The Republic of the Union of Myanmar

Barrier Analysis and Enabling Framework Report for Climate Change Adaptation

April 2021

Myanmar Barrier Analysis and Enabling Framework Report – Climate Change Adaptation

Country Coordination:

Environmental Conservation Department, MONREC

Project Coordinator:

U Kyaw San Naing - Director - Environmental Conservation Department, MONREC

National Consultant: Khin Lay Swe

Agriculture Sector Contributors:

Customs Department, Ministry of Planning, Finance & Industry
Department of Agriculture, Ministry of Agriculture, Livestock and Irrigation
Department of Agricultural Research, Ministry of Agriculture, Livestock and Irrigation
Yezin Agricultural University, Ministry of Agriculture, Livestock and Irrigation
Division of Bio Technology, Ministry of Agriculture, Livestock and Irrigation
Forest Department, Ministry of Natural Resources and Environmental Conservation Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation
Department of Trade, Ministry of Commerce
Food and Agriculture Organization of the United Nations
Myanmar Environmental Rehabilitation-Conservation Network
MyanSEED Co.Ltd.
Conservation and Development Association

Water Resource Management Sector Contributors:

Customs Department, Ministry of Planning, Finance & Industry
Irrigation and Water Utilization Management Department, Ministry of Agriculture, Livestock and Irrigation
Department of Rural Development, Ministry of Agriculture, Livestock and Irrigation
Directorate of Water Resources and Improvement of River System, Ministry of Transport and Communications
Dry Zone Greening Department, Ministry of Natural Resources and Environmental Conservation
Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation
Department of Trade, Ministry of Commerce
Department of Meteorology and Hydrology, Ministry of Transport and Communications
Nay Pyi Taw Development Committee
Yangon City Development Committee
Mandalay City Development Committee
Universal Service Reform Project, World Bank
World Wide Fund for Nature
Ecosystem Conservation and Community Development Initiative
Mercycorps, Myanmar

DISCLAIMER

FOREWORD

The adoption of climate technologies is key to reducing greenhouse gas emission while improving the competitiveness of major economic and industrial sectors, and thereby promoting low-carbon and green growth in Myanmar.

Recognizing these circumstances, the Republic of the Union of Myanmar has implemented the third phase of the "Technology Needs Assessment (TNA)" project whose objective is to promote investments in technology transfer and to improve access to environmentally sound technologies (EST) that are relevant for achievement of Myanmar's climate change adaptation and mitigation targets. Myanmar developed a national NDC in 2015 to confirm its commitment to climate change mitigation especially in the forestry and energy sector, and to adapt to the devastating effects of climate change in agriculture, forestry, water, infrastructure, and so forth.

This "Barrier Analysis and Enabling Framework Report" was coordinated by the Ministry of Natural Resources and Environmental Conservation (MONREC) through the Climate Change Division of Environmental Conservation Department (ECD), with the help of national consultants and local experts. MONREC acknowledges that the TNA project is funded by the Global Environmental Facility (GEF). The project is implemented by the United Nations Environment Programme (UNEP) through the UNEP DTU Partnership (UDP) with technical support from the Asian Institute of Technology (AIT) for the Asian Countries.

This analysis utilized a standardized methodology, in which ECD facilitated stakeholders' consultation meetings, and the consultant conducted a series of bilateral meetings, field visits, and user interviews to identify barriers hindering development and adoption of the technologies' market supply-chain, and proposing enabling frameworks necessary to overcome identified barriers. Therefore, all of the identified barriers were identified from a bottom-up approach to reflect the situation of technologies as prioritized by key stakeholders within Myanmar. I am honored to provide a foreword to the second report of the TNA Project.

I am happy to present this report to a wide range of stakeholders such as decision-makers, policymakers, potential investors, technology developers, scientists and researchers. I have high confidence that this report can be one of the solutions to achieving the government's commitment towards addressing the climate change-related issues, and to improve our county economic, environmental and social development goals by eliminating identify barriers. Additionally, this report is an alarm for us to take necessary steps to streamline policies, legislation, etc. to help transfer and diffusion of technologies prioritized.

Union Minister
Ministry of Natural Resources and Environmental Conservation
The Government of the Republic of the Union of Myanmar

ACKNOWLEDGEMENT

In the report on Barrier Analysis and Enabling Framework for Climate Change Adaptation, for priority climate change technologies under the TNA Project in Myanmar was developed in consultation with various national experts and personnel from relevant ministries, sectors, institutions, and factories.

The outcomes of the TNA Project will contribute to the achievement of the country sustainable development goals, as well as efforts 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". On this occasion, the Environmental Conservation Department would like to thank the Ministry of Natural Resources and Environmental Conservation for facilitating the administrative and legal procedures of the report and project development.

We hereby would like to express the sincerest gratitude to His Excellency Union Minister of MONREC, for his strong encouragement and leadership, as well as his continuous and precious suggestions and guidance in the whole period of the project's process.

Our heartfelt gratitude goes to GEF, which financed the project, and to UNEP and the UNEP DTU Partnership which implement the project in collaboration with AIT for their support, valuable comments, and helpful technical inputs for the project.

We extend our special thanks to various experts, stakeholders, and farmers for sharing their precious time for bilateral meetings and field visits to identify barriers in ground situations. Also, we acknowledge the important guidance made by the members of the National TNA Project Steering Committee of the Myanmar TNA Project.

Finally, we would like to thank the active participation of all national stakeholders of technical working groups which make the project success.

Last but not least, I would like to express my sincere appreciation to the national consultant, the national TNA team, and the staff of the Climate Change Division for their continuous efforts to develop the Barrier Analysis and Enabling Framework Report.

Director General
Environmental Conservation Department
Ministry of Natural Resources and Environmental Conservation

EXECUTIVE SUMMARY

Technology Needs Assessment (TNA) is a country-driven participatory process aiming to identify and prioritize environmentally sound technologies in agriculture and water resource management sectors for the climate change adaptation in Myanmar. Following the TNA Report I of technology prioritization, this Report II is the output of the second phase of the TNA process which covers barrier analysis on transfer, and diffusion of the prioritized technologies and enabling framework and measures for overcoming the barriers. The BA process consists of 1) setting up preliminary targets for technology transfer and diffusion of each technology option, 2) identifying key barriers, 3) investigating possible solutions to address the barriers for the transfer and diffusion of technology. These steps were conducted through expert opinions, literature review and brainstorming sessions with key stakeholders; development of barrier analysis tools including problem tree, objective tree and market mapping tool and etc. The Barrier Analysis and Enabling Framework (BA&EF) report reflects about eight months of discussions and consultations which include national workshops, small group meetings and brainstorming of Zoom workshop and individual field survey interviews with user -farmers. The Stakeholders includes representatives of related ministries, government agencies, academic institutions, private sector and non-governmental organizations. This whole process of technology barrier identification was also drawn from the literature review, meetings with stakeholders (farmers and input suppliers) and technology experts. The methodology also followed the TNA barrier analyses guidelines (Boldt et al., 2012), information and templates provided by the experts of UNEP-DTU Partnership during and after regional capacity training workshops. The technology barrier analysis process categorized the key economic and financial barriers and non-financial barriers. The latter was further divided into several sub-barrier categories including policy, legal and regulatory, institutional and organizational capacity, technical, information and awareness, and social, cultural and behavioral.

