in country

In 2014 the Department of Rural Development (DRD), working together with United Nations Children's Fund (UNICEF) and communities, launched a project to introduce metered water supply to 110 dry zone villages. The village contributed 40 per cent of the funds for the purchase and construction of the system. The residents have pay for their water use in order to cover maintenance costs – normally between Kyats 3000 and K5000 a month. UNDP: Human Development Initiative (HDI -1) project also installed solar pump water system from deep tube wells in several villages. It was noted that the two villages in Kyaukpandaung Township, the system is still in operation, which was constructed since 2000.

Climate change mitigation/adaptation benefits

Since the technology uses the solar energy with no emission of GHG, it can mitigate the climate change compared with the use of diesel engine or electricity. Under the drought conditions, supplementary irrigation is possible from tube wells or small rivers to field crops as well as vegetables.

Benefits to economic, social and environmental development

Economic benefit:
With the use of irrigation, farm income will be increased. Villagers can enjoy more other job opportunities and better household income.

Social Benefit:
The easy access of adequate clean drinking and household water will create more enjoyable living standard for the community. Less time of fetching water encourages them to work for other activities and leisure time.. The system will make the people in healthier condition and reduced water borne disease.

Environmental benefits:
There is no carbon foot prints for using solar energy. It also helps communities to be more resilient to drought and water scarcity under the climate change.

Financial requirements and costs:
Investment cost estimation for the system components,
Small-scale submersible pump (Myanmar), Up to 12 000 l/day, with 260 W panels and stand: US$ 375.00
Large scale for the village/ community use for drinking water and household use: US$ 2,000

Priority Technology (6)

Rural water supply with gravity flow system in hilly regions of Myanmar

Introduction

In the rural villages of hilly regions (Shan States and Chin States) the natural springs in hilly areas are freshwater sources for drinking and household use. With their indigenous knowledge, the communities have well conserved and maintained these springs for centuries. They maintain the natural forest, never cut the trees around the springs. Traditionally bamboo pipes are used to collect the water from these springs for their individual household use. These days, the population growth and economic development are source of pressure on freshwater resource. In addition, in many remote hilly villages there is lack of water supply system, no electricity, no public school, and no health centre. Generally, basic services and basic infrastructure are poor in these areas. In this background, the piped water from natural springs will provide the communities with safe and clean water. This water supply project will change the rural lives to a positive trend.

Technology characteristics

Based on the consultation with village authorities and communities on the relevance to local geographical and climatic conditions, the springs of safe water sources and its supply systems will be identified. Spring water will be collected in a collection tank at the collection point of hilly area, generally about 5 Km away from villages. From there, the water will be delivered with piping system (PVC pipes) to the village water collection tank. It will use gravity flow to move water downhill from the spring source to a designated spot in the village. It will provide a dependable supply of safe water for drinking and domestic use to all households. A water user committee will be formed and a common fund was also established with contributions from all households in order to maintain the water supply system for a long term.

Country specific applicability and potential

The technology complies with the main objective of Department of Rural Development (DRD) for the provision of rural save drinking water. DRD could not cover all the needy areas due to the insufficient budget for rural/urban infrastructures, including water and sanitation, and low income from water revenue vs. high water infrastructure cost.

Status of technology in country

UNDP ICDP (Integrated Community development Project) and UNICEF installed water supply with gravity flow system in several villages the Shan States during 2000-2010. The water supply system was conducted in two villages in Kayin State, with additional funding from the Japan Platform, to strengthen the community's capacity to implement and manage vital development activities.

Climate change adaptation benefits

In general, many natural springs do not dry up during the dry season although the water level is decreased. The community can access the spring water for drinking and household use even in the dry season. With the sufficient and convenient water access, the community will motivated for income opportunities, such as water related business of agriculture production and some other SME. The improvement in rural economy will provide the community more resilient to climate change impacts.

Benefits to economic, social and environmental development

Since the individual villager could not afford the piping charges, safe and clean water from spring sources was hard to access. In summer season when the nearby water sources are dried up, they used to walk for several miles to fetch water from unclean wells and streams and the springs of hilly areas. By improving their water access through pipe water system, clean water brings less water borne diseases and improves the community health condition. In addition to the obvious health benefits of safe water, the households will have an equal and fair share of water. They will enjoy their lives both simpler and healthier because of the construction of a water system that has made safe water readily accessible, even during the dry season. And ultimately, standards of living rise because people spend less time searching for water and more time on other activities, such as getting an education or earning a living.

Participation of gender

Rural women have primary responsibility for domestic water, sanitation and hygiene. All communities including women will participate in decision making for and managing the provision of water supply and sanitation services. During development and provision of services, including management, monitoring and service delivery, all organizations should mainstream gender.

Financial requirements and costs

The investment cost for water collection tanks and piping system of one unit per village will be 3 Million Kyats. The piping system connecting with individual household will be shared by the consumers. If the pumping is required, the diesel cost will be shared by collectively. The maintenance cost will be negligible, and managed by the water user committee.