Technology barriers and measures in agriculture sector

In achieving diffusion of the three prioritized technologies in agriculture sector of the TNA process, a number of barriers were identified and then prioritized through a series of the consultation processes with stakeholders, TNA Adaptation Working Group, and technology experts. For the wide spread of "solar powered drip irrigation technology" adoption, high initial cost of installation and maintenance was described as the key financial barrier. Other barriers identified were – underdeveloped market for technology importers and suppliers and the limited numbers of trained technicians locally available for the design and installation of the technology. For the conservation agriculture (CA) technology, economic cost of conservation practices and social constraints for small land holders since the technology needs a long-term development. Other key barriers are: inadequacy and poor enforcement of land use policies, laws and regulations encouraging the CA practices, limited machineries, tools and facilities suitable for CA technology. Inadequate numbers of agriculture extension staffs and of poor knowledge on land management techniques of rural communities are also major constraints. Similarly, the key barriers for salinity tolerance rice varieties technology were recognized as inadequate research and development facilities and technicians, insufficient financial resources and market barriers to the adoption of improved rice seeds by farmers. After identifying and prioritizing the barriers, the enabling measures were suggested to address these barriers. All stakeholders agreed that access to appropriate subsidy, grants, or soft loans to the farmers and financial resources for research and training of scientists and field extension workers can provide an enabling framework for these technology adoptions. It was observed that enabling measures are more

technology specific at a detailed level for each technology but the identified key barriers are more or less common to all three selected technologies. These enabling measures are summarized as follows- i) Set up financing mechanisms for these specific technologies, ii) Increase support to public and private research and development, iii) Formation and enforcement of relevant laws and regulations, and iv) Provide trainings for awareness to user-farmers and extension workers for the effective diffusion of the technologies.

Technology barriers and measures in water resource management sector

Under the second phase of TNA process, the key barriers of the three water related adaptation technologies prioritized in the first phase were identified and prioritized through the brainstorming consultative meetings of TNA working group, experts and the stakeholders.
The identified key barriers for the technology on "Renovation of village ponds and tube wells" are: high capital cost, inadequate allocation of national budgets, high interest rates of loans for importers and producers. Limited institutional structure and their skills, poor hydrology and research and development are other key barriers. For the flood disaster risk management technology, the key barriers were identified as "high capital cost (large investment and maintenance costs to adapt to climate change such as sea level rise) and weak in institution and related technology. The "Hazard and risk assessment" is a limited issue to identify areas at risk of flooding, and consequently to improve flood risk management and disaster preparedness. Similarly, key barriers identified for drinking water purifying technology are - large investment to cover the whole community, inefficient enforcement of national drinking water policy, weak institutional and organizational capacity and inadequate information and awareness. The limited understanding on the drinking water quality, poor accessibility and remoteness are also key barriers of the technology diffusion in remote rural villages.

To address these barriers, an enabling framework is proposed to overcome these barriers. The details of the key barriers and their enabling framework are described in the report. Most of these key barriers identified are similar and common to all technologies and they are grouped as common barriers. Enabling measures for these key barriers are described as follows – (i) Explore additional funds from donor agencies, private and public investors, (ii) Promotion of research and development for low cost technologies, (iii) Strengthen institutional capacities, (iv) Prepare and develop the policy and guidelines for good water management practices for surface water and groundwater, rural water supply and (v) Improve operation and maintenance practices of existing infrastructures, such as village ponds, tube wells, embankments, flood protection structures, water purifying plants and etc.

Table of Contents

BA	Barrier Analysis
CA	Conservation 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
ECD	Environmental Conservation Department
FGD	Focus Group Discussion
GAP	Good Agricultural Practices
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHGs	Greenhouse Gases
GORUM	Government of the Republic of the Union of Myanmar
IDE	International Development Enterprises
IFAD	International Fund for Agricultural Development
INDC	Intended Nationally Determined Contribution
INGO	International Non –Governmental Organization
IRRI	International Rice Research Institute
IWRM	Integrated Water Resource Management
IWUMD	Irrigation and Water Utilization Management Department
KII	Key Informant Interview
LIFT	Livelihood and Food Security Fund
MADB	Myanmar Agriculture Development Bank
MCSAS	Myanmar Climate Smart Agricultural Strategy
MNPED	Ministry of National Planning and Economic Development
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOE	Ministry of Education
MOHS	Ministry of Health and Sports

MONREC	Ministry of Natural Resources and Environmental Conservation
MOSWRR	Ministry of Social Welfare, Relief and Resettlement
MRSDS	Myanmar Rice Sector Development Strategy
NAPA	National Adaptation Programme of Action
NEP	National Environmental Policy
NGO	Non-governmental organization
STR	Salinity Tolerance Rice
TNA	Technology Needs Assessment
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WUG	Water User Group
WUA	Water User Association
YAU	Yezin Agricultural University

CHAPTER 1: AGRICULTURE SECTOR

Agriculture sector is a high priority for the Government of the Republic of the Union of Myanmar (GORUM) since it contributes 30 percent of national GDP and about 68 percent of rural population relies on crop husbandry and livestock for their livelihoods. Since August 2016, the MOALI with the support of Development Partners, (ADB), (FAO), and (LIFT), has prepared the Agriculture Development Strategies (ADS) and Implementation Plans (IP) for the 5-year period 2018-19 to 2022-23. The strategy builds off the recently developed agriculture policy and aims at setting clear priorities in the short, medium, and long term. However, being a developing and agrarian country, its economy and all-round development greatly relies on its annual agricultural production. About 80% of the total cultivated area is under the rain-fed system, highly exposed to the climate change impact. Due to its geographic natural setting, the country often suffered huge impacts of climate change over the last decades, such as floods, drought, storms surges and cyclones, and etc. Damages were the most serious in agriculture and water resource management among the country's socio-economic sectors. With growing concerns about the significant impacts of climate change, the GORUM has adopted the Myanmar Climate Change Strategy and Master Plan **(**MCCSMP, 2018-2030). It identifies priority actions in key development sectors to build the adaptive capacity of communities and sectors and to promote low carbon development. As the goals of MCCSMP, Myanmar will achieve climate resilient development and pursue a low-carbon development pathway by 2030 to support inclusive and sustainable development. Among the sectoral outcomes, it also mentions that the agriculture, fisheries and livestock sectors will adopt climate-resilient and environmentally sound adaptation technologies and climate-smart management practices, supported by international and domestic finance (MONREC, 2017).

Myanmar Rice Sector Development Strategy (MRSDS), 2015 targets the production growth that satisfies both domestic and export requirements. By 2030, production must reach at least 19.40 million metric tons (MT), 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 and characteristics will be produced to meet both domestic and foreign market demand.

The overall impacts of the ADS consist of the five dimensions – (i) increased food and nutrition security; (ii) poverty reduction; (iii) higher and more equitable income of rural households; (iv) competitiveness; and (v) strengthened farmers' rights. The related indicators of the impacts are reported, among others, as follows. Within the target five years, rural poverty reduction for landless rural household income will be increased by 40%; smallholder farmers' income will be improved by 50% and annual investment in Agri-food sector Increase by 40%. Moreover, the ADS has three objectives corresponding to the three strategic pillars of governance, productivity, and competitiveness. The selected targets for each objective of the strategy are presented. For the agricultural growth, during the target five years, the base line of 2% average annual growth will be reached to 4%. The "Increased productivity and farmers' income" was targeted to increase by 50%.