Priority Technology (7)

Rainwater collection from ground surfaces for land rehabilitation and water conservation in central dry zone

Introduction

The central dry zone of Myanmar is characterized with poor physical features of the land, such as sandy soil with low fertility and low moisture holding capacity. It is compounded by its rainfall

patterns which are intense and concentrated which encourage serious soil erosion. The rainfall in CDZ can be assumed as squall-typed, and the intense rains are strong enough to erode surface soil of farm lands. With these inherent harsh climatic and natural physical conditions, famers have evolved their farming systems most adaptable to their specific local conditions. Farmers traditionally practice diverse crops with inter-cropping, is –cropping, relay cropping and etc., to reduce the risk of crop loss under the unreliable and fluctuated rains. Almost all farmers practice contour cultivation and apply animal manures for fertility management. For physical measures, they also construct soil bunds to mitigate the erosion of cultivated lands. Other structural measures such as check dams, drainage ditches and waterways have also been constructed.

With their indigenous knowledge, dry zone farmers have been applying a range of traditional soil and water conservation (SWC) practices such as overflow bunds, gully plugging with rocks or crop residues, strip cropping, agroforestry techniques and etc. The other promising practices include deep tillage, reduced tillage, zero tillage, mulching and the choice of crops with low water requirement. However, due to the low incomes, lack of credits, and decreased farm sizes along with the population increase, many farmers could not afford SWC practices these days. The situation is often aggravated by the yield reduction caused by climate change. Therefore, external financial resources are required to implement SWC works. Landless and poor farmers could benefit from employment in such programs.

Technology characteristics

Prior to the introduction of technology, it will assess the relevance, appropriateness and effectiveness of soil and water conservation interventions. The technology will cover a range of land rehabilitation and conservation interventions on cultivated land, communal land and around homesteads. The appropriate designs for rainwater harvesting structures vary in different contexts such as the capacity of individual farmer, physical soil characteristics, cost, risk of siltation, surface water and groundwater availability, and etc. Community water user groups will be used as a model for management approach. Roles and responsibilities for managing and maintaining rainwater infrastructure at the village level will be clearly defined. The rain water harvesting practices of collection of runoff to farm ponds, storage tanks, will be implemented through the project. Different types of storage tanks will be introduced for collection and run-off of rainwater from various sources (ground surface catchment). Above and below ground water storage tanks will be constructed with varying designs and capacities. The most common physical measures such as Stone Bunds, Soil bunds (Contour bunds), Check dams are applied to prevent severe erosion. The vegetative measures like hedgerows will also be utilized for retaining water and preventing erosion.

The technology complies with the major programs in watershed management, integrated plan for 30 years 2001-2031 of Dry Zone Greening Department, MONREC.

Benefits:

It will promote soil and water conservation which will help revitalizes degraded land, protect infrastructure from sediment damage; and appropriately manage water at the field and watershed levels. Particular benefit was emphasized to evolving patterns of groundwater use for agriculture, in the light of its increasing importance and concerns about sustainable use of the resource.

Country specific applicability and potential

Although the Dry Zone is the most water-stressed region of the country, it is vital to Myanmar's agriculture sector, the largest areas of sesame, groundnuts and pulses are concentrated in these areas. Due to the mismanagement in development activities for several decades, the high rate of deforestation and land degradation are currently prevalent in the dry zone. Combined with the harsh weather condition and climate change, the farmers' indigenous technologies will no longer

be effectively applied to adapt and cope with these environmental issues. Soil and water conservation measures are too costly to apply for the individual farmer.

Status of technology in country

A considerable number of relevant physical measures were conducted in several Townships of Dry Zone by the UNDP – ICDP (Integrated Community Development Program) project during 2000s. For the rainwater harvesting in dry zone area, the "Water Saving Agricultural Technology (WSAT)" project has recently completed by JICA. Under the project, by storing rainwater into the pits with size of about 0.5 m depth x 1.0m length x 0.4 to 0.5 m width, soil moisture can be improved and also soil erosion can be prevented. The physical measures as well as vegetative measures were applied under the project. The trees, grasses and shrubs were planted in the water catchment areas, which can help to stabilize soils. The trees are planted in the farm boundary and the branches and leaves are applied as mulching for the field crop.

Climate change mitigation/ adaptation benefits

Through the water harvesting technologies, the physical condition of farm lands (such as soil fertility, soil moisture) will be improved. The better soil health can adapt more to the adverse impact of climate change comparing with degraded and poor soils. Conservation agriculture techniques can help soil carbon sequestration which also gives climate change mitigation potential.

Benefits to economic, social and environmental development

The technology will provide a long term sustainable production, which will bring about all economic, social and environmental benefits.

Financial requirements and costs

The technology cost will be high for the physical measures, depending upon the farmers' need; the estimated costs are not available at this moment.

Priority Technology (8)

Renovation and upgrading the existing irrigation schemes for the efficient use of irrigation water

Introduction

Since 1998, the Ministry of Agriculture, Livestock and Irrigation (MOALI) has made huge investments to expand irrigation infrastructure. However, the performance of these irrigation schemes has been suboptimal, and the actual area irrigated is much lower than the planned command area. It is attributed to a mix of issues, such as inadequate budgets, failure in suitable design, limited technical capacity for operating and maintaining facilities, and etc. The major constraint was deterioration of canals, high water loss and very low conveyance capacity. It affected the shortage of irrigation water to the tail portion of the canals. Due to the heavy siltation and sedimentation of canal structures, the flow of irrigation water is severely disturbed. The problems are local slope instabilities and cross drainage problems causing canal blockages and breaches of embankments, sedimentation and erosion. In most irrigation systems, tertiary and on farm irrigation and drainage infrastructure is not yet developed. These facts adversely affect farm productivity so that the crop yields in the system are lower than the optimal. The improvement and upgrading of the physical infrastructure and management of these irrigation and drainage systems are of critical importance for enhancing crop productivity.

Technology characteristics

The technology intended to support modification, rehabilitation and modernization of existing irrigation systems in the selected areas. It includes renovation and upgrading the existing irrigation schemes for the efficient use of irrigation. The natural drainage will be repaired and

upgraded. The “natural flooded drains or natural drainage channel (locally known as “Yoe”)” are reliable sources for farmers to irrigate their fields. In most irrigated areas, farmers built embankment of natural drains or creeks which usually known as “village embankment and village irrigation (VEVI) with their own effort. Farmers collectively repair and maintain every year. Because they were not systematic structures and easily damaged by heavy rains. Some cases are beyond their capacity to repair several times a year. If these natural drainage / “Yoe” are systematically repaired and upgraded, the irrigated areas can be extended and he flood‘s severity of low land areas will also be reduced.

Country specific applicability and potential

The institutional management system in relation to operation and maintenance of the irrigation facilities and drainage structures is supervised by the Agricultural Coordinating Committee (ACC) at township level. The committee is chaired by the Head of the General Administration Department (GAD), includes the staff of DOA and IWUMD.

Seasonal maintenance works of canal system such as desilting, re-sectioning and maintenance of infrastructures are the keys for the canals to function well. The institutional set up particularly for the efficient operation and maintenance of irrigation and drainage facilities needs to scale up and upgraded. For the effective irrigation system, the formation of “water courses” should be implemented in all farm lands, in line with the regulation set by IWUMD. It also needs to provide on-farm water management development training for farmers’ water user associations.

The timeframe for the project implementation: medium to long term

Status of technology in country

The majority of irrigation schemes in Myanmar are gravity-fed canal systems that draw water from storage dams, reservoirs or weirs, which are designed mainly for irrigating paddy fields. The repairing and improving the system is a high priority of the farmers who have access to formal irrigation infrastructure. The improved irrigation water service delivery system and stable water supply through well designed watercourses and canal structures will be an entry point for the rural community development. However, there is weak organizational capacity of water user groups (WUGs). The stronger and closer coordination is required among participating agencies in water resource management. The WUGs and farmer association would complement the concerted effort to strengthen institutional capacities in the rehabilitation and improvement of irrigation operation and management. The IWUMD is currently implementing several projects on rehabilitation and upgrading canals with the collaboration of international funding agencies, such as WB, JICA, and ADB. However, it does not cover all the necessary areas. There still exists a significant scope for improving irrigation efficiency and crop water productivity.

National Water Policy (NWRC, 2014) stated that water users have right to manage water delivery through their water courses. Community participation has an important role in the management of water resources. In order to support efficient and effective use of irrigation water, more water-user groups should be formed. Awareness and education measures for water users regarding community self-management systems should also be strengthened.

Climate change mitigation/adaptation benefits

The rehabilitation of canal systems of an irrigation scheme will create the effective water distribution and a good water access to all farmers under the irrigated area. Due to the proper water flow of the canal network, floods will be reduced in low land areas during the rainy season, contributing resilience to climate change.

Benefits to economic / social and environmental development

Economic benefit:

The direct outcome of this technology will increase in yield, cropping intensity and rural income. It will provide the landless farmers, casual laborers and women with positive impacts such as better job opportunities, health and social welfare.

Social benefit:

It would contribute to the socio-economic well-being of farmers and rural people and further development of the national economy in Myanmar. The fair and stable irrigation system will mitigate the conflicting water use and avoid social conflicts among the farmers of upstream and downstream areas. Along with the better crop yield and better income, women status will be improved; more participation in education access, social activities not only at household level but also in community level.

Financial Requirements and Costs

The estimated budget for renovation of drainage of one irrigation scheme: about US$ 10,000.