It was reported that, between 2005 and 2017, monetary poverty in Myanmar decreased substantially, yet in 2017, poverty and vulnerability are still an issue. The Poverty Report (CSO, UNDP and WB, 2019) highlights the decline in the poverty rate, which went from 48.2 percent in 2005 to 24.8 percent in 2017. However, one in four people are still considered poor and another 32.9 percent of the population has consumption levels that put them at risk of falling into poverty (CSO, UNDP and WB, 2020).

1.1 Preliminary targets for technology transfer and diffusion

The agriculture policy states - "by 2030, Myanmar achieves inclusive, competitive, food and nutrition secure, climate change resilient, and sustainable agricultural system contributing to the socio-economic well-being of farmers and rural people and further development of the national economy".

The overall goal to develop adaptation technologies in agricultural sector is based on the existing sectoral strategies, plans and national programs, in general. Based on the above general targets, specific targets for "improved water saving technology, use of salt tolerance rice varieties and conservation agriculture for the sustainable crop production" were identified. The preliminary targets for agriculture technologies were described in Table 1.1.

(1) In the context of growing water scarcity due to the unreliable and fluctuated rains, solar powered drip irrigation is a proven technology for improved water use efficiency. It generates year-round production which helps to build resilience in agricultural systems by increasing diversity to withstand climate related shocks. Use of fertigation precision (adding soluble fertilizers in the water source) could match water and fertilizers as needed, avoiding overuse of inputs thereby protecting soil health and environment. Despite these benefits, the current scale of application of this technology is in low demand due to the various constraints and barriers to widely adopt the technology across the country. Accordingly, the TNA project set up the preliminary targets for transfer and diffusion of this technology as follows.

    Criteria for selection of farmers to be small to medium sized farms and able to afford the balance amount after subsidy to purchase the irrigation kits. They should have easy access of water source such as dug well, ponds, streams or tube wells. Additional costs will be needed to provide necessary capacity building activities for local farmers. The project will be phased in five years and after project the beneficiaries' farmers will be 5,000 farmers in the central dry zone of Myanmar (Mandalay, Magway and Sagaing Regions).

(2) Soil degradation and erosion have already taken place to various degrees in the country; particularly the Central dry zone, Chin State, Shan State are facing with the serious environmental problems. It badly affects the agriculture production and remains a critical constraint for sustainable development. There have been some efforts of DOA and Land Use Division of MOALI, however, CA technology has not been widely adopted effectively. Therefore, appropriate corrective and supportive actions need to be undertaken for transfer and diffusion of CA practices. CA aims at sustaining healthy soil and restoring degraded land for ensuring food security, alleviating rural poverty and building resilience of local communities to major environmental challenges. It will focus on restoring such degraded land while preventing further degradation of unaffected land to ensure continued ecosystem services. The preliminary targets for this technology transfer and diffusion are as mentioned below.

    Restoration of fertility status of 2,500 ha of upland rice lands (for 1,000 HH) and 5,000 ha of highlands (*Taung-ya*) (for 2,000 HH) cultivated with other food crops over a period of 7 years will be targeted for CA practices. The interventions will involve improvement of physical, chemical and biological properties of soil for optimum crop production through soil amelioration and adoption of better land and crop management practices (terraces and contour farming). The project will target a total of 3,000 agricultural HHs in Southern and Northern Shan States; each HH will be provided with 50 fruit trees for 1 acre (0.4 ha) of lands for the inclusion of agro-forestry component.

    The capital investment costs include, among others; purchase of new crop seed varieties, on-farm equipment, labor, training costs, and etc. The estimated total cost of a seven -year project is 1,000 USD per HH. Based on the cost sharing model, each HH (of total 3,000 HH) will be supported with 500 USD. This translates to a unit cost of 500 USD per farming household and the cost to cover 3,000 agricultural households will be 1500,000 USD.

(3) Increased salt intrusion has already been a challenging issue to the rice farmers in the delta and coastal areas of Myanmar. Similarly, the inland saline affected areas of dry zone are worse than before due to the warmer climate and more drought years these days. The farmers are using local salt tolerance varieties for many decades which are degraded and low purity,

producing very low yield, but there has been limited research for the improvement of these local varieties. Rice Division of DAR has been conducting the development of stress tolerance rice varieties, such as flood, drought and saline tolerance varieties, as one of their research components. Currently, seven new saline tolerance rice varieties have been released and cultivated in experimental yield trail stage in the salt affected areas. However, with very low national research and extension budgets, the technology development and adoption by farmers is a rudimentary.

Due to brackish water intrusion, more serious in summer season, there are thousands of salt affected rice areas in Wakema, Pyapon and Latbutta Towships of Ayeyarwady delta. The improved salinity tolerance rice varieties released by the DAR will be introduced in these areas over the 5- year time frame. One-thousand HH of each Township will be selected as model farmers and supported for 2 acres of rice production. With the use of a cost sharing model, 200 USD will be provided to each household for 2 ac. of salt affected land. The technology coverage will be 6,000 ac. of salt affected land with 3000 beneficiary HH. (Note: 1ha = 2.471 acre)

Regarding inland salinity areas, Taungthar Township in Magway Region and Wundwin and Kyaukse Townships of Mandalay Region will be selected for the project site due to their seriousness of salinity. From each Township, 2000 farm HH will be provided with the technology covering 2 acres for each HH. The total coverage of salinity rice variety is 4000 acres with the beneficiary HH of 2000. With a cost sharing model, each HH will be provided with 200 USD for 2 acres of rice production. Farmers will save some of their harvest for the next year cultivation.

Table 1.1 Preliminary targets for the climate change adaptation technologies in agriculture sector

Technology	Number of Households	Cost Per Household (USD)	Total Direct Costs (USD)	Project Admin Cost (15%)	Total Cost (USD)
Solar powered drip irrigation	5,000	400	2,000,000	300,000	2,300,000
Conservation agriculture	3,000	500	1,500,000	225,000	1,725,000
Development of salt-tolerance rice varieties	Ayeyarwady Region: 3000	200	600,000	90,000	690,000
	Central dry zone: 2000	200	400,000	60,000	460,000
Total	12,500	-	4,400,000	660,000	5,175,000

1.2 Barrier analysis and possible enabling measures for "Solar powered drip irrigation technology"

1.2.1General description of the technology

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 in 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 at the off-season. It can also produce improved product quality, and earlier maturity, which can catch higher prices. However, the system requires an appropriate design of hardware and software. The initial cost is high and it needs a careful maintenance of relatively clean water, and the tendency of emitters of the water pipes to clog with contaminants. It is also important to disseminate the technical knowledge for farmer education and on-farm demonstration. Use of solar power will substitute the diesel power engines, reducing the air pollution and GHG emission to the environment. The use of this technology will mainly focus on the production of high valued crops, such as vegetables, kitchen crops and fruits for the higher income of the farmers.

Current status of the technology

Modern commercial drip systems from Netafim were first introduced to Myanmar in collaboration with Myanmar Agriculture Service (MAS) in 1994 and by an Israeli-local joint venture in 2006. These efforts were soon discontinued or abandoned, however, due to their high management requirements and expense. Other problems were - iron precipitate clogging and seasonal removal and disposal of used drip laterals, and the tubing damaged by rodents or other animals. More importantly, there were also perceptual barriers to adoption as many farmers are accustomed to applying ample amounts of water to crops and are unfamiliar with drip or their crops' actual water requirements. The systems were considered too complex and costly for widespread adoption by local vegetable growers.