Priority Technology (9)

Improvement in rooftop rainwater harvesting for adaptive delta management in Myanmar

Introduction

In the delta region which covers large parts of Ayeyarwaddy, Yangon and Bago Regions of the country, the villages are generally situated nearby small rivers and streams. Since water quality is poor with high turbidity, the communities use only for bathing and washing. They traditionally collect rainwater through rooftops and keep them in large jars for storage. It can sustain for 2 -3 months of summer time. In the delta region the amount of rainfall is sufficient for the rooftop harvesting. However, improvements for rain water harvesting are necessary for the poor people. Most household collect the rainfall in vessels at the edge of the roof or channeled to a storage tank or a vessel via gutters and pipes. Roofs are constructed with a range of materials, such as corrugated iron, aluminum cement sheets, and tiles and slates. Roofs of many poor households are thatch or palm leafed roofs which are difficult to clean and can taint the runoff water. The technology is an approach for multiple use water resources; a participatory approach to water that improves livelihoods and health. It also protects the environment, increases sustainability, and ultimately improves people's lives. By addressing people's multiple water needs, it will maximize the impact over the long term.

Technology characteristics

The technology will include

- Infrastructure improvement of existing rooftops of poor community (use of corrugated iron sheets)
- Rooftop rainwater harvesting through "Recharge Pit" will be constructed at the potential areas such as schools, health centers, monasteries, community halls and etc.
- Provision of household rain water jars, rainwater tanks to the poor communities as well as for schools and health centers
- Water testing kits and capacity development on water quality monitoring and water and sanitation safety planning will be provided to all the project target communes to ensure safe drinking water within the national drinking water standards.

Public consultations will be held with the local authorities and communities to assess of the current water supply in target villages and to identify the needs, priorities, potential options and solutions and discuss water supply improvements proposed by the local authorities and villagers.

Trainings on the "Recharge Pit" technology and use of water test kits and safety planning will be provided to all the project target communities.

Village Water Committees will be formed for the guidance and for collection of information on existing water supply systems. The guidelines will include preparing community members in the development, construction, operation and maintenance of water supply services and etc. It will also set up the procedure and criteria for community contribution. The awareness programs including encouraging people to use the clean water, hand washing and drinking safe water, and improved latrines in all the target villages. It will support adaptive delta management for resilience to climate change by improving health, gender, and living conditions, and reducing vulnerability of the targeting poorest and vulnerable households.

Country specific applicability and potential

The overall objective of the proposed project aligns with the Government's National Strategy for Rural Water Supply, Sanitation and Hygiene (WASH) WASH in schools and WASH in health facilities 2016 – 2030. The project design also goes well with the SDG- 6 "Ensure availability and sustainable management of water and sanitation for all" and the related targets and indicators. The project will improve the health and quality of life for tens of thousands people through improved access to safe water supply, elimination of open defecation and equitable and sustained access to improved sanitation and hygiene practices.

Status of technology in country

The rooftop rainwater harvesting is a traditional technology of the community of delta area. Around the year 2000 the UNDP- ICDP projects provided the rural villages of Ayeyarwady delta with small water storage tanks at household level and large storage tank for community level. Other improvement measures were not provided by any government agencies, local NGOs or INGOs. Construction of "Recharge Pit" is also a new technology for the country.

Climate change adaptation benefits:

With the better facilities of rooftop for rain water harvesting and storage, the drinking water use will last longer than before. The "Recharge Pit" will help more water collection in the tube wells of communal use and higher ground water level. It will help the community more resilience to drought during the dry season. With the access of sufficient safe and clean drinking water, the healthy people can adapt more to the climate change related health problems. The impacts of natural hazards will be mitigated through integration of adaptation and risk reduction for WASH services.

Benefits to economic, social and environmental development

Economic benefit:

It will conserve more rain water and also provide more water at the time of drought. In addition, the high valued crops of vegetables can be cultivated, which can increase the income.

Social benefit:

Health benefit: Rural water supply infrastructure and clean drinking water improved and expanded as a project outcome. Individual household will have sufficient drinking water, especially during the summer months; Improve sanitation and drinking water quality; reduced the water borne disease and better health condition. By reduce the drudgery time of women and children to fetch the water away from home; they will have more time for education, social and economic activities. Due to the better domestic and drinking water supply, the household members will enjoy healthy life.

Environmental benefit:

Rain rainwater harvesting through roof tops has a potential for alleviating storm-water runoff and reducing groundwater extraction. It will conserve more rain water and also provide supplementary irrigation water at the time of drought. It protect soil erosion and increasing its fertility; conserving soil and water, natural properties of land. The "Recharge Pit" prevents village wells and tube wells from drying up, and better ground water recharging.