Around 2008, the Myanmar NGO, Proximity Design (international NGO: IDE) developed affordable irrigation products (treadle pumps, drip irrigation sets and water tanks to meet both the needs and aspiration of consumers. solar pumps for drip irrigation. It has created a market for not only a new product, but an entirely new system of irrigation. It also developed training aids and tools which help change farmers' perceptions and simplify and explain the technology to both staff and farmers. Loans and credits made available to its customers since 2009 have accelerated adoption of drip and helped access to the technology to a certain extent. Over 5,000 sets have been installed in the project sites across the country for a wide range of crops such as vegetables, fruit crops, ornamental, betel leaves and coffee. The irrigation products are sold under the brand name of "Yetagon".

There are currently As of March 2014, it was noted that about 90,000 active pump users are in 5,000 villages. (Source: https//proximitydesigns.org/service/farm-tech/). High price of labor charges due to the labor scarcity encourages many growers to apply drip and sprinkler irrigation. The adoption of drip and sprinkle irrigations has recently started in vegetables and flowers production in Mandalay, Bago and Yangon Regions. Commercial production of water melon, tomato and onions with drip irrigation has been common since 3-4 years ago. The drip irrigation fits well to a net house system of high-valued crops and cash crops which can reduce use of chemical pesticides and fertilizers. Therefore, these products are safe food compared with conventional irrigation system. Consumers' choices are becoming more priority to safer foods these days, the demand of good quality crop products with drip irrigation system will be greater in near future.

Regarding the technology category and market characteristics in the country, solar powered drip irrigation is generally applied by medium and large growers so that can be categorized as consumer good.

Market characteristics for "Solar powered drip irrigation" are:

i) It can be used in green houses as well as in open garden,
ii) It requires importation of engine pumps, local manufacturing of pipes, tanks;
iii) Solar panels /sets are imported. Some of inputs for drip irrigation are available locally while some components are imported

1.2.2 Identification of barriers for "Solar powered drip irrigation" technology

The methodology followed in performing the TNA identification of barriers were -

- It was ensured the full use of TNA barrier analysis guidelines (e.g. Boldt et al., 2012), resources, information and templates provided by specialists of UNEP-DTU Partnership during and after regional capacity building workshops.
- The national TNA team undertook the identification and involvement of wide range of stakeholders which include experts from agriculture and its related sectors, officials from relevant ministries and departments, farmers, representatives of NGOs, representatives of suppliers and manufacturers, and officials of some international donor agencies in the series of consultation processes.
- The BA process was done through brainstorming and discussion sessions with stakeholders and it Adaptation Technical Working Group (TWG) in a series of workshop. Then it was reviewed by the TNA Team. Under the COVID 19 outbreak in Myanmar, a Zoom meeting was organized by TNA team of Nay Pyi Taw (Agriculture Sector on 16 June, and Water Sector on 17 June 2020). One week prior to the meetings, power point presentations were sent to the participants. Three discussion sections were separately organized for each technology. The participant lists of Zoom meetings were described in Attachment I (A) and I (B) for agriculture sector and water sector, respectively. The brief meeting notes for Agriculture Sector were described in the Attachment IV. The participants actively discussed and provided comments on barriers and measures. Most comments were generally agreed by all participants and TWG. The consultant added them accordingly under barriers and measures of the respective sections of the technology.

- The first draft of BA report (checked by UDP and AIT) was distributed to all stakeholders and TNA Team in the last week of August, 2020. Their comments, suggestions and recommendations on the barriers and measures were gathered through E-mails. Taking their feedbacks into consideration, the BA report was revised again. The comments and feedback from various stakeholders and responses were recorded and submitted to ECD and the Minister of MONREC for the approval on 4th November, 2020. The stakeholders participating in providing feedbacks via Emails were also listed in the Attachment II (A) for Agriculture Sector and Attachment II (B) for Water Sector. Some notes from their feedbacks via Emails for inputs on barriers and measures for Agriculture Sector were presented in Attachment V.

- To acquire the information on the key barriers, the Focus Group Discussion (FGD) with several users' farmers were conducted in Myitthar Township (pepper farmers) and Pyin-Oo-lwin Townships (tomato farmers) of Mandalay Region in June 2020. The national expert also discussed with suppliers and manufacturers of drip sets and solar panels in Mandalay City market and Paleik Market of Mandalay Region.

Through the extensive literature review and brainstorming meetings, the national experts and TNA national team listed down potential economic and financial and non-financial barriers to the diffusion

of each prioritized technology. Later non-financial barrier category was further broken down into many other barrier categories including policy, legal and regulatory, institutional and organizational capacity, technical, information, awareness and etc. The long lists of barriers for all selected technologies were noted. For the "solar powered drip irrigation" technology, was recorded that five (5) economic and financial barriers and ten (10) non-financial barriers, including the farmer level of seven (7) barriers were listed in first stage (Attachment III (A)).

- The barriers were screened through voting. All barriers are entered in random order, and each participant was asked to give each barrier a mark (from 1 to 5), according to how important the barrier is from the participant's own perspective. The barriers were then ranked after adding up all the marks. After assessing the long lists of random barriers, the categorized identified barriers were screened according to their most relevant in the adoption and diffusion of technology by using a simple voting method. The key barriers were identified, which definitely needs to be addressed for effective transfer and diffusion of the technology.
- For the screening process, the screening categories include "killer (non-starter), crucial, important, less important, and insignificant (easy starter). The lists of non-key barriers were also noted and checked again to assess whether some of them should be re-classified as key barriers. An initial analysis of the barriers that remain after screening was conducted by discussing whether some barriers are actually composed of some of the other barriers, or whether one barrier is just a more concrete formulation of an overall barrier category.

Market mapping

Through the stakeholder discussions**,** the barriers were decomposed. By applying the Market map (Annex 1A) the consultant and the stakeholders analyzed the causal relations between the decomposed barriers by looking at the main barrier or the starter problem, which is high cost of initial installation of the technology. "Market mapping' describes the broader market system for technology transfer, including assessment of where in the system blockages or inefficiencies exist. It includes detailed descriptions of interactions between market actors.

- The analysis includes three key elements: (i) the enabling business environments; (ii) the market chain; and (iii) the input and service providers. The central component is the market chain consisting of the economic actors who produce and transact a particular product as it moves from primary producer to final consumer. The second component, the enabling business environment, is a charting of the critical factors and trends that shape the market-chain environment and operating conditions. This element relates to the local, national institutions, rules and practices of governments, and others as part of the institutional context. The third component, the input and service providers, is concerned with mapping the services that support the market chain's overall efficiency. It focuses on the relation between the market actors, and how the enabling framework can hinder or support the functioning of the market chain is useful in identifying the barriers to and measures for the further diffusion of specific technology.

- For the "Solar powered drip irrigation technology", the casual relationship was done by looking at root causes of barrier and the effects of barriers on communities. The analysis showed that the high cost of initial installation of the technology is due to the cost of components as a result of inadequate credit facilities and high interest rates, taken up by the private sector companies / entrepreneurs. As a result, only a few farmers are adopting the technology leading to reduced acreage under drip irrigation technology. Barriers analysis included detailed analysis with logical problem tree and translating these barriers into

measures using logical solution tree and 'Market Mapping' tools. For the "Solar powered drip irrigation" Technology, Market map, Problem tree and Solution tree were described in Annex I (A), I(B) and I (C), respectively.

The Market map covers the following –

(1) Market chain actors and linkages

The following are the "market chain actors" who produce and transact solar powered drip irrigation technology at various levels.

a) Importers of materials for making drip irrigation kits –mainly private sector entrepreneurs /private companies. The kits are manufactured by local technical expertise. Currently the importer and manufacturers are only a few numbers,

b) Retailers of kits, engine pumps and storage containers, solar panels and its accessories, water pipes (PVC pipes and plastic pipes) – mainly private sector,

c) Manufacturers of water containers such as buckets, drums and tanks, water pipes – mainly private sector actors. Wholesalers provide water storage containers and pumps to the retailers, which enables sufficient supply of goods.

d) Manufacturers of water pumps and distribution to users – private sector actors who import from China, Thailand and Japan

The above mentioned "market chain actors" are important in making the market function. The constraints include high costs because the materials used are mainly imported. Moreover, there are few suppliers of these materials and farmers have to pay high prices.

(2) Service providers

Service providers are responsible for providing services to enable overall market chain efficient. There is limited financial and legal services, limited capacity building and public awareness for the technology distribution. Some local NGOs have offered training and awareness raising in the central dry zone farmers but they relied on donor funding projects which was not sustainable. For the effective consideration of barriers, a market map for the technology was created. Detailed market map for "solar powered drip irrigation technology" is presented in Annex I (A). During the first stage of the BA process, the broad / common barriers were considered. The barriers were then grouped into various categories and described in order to facilitate analysis and screening. Categorization and description of barriers of the technology was shown in Table 1.2.

Table 0.2 Categorization and description of barriers of "Solar powered drip irrigation"

Broad Barrier/ Barrier Category	Barrier Dimension	Main Barrier	Barrier Description
Economic and Financial	Cost	• High Initial Cost for farmers, • High-interest rate for technology developers, • Inadequate credit and loan facilities for farmers	• Most technology components are imported; Although there is no custom duties for the imports of the technology components (agriculture inputs, drip sets and solar), due to the fluctuation of the exchange rate of foreign currency and the world's oil market prices, the price of import items are usually high, • Interest rates of Government / commercial bank loans are high so that it

Broad Barrier/ Barrier Category	Barrier Dimension	Main Barrier	Barrier Description
			is difficult for farmers to invest for the technology, • A large part of the country is still in-accessible and remote areas have very few formal financial service providers such as SME loans and microfinance. • The interest's rates of government's banking loans or cooperate with local banks are 15%, in general. Through the FGD, the entrepreneurs said that they want to access loan and their affordable interest rates is less than 10%, • Initial installation of the technology is constrained by lack of access to financial support for initial investments and maintenance, • Cost of skilled labor needed for installation and maintenance - high cost of maintenance - repair of clogging emitters and replacement of broken pipes and breakage of filters, • A Few local manufacturers / suppliers of the kits
Non-Financial Barriers	Policy, legal and regulatory	• Limited policy and guidelines to encourage the use of efficient water use technology	• Agriculture extension policies mainly emphasize on increased crop production, • Limited policies, rules and guidelines which encourage directly or indirectly to the adoption of the technology, • DOA as well as farmers do not give priority to water scarcity.
	Technical	• Limited capacity and limited numbers of technicians who can manage and operate the technology properly	• Highly skilled labor is needed for installation, operation, storage and movement of irrigation systems from plot to plot, • Drips pipes are easy to be damaged by cattle and poor handling, • Breakage and leakage of filter plug due to brittleness of the plastic used • Clogging of some emitters, insufficiency knowledge due to the complicated technology • No uniformity of emitter discharge often happens along the lateral lines

Broad Barrier/ Barrier Category	Barrier Dimension	Main Barrier	Barrier Description
	Institutional and organizational capacity	Inadequate extension services	• Low capacity of DOA, inadequate numbers of extension staff • DOA extension more emphasizes on increased crop production of major crops (rice, pulses, etc.) than other issues, • Out of the initial capital budget of MOALI (Year 2016 – 2017), DOA shares 3.5%. Due to the low budget allotted, it is difficult to ensure to implement the policy goals and activities successfully (Source: MOALI, 2018).
	Research and development	Limited research and development activities	• Weakness in agriculture research activities in general, and the activities do not focus on this particular technology, • Very low budget allotted in agriculture research and development sector. Out of the Initial Capital Budget of MOALI (Year 2016 – 2017), YAU and DAR shares the 0.4% and 0.6%, respectively. (Source: MOALI, 2018) • Research programs are prioritized to the most important crops – rice, pulses production,
	Information, awareness and networking	• Insufficient information and awareness of the technology by the farmers and community	• This technology was introduced two decades ago in the country but it has not been widely disseminated, • The users of the technology face the challenges because of the inadequate information and networking, • Inadequate strategic market plan and support for investment,
	Farmers' Skills	• Low capacity to sustainable use of technology	• This technology needs skills to accurately manage and maintain water flow control for maximum efficiency, • Low education levels of farmers are a possible cause for the poor management in implementations leading to discourage the adoption of the new technology, • For regular monitoring, labor intensive needs for checking whether the pipes have clogged or not, and etc.

Broad Barrier/ Barrier Category	Barrier Dimension	Main Barrier	Barrier Description
	Socio-Cultural	• Farmers' perception - Preference to other irrigation methods,	• Conventional irrigation methods, like furrow irrigation is less complicated and easier to use, • Farmers tend to bear the burden of fetching water, rather than using the complicated technology, • Insecurity of the apparatus if the farm is away from home, • Farmers are used to wetting the soil and be able to visibly see the moisture on the soil. Many of them find drip irrigation to be derisory and inadequate for the plants to grow well,

Screening of barriers

As mentioned above, the categorized identified barriers were screened according to their significance in the adoption and diffusion of technology. The main barriers were identified, which definitely needs to be addressed for effective transfer and diffusion of the "solar powered drip irrigation" technology. It was done through brainstorming and discussion sessions with stakeholders and Adaptation TWG in a series of workshop. In addition, it was reviewed by the TNA Team. After the screening process, the following key barriers were selected for further analysis:

- High cost of technology, High-interest rate for the technology developers, Inadequate credit and loan facilities for farmers
- Limited policy and guidelines,
- Limited capacity / technicians
- Inadequate extension services
- Insufficient information awareness

1.2.2.1 Economic and financial barriers

The screened barriers were decomposed through discussion to check whether some barriers are actually composed of some of the other barriers, or whether one barrier is just more concrete. Economic and financial barriers were identified as key and decomposed in two levels (Table 1.3). Decomposition of the economic and financial barrier revealed that the high cost of initial installation is associated with high cost of unit kits because several components of the technology are imported, and high interest rate for the technology developers Therefore, there are very few local manufacturers of local kits and lack of incentives.

Since solar powered drip irrigation is a market good the economic and financial barrier was evaluated using a financial calculator to assess NPV, IRR for the technology. The project description and detail calculations were described in the Attachment VII (A) and (B). The project will invest 11,937 Million Kyats (around 9 Million USD) to promote solar pumping and drip irrigation system, and provide the technology to 6,900 farmers in the five years project phase.

As the IRR rate of 18 % is greater than the interest rate (Opportunity Cost, 6%), and Net Present Value (NPV) is positive the project is profitable.