Gender participation:

More water availability condition in the village promotes the women's roles in daily life. They can do more jobs related with water availability. It will also identify suitable actions for gender inclusiveness in water resources and sanitation management, decision making for the behavioral change. Effective gender mainstreaming will be focused in the water management for sustainable livelihoods. The WASH services are generally responsive to gender-specific needs and capacities, while creating spaces for meaningful participation of women and men as rights holders.

Financial requirements and costs

The project will target 3 Townships of which will cover at least 10 villages in each Township (30 villages in total) and aims to achieve 100% access to safe and sustainable water supply in all the target villages.

- Capital, operating costs – the estimated cost for a project village: USD 3000
- Total cost for 90 villages: USD 90,000
- Maintenance cost will be borne by the Village Water Committee (VWC), shared by stakeholders.

Annex II. List of stakeholders involved in Scoping Mission Workshop on 27 September 2018

Government Sector				
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1.	U Hla Maung Thein	Director General	Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation	hlamaungthein.env@gmail.com
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36.	Dr. Nyo Mar Htwe	Deputy Director	Yezin Agricultural University, Ministry of Agriculture, Livestock and Irrigation	
INGO				
37.	U Kyaw Moe Aung	Project Coordinator	SNC Project	kyawmoeaung@nationalcommunication.org
Private Sector				
38.	Daw Ei Ei Kyaw	Staff officer	Thilawa Special Economic Zone, Management Committee	eieikyaw.chemical@ gmail.com

Annex III. List of stakeholders at Inception Workshop held at ECD office, MONREC, Nay Pyi Taw on 2nd July, 2019

TNA Sectoral Working Group for Climate Change Adaptation

(a) Agriculture Sector

Sr.	Name	Designation, Organization	Mobile No. and Email Address	Topics Discussed
1	Dr. Aung Kyaw Thu	Research Officer , Department of Agriculture Research, MOALI	Tel: 067-3416531, 3416534 Email:aungkyawthu.dar@gmail.com	Organic farming technology
2	Dr. Tin Tin Hla	Professor, Department of Bio-Technology, Mandalay Technological University (MTU),	Tel: 0257360 Email: myomyintbiot@gmail. com	Conservation Agriculture (CA) technology
3	Daw Myint Myint Aye	Deputy- Director, Department of Agriculture, MOALI	Mobile: 09-420700440, Email: mmayeysg@gmail.com	Climate Smart Agriculture Villages (CSV), Salinity tolerance rice varieties
4	U Saw Khu Se	Research Officer, Department of Research and Innovation, Ministry of Education (MOE)	Mobile: 09263635822 01-665292, Email: sawkhusay@gmail.com	Biochar technologies
5	Dr. Win Min Oo	Deputy Director, Department of Rural Development, MOALI	Tel: 067418655 Email: winminoomyanmar@ gmail.com	Dry mulch and living mulch for sustainable upland crop production
6	Dr. Khin Myat new	Deputy Director, Livestock Breeding and Veterinary Department, MOALI	Mobile: 09-250187894, Email: kmnwe2006@gmail.com	Salinity tolerance rice varieties
7	U Myo Than Tun	Lecturer, Yezin Agricultural University, MOALI	Tel: 067-3416514, 067-3416513 Email: nanghsenghom @ gmail.com	Paddy dryers

8	Daw Thi Thi Soe Min	Assistant Director, Environmental Conservation Department (ECD), MONREC	Mobile: 09401560983 Email: thithi.malun @gmail.com	Weather index-based crop insurance
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10	U Aung Myo Win	Staff officer, Dry Zone Greening Department, MONREC	Tel: 02-57032 Email: dgdzgdmonrec@gmail.com	Conservation Agriculture (CA) technology
11	U Myo Aung	Staff officer, Dry Zone Greening Department, MONREC	zmoeaung08@gmail . com	Climate Smart Agriculture Villages (CSV)
12	U Htun Htun Zaw	Program Officer, Myanmar Environmental Rehabilitation-Conservation Network (MERN)	Mobile: 09975255705, Email: tunzayarzaw 009 @gmail.com	Dry mulch and living mulch for sustainable upland crop production
13	U Kyaw Thet Naing	Project Manager, Forest Resources Environment, Conservation and Development Association (FREDA), Yangon	Mobile: 09961222289; Email: kyawthetnaing.2014forestry@gmail.com	Salinity tolerance rice varieties
14	Daw Theiant Theiant Aung	Executive member, Ecosystem Conservation and Community Development Initiative (ECCDI), Yangon	Mobile: 095181293 Email: theiantaung09 @gmail.com;	Paddy dryers; Salinity tolerance rice varieties

(b) Water Resource Management Sector

No.	**Name**	**Designation, Organization**	**Mobile No. and Email address**	**Topics discussed**
1	Daw Saw Sandar Win	Assistant Director, Directorate of Water Resources and Improvement of River System, Ministry of Communication and Transport (MCT)	Mobile: 09-794086976; Email: sawsandarwin @gmail.com	Low-pressure and Solar Powered Drip Irrigation
2	Dr. Kyu Kyu Sein	Assistant Director, Department of Meteorology and Hydrology, MCT	Mobile:09-250954661; Email: sein.dmhmdy @gmail. com	Alternative Wetting and Drying (AWD) Irrigation