Table 0.3 Decomposition of economic and financial barriers for "Solar powered drip irrigation" technology

Barrier Dimension	Main Barrier	Elements of a barrier
Cost	• High cost of technology	• Lack of financial support to the user-farmers, • High cost of unit kits
	• High-interest rate for the technology developers	• The interest rates of the commercial /government banks are high for the investment , • No special loan or credit systems for the developer / importers of the technology • Inadequate credit and loan facilities for farmers

After decomposing the barriers, the consultants analyzed the causal relations between the decomposed barriers by looking at the main barrier or the starter problem, which is high cost of initial installation. The casual relationship was done by looking at root causes of barrier and the effects of barriers on the communities. The analysis showed that the high cost of initial installation of the technology is due to cost of components as a result of high cost of credit facilities, inadequate credit facilities and high interest rates, taken up by the private sector companies / entrepreneurs. As a result, only a few farmers are adopting the technology leading to reduced acreage under drip irrigation. The detailed logical problem analysis was described on barriers for the drip irrigation technology in the Problem Tree of Annex I (B).

1.2.2.2 Non-financial barriers

As one of the main non-financial barriers, policies and guidelines are limited to encourage the use of water efficient use technology. In addition, there are insufficient farmers' skills / technical requirement for planning, installation and maintenance of drip irrigation. They include specialized skills for preparing pipes and filters; lay out plans of the pipes, technician for repairing the pipes and solar system. Currently, there are very few trained technicians in Myanmar and low institutional and organizational capacity. Besides, inadequate awareness and low education levels of farmers are significant constraints. Non-financial barriers were decomposed as shown in Table 1.4.

Table 0.4 Decomposition of non-financial barriers for "Solar powered drip irrigation" technology

Barrier Dimension	Main Barriers	Elements of a barrier
Policy, legal and regulatory	Limited policies and guidelines to encourage the use of water efficient use technology	• Limited legal instrument forcing people to use water efficient technologies, • Low level of integration of the climate change adaptation plans with the development plans, • Weak agriculture extension policies and implementation for climate change adaptation,

Technical	Limited capacity / technicians who can install the technology properly	• Farmers and extension agents (public and private) have limited skills and trainings of solar powered drip systems, • Extensive technology requirements for installation and maintenance of drip sets and solar power systems
Institutional and organizational capacity	Inadequate extension services	• Insufficient capacity and numbers of DOA extension staff, • Lack of trainings for the DOA extension staff and other extension institutions, CBO and local NGOs, • Financial and facility constraints of the department for providing services to the farmers (e.g., travel charges, daily allowances, etc.),
Information, awareness and networking	Insufficient information awareness for the use of technology,	• Inadequate information and networking, • Limited market and market information of the technology,

In most cases, water sources for drip irrigation are nearby wells, streams and small rivers. Access to available water resources is hampered by the need to use other technologies for harvesting and storage. Some farmers require extracting borehole for underground water source which are costly. Electricity is not available in most rural areas; diesel engine pumps are used. In such case, installation of solar powered technology for water extraction has a potential in the Myanmar Dry zone region where the sun shine hour is sufficient. Use of solar power will reduce the air pollution and GHG emissions to the environment. However, the solar power technology components such as solar panel, controller, inverter, and charger technology are complicated for the majority of farmers. Therefore, the solar system irrigation is not applied in commercial production level.

1.2.3 Identified measures of "Solar powered drip irrigation" technology

The methodology used to determine measures for main barriers identified was reformulating all the problems as positive statements and developing an "Objective / Solution Tree" (Annex I (C)). The process of identification of measures was undertaken by the consultants and stakeholders during a series of stakeholder consultation workshop. These measures were also evaluated by the Adaptation TWG and the TNA team. During the process, application of the knowledge and literature review including market chain analysis of the consultant, combined with the stakeholders' experiences and advice, the measures were identified. This has been done only for the starter problem which is an economic and financial measure.

1.2.3.1 Economic and financial measures

The measures were analyzed using an "objective tree" which gives the measures to overcome the root cause barrier and the resultant effects. Based on the Zoom meeting of stakeholder's discussion, it is noted that there is zero custom duty for importing drip irrigation facilities and solar panels since they are the agricultural related import materials (Source: Customs Department and Department of Trade).

Economic and financial measures should be put in place to increase credit facilities leading to adequate credit for the farmers and entrepreneurs. It is expected that local communities can widely adopt the technology if measures for provision of credit facilities and reduce interest rates are

undertaken. Similarly, the local entrepreneurs access reduced interest rates of credits for the business, it will lead to more manufacturers of kits and their products (drip sets, solar panels) will be sold at cheaper price. Measures to train more technicians, extension services are undertaken; it will result in more specialized manpower and better service delivery. These will contribute to lowering the cost of initial installation and these measures will result in more farmers adopting drip irrigation and increased acreage with this technology.

1.2.3.2 Non-financial measures

Non- financial measures include development of human skill involving capacity building for both farmers and technicians. Enhancement of information and awareness will promote use of solar powered drip irrigation and reduce social and cultural barriers and enhance community participation. Undertaking adequate training will enhance farmer's skills. The agriculture policy for promotion of crop diversity of vegetables and food policies for the less use of pesticides should be set up. It will encourage the use of net-house/ glasshouse farming system equipped with drip irrigation. The barriers related to information and awareness for adaptation and diffusion of technologies is caused by the inadequate awareness of the technologies. Appropriate communication and extension approaches should be applied.

1.2.4 Key barriers and measures identified for the "Solar powered drip irrigation technology"

As described in the previous section, barriers and measures for effective technology transfer and diffusion were identified through an extensive consultative process including FGD, KII and experts' inputs. The outcome was validated using zoom meeting sharing the national and international experiences to overcome these barriers. The stakeholders also sent back their comments and feedbacks on the BA and measures to the TNA team. These selected key barriers and measures are discussed below under the categories of economic & financial and non-financial measures (Table 1.5).

Table 0.5 Key Barriers and measures identified for the "Solar powered drip irrigation technology"

Barrier Dimension	Main Barriers	Measures Identified
Economic and Financial Barriers		
Cost	High cost	• Explore international and national investment (e.g., joint venturing), • Explore funding agencies or national and international private investors, • Access loans and grants from World Bank, ADB, GEF, GCF, and IFAD funds, LIFT-assisted village development planning programs), etc.
	High-interest rate for the technology developers and dealers	• Reduced interest rates of government banks and commercial banks to support the development of technology, • The interest rates of government's banking loans or cooperate with local banks are 15%, in general. Reduce the interests to their affordable value (e.g., less than 10%), • Access the formal financial service providers such as JICA SME Two Step-Loans with interest rates of 5.5

Barrier Dimension	Main Barriers	Measures Identified
		to 10%, which is only eligible for SMEs which are obliged with Small and Medium Enterprises Development Law (2015),
	Inadequate credit and loan facilities for farmers	• Initiate a credits or loan system (e.g) cost-sharing supports or subsidies by the government, • Create contract farming system to reduce the farmers' investment and ensure the income of the product.
Non- Financial Barriers		
Policy, legal and regulatory	Limited policy and guidelines to encourage the use of water efficient use technology	• Set the main policies and related policies encourage to alternative irrigation systems of less use of water (drip, sprinkler), • New Irrigation Law was developed but Irrigation Act needs to be developed, incentivizing efficient irrigation technologies for water stressed areas,
Technical	Limited capacity / technicians who can install the technology properly	• Give Trainings for technology knowhow to provide farmers, associations and private and public extension agents, • The Government should fund this through internal budgets or with funding from development partners,
Institutional and organiza - tional capacity	Inadequate extension services	• Create sufficient financial and facility support for the government departments for extension services, • Recruit the numbers of extension staff,
Information, awareness and networking	• Insufficient awareness of the technology • Limited market and market information of the technology	• Organize workshops and programs for raising awareness to the farmers, use of media (television, radio, Farmers' Channel, etc. for technology information • Make demonstration plots showing the use and benefits of the technology, establish FFS (farmers field schools wherever feasible), • Create good networking among developers, user-farmer, DOA and NGOs, etc. • Encourage contract farming for the strong market networking,

1.3 Barrier analysis and possible enabling measures for technology on "Conservation agriculture"

1.3.1 General description of the technology

Soil erosion and degradation and impacts of climate change, particularly drought and floods are the long-term main 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. CA that combines minimum tillage and permanent soil cover and organic farming are promising adaptation options to be promoted in various regions of Myanmar. Aside from the three fundamental components of conservation agriculture (e.g., minimum tillage, crop rotation and the use of soil cover), other techniques that make use of labor-saving tools, draught animal power or mechanical equipment will be utilized. Although, CA is a climate change adaptation technology, it also helps mitigating GHG emission through efficient use of fertilizer, better management of farm yard manure combined with integrated plant nutrient management and by increasing organic carbon content in the soil.

Current status of the technology

As part of CA technology, application of leguminous-based cropping system, crop rotation and intercropping practices have been practicing in Myanmar since several decades ago. Application of cover crops and zero tillage or minimum tillage practices are common as farmers' traditional practice. Crop rotation, relay cropping and mix cropping are prevalent in several areas of the country. Therefore, CA technology needs to extend and improved for sustainable productivity and to be resilient to climate change.

Land degradation has already taken place to various degrees in Myanmar. Actually, land degradation is widespread and occurs in all agro ecological regions at different intensities. Land degradation and soil erosion is prevalent in Chin State and Shan State where the most serious environmental problems exist. The objective of CA is to focus on restoring such degraded land while preventing further degradation. It will ensure sustainable ecosystem health and functions. CA technology has not been currently adopted widely and effectively in Myanmar. In the Shan States the fertility degradation remains a critical constraint for annual crop production. Farmers have to apply huge amount of chemical fertilizers and farmyard manure every year. Therefore, appropriate corrective actions need to be taken to address issues and the related technology needs to transfer and diffusion for adoption of CA practices.

CA technology is generally categorized as, non-market goods for production of goods and services available (free or paid) to the public or a large group of persons. The technology has a higher share of the software and orgware components compared to the hardware component. However, in the geological setting of Myanmar landscape, the hilly regions (the southern and northern Shan States) are prone to soil erosion. With the favorable rainfalls, weather and good market access from Chinese border, intensive production of high valued crops and kitchen crops (potato, ginger, onions, garlics and vegetables has been taken place for several decades. Consequently, the lands are seriously eroded and degraded. For the land reclamation and restoration in these areas, the CA technology with contour and terrace farming will be applied so that the initial cost of land preparation will be high for the local farmers.

As the concept of 'publicly provided goods, it denotes technologies that are procured and diffused by public entities to a large population of users and beneficiaries. Single or individual efforts of establishing CA farms are not effective so that coordination among stakeholder organizations is required to organize several CA farms in a targeted area. Market mapping was not conducted since the introduction of technology will be undertaken by government organization, NGOs or INGOs.

1.3.2 Identification of barriers for Conservation Agriculture

The similar processes of previous technology were undertaken for the barrier analysis of CA technology. The process of identification of barriers and measures included not only literature reviews, but also the stakeholder consultations (online and in person) and FGD, KII and interviews with sector specialists and user farmers. Managing land degradation and promoting CA were used for consultation. The analysis of results was undertaken based on the national and international experiences of experts and stakeholders. These prioritized barriers categorized with stakeholder consensus were described below (Table 1.6).

Table 0.6 Categorization and description of barriers of CA

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
Economic and Financial	Cost	High initial cost of establishment for small holder farmers	▲ A considerable cost required for the establishment of contour bunds and terrace construction (Sloping land conservation component), growing perennial trees (ago-forestry component), land preparation, and buying of suitable equipment and tools, ▲ For land preparation, hiring cost of construction machines (excavator, bulldozer, etc.) are high. ▲ Farm machinery are imported; although there is no custom duties for the imports of the technology components related with agricultural tools and equipment, due to the fluctuation of the exchange rate of dollars and the world market fuel prices, the price of import items and hiring charges are usually high,
		Inadequate credit and loan facilities for farmers	• Resource poor farmers cannot afford the initial cost, • Long period required for the establishment of CA farms, with low income for 3-4 years for realization of the investment, • The seasonal loans from MADB is only for major crops, not included the upland-hilly crops,
Non - financial	Policy, legal and regulatory	Very few policies and guidelines to encourage the farmers to use the CA	• The policies, rules and guide lines which encourage to directly or indirectly encourage the adoption of the CA are very few, • Agriculture policies mainly focus on increase production rather than the conservation and sustainable crop production, • Land fragmentation and due to the weakness in land tenure, many farmers do

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
			not access the official "Land use right or certificate", Customary rights for the ownerships are often neglected. Consequently, farmers have less sense of ownership, and less interest to improve their land and sustainable development,
	Technical	Limited technical knowhow of extension workers of DOA and Land Use Division for CA technology	• CA technology is lagging behind due to the poor mechanization effort in hilly and upland areas. • Mechanization is needed for the technology, to be up-scaled, which also needs mechanized planter's seeder, upland preparation for contour bunds and terraces, etc. • Specialized skills for preparing / building up the lands required for 3-4 years
	Institutional and organizational capacity	Inadequate extension services by the DOA and Land Use Division	• DOA extension services emphasize more on increased crop production than the conservation so that CA technology was not much familiar to the staff. • Low national budget allotted to the extension services (e.g., not sufficient travel allowance, daily allowance); DOA shares only 3.5% of the total annual budget of MOALI,
	Research and development	Limited research and development activities	• Weakness in agriculture research activities in general, and there has been few research activities on this particular technology, • Due to the low national budget allotted in agriculture research and development sector, research programs are prioritized to the important cash crops
	Information and Awareness	Inadequate Information of technology to communities and agriculturists	• Inadequate knowledge of famers on appropriate land management and conservation techniques for conservation sustainable development, • Single or individual efforts are not effective for this technology, by designating a large community will be more effective to apply the technology
	Farmers' Skills	• Poor farmers' skill and technology	• Low education levels of farmers are a possible cause for the poor land management in implementations leading

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
		knowledge	to discouragement adoption, • Farmers are used to the conventional farming method and not familiar with the CA technology,
	Socio-Cultural	Farmers' perception	• Preference to conventional crop production methods which produces more yields in an immediate cash return,
		Resource poor farmers	• Limited income for long development period (3-4 years) for realizing return on investments, necessary for building up a good soil structure and land development,

Screening of barriers

The categorized identified barriers were screened according to their significance in the adoption and diffusion of technology. When the main barriers are identified, they definitely need to be addressed for effective transfer and diffusion of the technology. It was done through brainstorming and discussion sessions with stakeholders and Adaptation TWG in a series of workshop. In addition, it was reviewed by the TNA Team.