3	U Zaw Win Naing	Assistant Director, Inland Water Transport, MCIT	Mobile: 09450025681, Email: scertificate @dma.gov. mm	Hydroponic Vegetable Production
4	Dr. Myint Than Soe	Assistant Director, Department of Fishery, MOALI	Tel: 067 418534 Email: myintthansoe96 @gmail.com	Renovation and Upgrading the existing irrigation schemes
5	U Hein Latt	Assistant Director, Environmental Conservation Department, MONREC	Email: nyilatt48@gmail.com	Improvement of Rainwater Harvesting
6	U Htin Lin Khant	Division Head, Engineer Section (Water and Sanitation), YCDC	Mobile: 09-5018557 Email: htinlinkha01 @gmail. com	Soil and Water Conservation Technology
7	U Khin Maung Thin	Assistant Director, Engineer Section (Water and Sanitation), MCDC	Mobile:09-91004768, 0933032418 Email: khinmaungthin @gmail.com	Improvement of Rainwater Harvesting;
8	Daw Kyi Kyi Myint	Assistant Manager, Myanmar Port Authority, Ministry of Transport and Communication (MCIT)	Tel: 067 379141, 067 246375 Email:mpa@mptmail. net.mm	Renovation and Upgrading the existing irrigation schemes
9	Daw Su Su Lwin	Staff officer, Environmental Conservation Department, MONREC	Mobile: 09401579883 Email: susulwin.ecd@gmail.com	Soil and Water Conservation Technology
10	U Aung Myat Lin	Staff officer, Irrigation and Water Utilization Department, MOALI	Mobile: 09976593100 Email: hydrooml@gmail.com	Renovation and Upgrading the existing irrigation schemes
11	U Sithu Aung	Staff officer, Forest Department, MONREC	Tel: 067 405079 Email: sithuaungforestry@gmail.com	Soil and Water Conservation Technology
12	Daw Nanda Nwe	Environmental Researcher and NWRC Secretariat Support Officer, Hydro-Informatics Center, Yangon	Email: nadarnwe@gmail.com	Soil and Water Conservation Technology
13	U Salai Thura Zaw	Program Officer , Fresh Water Resources Program Department, WWF	Mobile: 0951229331, Email: www.wwf.org.mm	Improvement of Rainwater Harvesting

14	Daw Khin Saw Mu	Chairman, Community Driven Delopment and Capacity Enhancement Team (CDDCET)	Mobile: 09401523962 Email: khinsawmumu@gmail.com	Improvement of Rainwater Harvesting;
15	Dr. Yar Zar Hein	Member, Climate Smart Agriculture Center	Mobile: 0943188246 Email: yarzarhein@yau.edu.mm	Alternative Wetting and Drying (AWD) Irrigation; Hydroponic Vegetable Production
16	U Ye Thu Aung	Junior Researcher@Hydro-Informatics Centre Component(1), AIRBM Project	Mobile: 09 977003351 Email: yta.hic.researcher@gmail.com	Improvement of Rainwater Harvesting; Soil and Water Conservation Technology

Annex IV The composition of the National TNA Project Steering Committee

No	Name	Designation / Department	Responsibility
(1)	U Hla Maung Thein	Director General, Environmental Conservation Department, MONREC	Chairman
(2)	U Than Zaw	Deputy Director General, Central Statistical Organization Ministry of Planning Finance and Industry	Co-Chair
(3)	Daw Thu Zar Myint	Director, Department of Agriculture (DOA) / MOALI	Member
(4)	Daw May Khin Chaw	Director, Department of Meteorology and Hydrology (DMH) / Ministry of Transport & Communications (MOTC)	Member
(5)	Dr. Thaung Naing Oo	Director, Forest Department,MONREC	Member
(6)	U Ohn Lwin	Director, Department of Mines, MONREC	Member
(7)	U Zaw Win (9)	Director, Dry Zone Greening Department (DZGD), MONREC	Member
(8)	Daw Khin Khin Aye	Director, Kerosine & Natural Gas Administration Department, Ministry of Electricity & Energy	Member
(9)	U Myat Zaw	Director, Department of Industry Cooperation, Ministry of Planning, Finance and Industry	Member
(10)	U Thaung Oo	Director, Industrial Supervision & Inspection Department Ministry of Planning, Finance and Industry	Member
(11)	Daw Win Min Phyo	Director, Trading Department, Ministry of Commerce	Member
(12)	Dr. Aung Moe	Director, Department of Research and Innovation, Ministry of Education	Member
(13)	U Hla Myo	Director, Cleaning Department, Mandalay City Development Committee	Member
(14)	Dr. Myat Taw Htet	Dupty Director (Engineer), Nay Pyi Taw Development Committee	Member
(15)	Dr. Win Win Mar	Assistant Director, Thi Lawa Special Economic Zone (SEZ) Management Committee	Member
(16)	Dr. Moe Moe	Section Head, Environmental Conservation & Cleaning Department , Yangon City Development Committee	Member
(17)	U Pyae Phyo Aung	Energy Officer, World Wide Fund for Nature (WWF)	Member
(18)	U Htun Htun Zaw	Program Officer, Myanmar Environment Rehabilitation Conservation Network (MERN)	Member
(19)	Dr. San Oo	Deputy Director General, MONREC	Secretary

Annex V Participant lists of TNA Working Group meeting for Climate Change Adaptation

(a) Agriculture Sector (10-9-2019 Morning session)

Sr.	Name	Designation, Organization	Mobile No. and Email address
1	U Zaw Nyunt Oo	Assistant Director, Department of Rural Development (DRD)	09-256252285, drdusp@gmail.com
2	U Saw Ku Sal	Assistant Director DRI, Ministry of Education	09-265635822, Sawkhusay@gmail.com
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4	U Moe Aung	Staff Officer, Dry Zone greening Department (DZGD)	0673405387, moeaung@gmail.com
5	Daw Khin San Ngwe	Assistant Director, Department of Planning, Ministry of Planning, Finance and Industry	067410111, khinsannwe86@gmail.com
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(b) Water Resource Management Sector (10-9-2019 Afternoon session)

No.	Name	Designation, Organization	Mobile No. and Email address
1	U Si Thu Aung	Staff Officer, Forest Department	09-5331145, sithuaungforestry@gmail.com
2	Dr. Myint Than Soe	Assistant Director ,Department of Fishery	09-253804084 myintthansoe96@gmail.com

3	U Ye Phyoe Aung	Staff Officer, Irrigation and Water Utilization Management Department (IWUMD)	09-776580468, Yephyoeaung.hydro@gmail.com
4	U Kyaw Naing Oo	Deputy Director, DWIR	09-776038332, knaing001977@gmail.com
5	Dr Kyu Kyu Sein	Assistant Director, DMH	09-250954661, sein.dmh.mdy@gmail.com
6	Daw Thin Thuzar Win	Deputy Director, ECD	thinthuzar1981@gmail.com
7	Daw Zin Mar Phyu	Staff Officer, ECD	09-250969549, zinmarphyu123@gmail.com
8	Daw Kyi Kyi Win	Deputy Staff Officer, ECD	Kyikyiwin.ecd@gmail.com

Annex VI Participant lists of TNA Bilateral meetings for Climate Change Adaptation "Agriculture Sector and Water Resource Management Sector"

Yezin Agricultural University (YAU), Yezin, Nay Pyi Taw (Agricultural Sector) (20-9-2019)			
No.	**Name**	**Designation, Organization**	**Mobile No. and Email address**
1	Dr.Nang Hseng Hom	Rector, YAU	09 444688810, dr.nanghsenghom@yau.edu.mm
2	Dr.Tin Tin Aye	Professor, International Relations	09 33377115, dr.tintinaye@yau.edu.mm
3	Dr.Yar Zar Hein	Lecturer, Department of Agricultural Economics	09 43188286 yarzarhein2007@gmail.com
Department of Agricultural Research, Yezin, Nay Pyi Taw (Agricultural Sector) (20-9-2019)			
1	Dr. Naing Kyi Win	Director General, DAR	dgdar.moai@gmail.com
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3	Dr. Aung Kyaw Thyu	Research Officer, DAR	09 420700614, aungkyawthu.dar@gmail.com
4	Dr.Thida	Senior Research Assistant, *DAR*	thida.biotech@gmail.com
5	Dr. Sandar Moe	Senior Research Assistant, DAR	sandarmoe@gmail.com
Department of Agriculture, Yezin, Nay Pyi Taw (Agricultural Sector) (20-9-2019)			
1	Daw Htay Htay Yi	Assistant Director	DOA
2	U Tin Naing Oo	Assistant Director	DOA
3	Daw San San Aye	Staff Officer	DOA
4	Daw Aye Aye Khaing	Staff Officer	DOA
5	Daw Su Mon Htet	Deputy Staff Officer	DOA
Irrigation and Water Utilization and Management Department (Water Resource Management Sector) (20-9-2019), Nay Pyi Taw			
1	Dr. Zaw Lwin Tun	Deputy Director General	IWUMD
2	U Kyi Wai	Director	IWUMD
Department of Rural Department (DRD) (Water Resource Management Sector) (25-9-2019)			
1	U Hla Khaing	Director,	DRD
2	U Zaw Nyunt Oo	Assistant Director,	DRD
3	Daw Khaing Su Han	Assistant Director,	DRD

Annex VII. Scoring Options of Agriculture Sector

Technology	Costs		Benefits						Others
			Economic	Social			Environmental		Climate related
	Capital	O & M cost	Income	Health	Job creation	Gender Participation/ equity	Less pollution/ less GHG	Ecosystem Protection	Resilience to CC
(1) CSA villages	95	60	43	3	3	3	4	4	5
(2) Conservation Agriculture	80	55	68	4	4	4	5	5	5
(3) Salinity tolerance rice	60	40	70	3	3	3	3	3	4
(4)Paddy dryers	80	48	42	2	2	2	2	2	3
(5) Solar dryer for cash crops	80	45	46	4	4	3	4	3	4
(6) Submergence tolerance rice	75	45	63	2	2	2	2	3	4
(7) Weather index crop insurance	90	38	38	2	2	2	2	2	4
(8) Solar drip irrigation	70	38	84	5	4	4	5	5	5
(9) Hydroponic	85	47	62	4	3	3	4	4	4
(10) SWC in hilly regions	95	35	65	3	3	3	3	4	3

Annex VIII. Normalized scores (Option 2 result) of Agriculture Sector

Technology	Costs		Benefits						Others	Total score
			Economic	Social			Environmen-tal		Climate related	
	Capital	Operation & Maintenance	Income	Health	Job Creation	Enhanced Gender Participation	Less pollution/ less GHG	Ecosystem protection	Resilience to CC	
(1) CSA villages	0	0	2.17	3.33	7.5	2.5	5.33	6.67	12	39.51
(2) Conservation Agri	5.14	1.6	13.04	6.67	15	5	8	10	12	76.45
(3) Salinity tolerance rice	12	6.4	13.91	3.33	7.5	2.5	2.67	3.33	6	57.65
(4)Paddy dryers	5.14	3.84	1.74	0	0	0	0	0	0	10.72
(5) Solar dryer for cash crops	5.14	4.8	3.48	6.67	15	2.5	5.33	3.33	6	52.25
(6) Submergence tolerance rice	6.86	4.8	10.87	0	0	0	0	3.33	6	31.86
(7) Weather index crop insurance	1.71	7.04	0	0	0	0	0	0	6	14.75
(8) Solar drip irrigation	8.57	7.04	20	10	15	5	8	10	12	95.61
(9) Hydroponic	3.43	4.16	10.44	6.67	7.5	2.5	5.33	6.67	6	52.69
(10) SWC in hilly regions	0	8	11.74	3.33	7.5	2.5	2.67	6.67	0	42.41

Annex IX. Scoring Options of Water Resource Management Sector

Technology	Costs		Economic	Social			Environmental		Climate
	Capital	O & M cost	Income	Health	Job creation	Gender	Water Saving/ GHG Reduction	Ecosystem protection/ Erosion	Resilience to climate change
(1) Renovation village ponds & tube wells	75	35	80	5	5	4	5	4	5
(2) Rooftop rainwater harvesting	58	40	45	4	2	3	3	3	4
(3) Desalination in coastal areas	60	70	50	4	3	3	3	2	4
(4) Water purifying technology	60	40	58	5	3	4	3	3	4
(5) Solar powered water pump	80	40	56	3	3	3	3	3	4
(6) Water supply with gravity flow	90	55	50	3	3	3	4	3	3
(7) Rainwater collection from ground surfaces	93	70	75	2	3	4	4	4	4
(8) Renovating irrigation schemes	95	80	80	3	4	3	4	4	4
(9) WRM for Disaster Management	83	60	90	4	5	4	5	4	5

Annex X. Normalized score (Option 2 result) of Water Resource Management Sector

Technology	Costs		Benefits						Others	Total score
			Economic	Social			Envirnmental		Climate related	
	Capital	O & M cost	Income	Health	Job Creation	Enhanced Gender Participation	Reduced Chemical use	Ecosystem protection	Resilience to CC	
(1) Renovation village ponds & tube wells	8.11	8	21	10	8	5	10	7	10	87.11
(2) Rooftop rainwater harvesting	15	7.11	0	6.67	0	0	0	3.5	5	37.28
(3) Desalination in coastal areas	14.19	1.78	3	6.67	2.67	0	0	0	5	33.30
(4) Water purifying technology	14.19	7.11	7.8	10	2.67	5	0	3.5	5	55.27
(5) Solar powered water pump	6.08	7.11	6.6	3.33	2.67	0	0	3.5	5	34.29
(6) Water supply with gravity flow	2.03	4.44	3	3.33	2.67	0	5	3.5	0	23.97
(7) Rainwater collection from ground surfaces	0.81	1.78	18	0	2.67	5	5	7	5	45.26
(8) Renovating irrigation schemes	0	0	21	3.33	5.33	0	5	7	5	46.67
(9) WRM for Disaster Management	4.87	3.56	27	6.67	8	5	10	7	10	82.09