The detail steps for elaboration of barrier screening using market mapping, problem tree and objective tree were the same as mentioned in the previous section/ technology. The long list of draft barriers before screening process was described in Attachment III (B). It was recorded that seven (7) economic and financial barriers and eighteen (18) non-financial barriers, including the farmer level of four (4) barriers were listed in the first stage. They were again narrowed down to a smaller number of barriers in a similar way as conducted in the previous technology. The following barriers were selected for further analysis:

- Limited financial supports
- Limited CA policy encouraging the sustainable crop production
- Weakness in land tenancy tenures
- Few trained technicians
- Very few research

1.3.2.1 Economic and financial barriers

The screened barriers were decomposed through discussion to check whether some barriers are actually composed of some of the other barriers, or whether one barrier is just more concrete. Economic and financial barriers were identified as key and decomposed in two levels (Table 1.7). Decomposition of the economic and financial barrier revealed that the high cost of initial installation is associated with high cost of construction of physical conservation measures such as contour bunds, and growing agro-forestry, growing of cover crops, hedge rows, etc.

Table 0.7 Decomposition of economic and financial barriers for CA

Barrier dimension	Main Barrier	Elements of a barrier
Cost	High cost of initial establishment	• Limited financial support from national and internal funding agencies, • Construction of contour buds and terraces • Mechanized planter and seeder,
	Inadequate credit and loan facilities for farmers	• No agricultural seasonal loan from MFTB for upland farming and land use management, • A high interest rate to borrow money from commercial and private banks to buy farm machineries for the developers

After the decomposing the barriers the consultants analyzed the causal relations between the decomposed barriers by looking at the main barrier or the starter problem, which is high cost of initial installation. The casual relationship was done by looking at root causes of barrier and the effects of barriers on the communities. The analysis showed that the high cost of initial installation of the technology is due to the initial cost which needs to construct the contour bunds, terraces growing perennial trees and etc. The details of the barriers were shown in the "Problem Tree" in Annex II (A).

1.3.2.2 Non-financial barriers

The limited policies and guidelines are one of the main barriers to encourage the farmers to use the technology. In addition, the other main non-financial barriers include the farmers' skills / technical requirement for construction of contour bunds, hedge row or windbreak planting of perennial trees and etc. Besides, inadequate awareness and low education levels of farmers are significant constraints for the technology. The requirement is training of farmers as well as the technicians to enable them to adopt and distribute this technology. The decomposition of non -financial barriers for CA was in (Table 1.8).

Table 0.8 Decomposition of non -financial barriers for CA

Barrier dimension	Main Barrier	Elements of a barrier
Policy, legal and regulatory	Limited policy and guidelines to encourage the farmers to use the technology	• Limited CA policy which improve the sustainable crop production, • Very few integrations of CA/ sustainable agriculture in the development plans and weak in implementation, • Weakness in land tenancy arrangements; Insecure land ownership
Technical	Limited technical knowhow of extension workers of DOA and Land Use Division	• Weak in CA technology due to inadequate extension efforts, • Specific technologies for land management techniques of CA farms with relevance under the diverse land, weather, soil, terrain, size, land formation, and etc.

		• Weak integration of conservation or sustainable agriculture in future development plans,
Institutional and organizational capacity	Limited institutional capacity	• Financial and facilities constraints of the government departments, • A few trained technicians for the technology and inadequate extension services, • Weak coordination among stakeholder organizations, public and public sector,
Research and development	Limited research and development activities	• Low national budget allotted in agriculture research and development sector, • Few public and private investment on research and development, • Very few research or experiment of this technology at DAR and YAU
Information and awareness	Inadequate information and awareness of the community	• Low awareness training and workshops to the community • Lack of coordination among stakeholder organizations, public and public sector organization,
Farmers' Skills and interest	• High farmers' skills and interest requirement	• Inadequate knowledge to maintain the soil and water conservation practices

1.3.3 Identified measures for CA

The methodology used to determine measures for main barriers identified was reformulating all the problems as positive statements and developing an Objective Tree/Solution Tree (Annex II (B)). The process of identification of measures was undertaken by the consultants and stakeholders during a series of stakeholder consultation of online communications and workshop. These measures were also evaluated by the Adaptation Technical Working Group and the TNA team. During the process, application of the knowledge and literature review including market chain analysis of the consultant combined with the stakeholders' experiences and advice, the measures were identified. This has been done only for the starter problem which is an economic and financial measure.

1.3.3.1 Economic and financial measures

The measures were analyzed using an objective which gives the measures to overcome the root cause barrier and the resultant effects. Economic and financial measures should be put in place to reduce interest rates and increase credit facilities leading to adequate credit for the farmers. If measures to train more technicians are undertaken, it will result in more specialized manpower leading to better service delivery. The implementation of these measures will result in more farmers adopting the CA technology and increased acreage under this technology.

1.3.3.2 Non-financial measures

Non- financial measures include development of human skill involving capacity building for both farmers and technicians. Enhancement of information and awareness will promote use of CA and reduce social and cultural barriers and enhance community participation. It is expected that local communities can adopt the technology if measures for provision of credit facilities, reduce interest rates. The barriers related to information and awareness for adaptation and diffusion of technologies is caused by the inadequate awareness on the concept of sustainable agriculture production, including agro-forestry practices. Undertaking of adequate awareness and technical training will enhance farmer's skills.

1.3.4 Key barriers and measures identified for the "Conservation Agriculture (CA) technology"

Barriers and measures for effective technology transfer and diffusion were identified through an extensive consultative process including literature reviews and expert inputs. The outcome was validated using zoom meeting sharing the national and international experiences to overcome these barriers. These barriers and measures are discussed below under categories of economic & financial and non-financial measures (Table 1.9).

Table 0.9 Key Barriers and Measures Identified for "Conservation Agriculture (CA) technology"

Barrier dimension	Main Barriers	Measures Identified
Economic and Financial Barriers		
Cost	High initial cost for establishment	• Explore international funding organizations, such as World Bank, ADB, GEF, GCF, LIFT and etc. • The MOALI, funding agencies, INGOs, LNGOs, provide subsidies (e.g., 50%) for farm equipment, • AMD helps farmers with reduced hiring cost for land preparation of contour bunds, terraces,
	Inadequate credit and loan facilities for farmers	• Improve current credit scheme for smallholder farmers to provide special credit system for the technology innovation
Non- Financial Barriers		
Policy, legal and regulatory	Very few policies and guidelines to encourage CA farms	• Securing land ownership and land tenure, • Introducing and enforcement of land management policies, laws and regulations for CA practices, • Integration of CA into the future agriculture development plans,
Technical	Limited technical knowhow	• Raising knowledge on appropriate land management techniques, • Improving CA technology to farmers and extension agents -Further studies for YAU students and DOA staff for specialization of CA and sustainable agriculture
Institutional and organizational capacity	Limited institutional capacity	• Provide capacity building of public and private extension staff of DOA and Land Use Division, • Recruit the adequate numbers of extension staff, • Improving the institutional and organizational capacity and coordination and network among private –public partnerships (such as NGOs, CBOs and extension agencies),
Research and development	Limited research and development	• Increase national budget to agriculture research and development sector,

	activities	• Encourage research and development programs in collaboration with international universities and organizations, • Encourage graduate studies programs majoring in the CA at the agricultural universities and institutes,
Information and awareness	Limited knowledge of CA technology by the extension staff and farmers	• Raising knowledge on appropriate land management techniques and new challenges, • Create awareness amongst farmers and extension staff through setting up demonstration plots/ sites and conducting site visits.

1.4 Barrier analysis and possible enabling measures for the technology on "Improvement of salinity tolerance rice varieties in coastal and inland salinity areas of Myanmar"

1.4.1 General description of the technology

According to UNESCAP (2009), problem soils in Myanmar occupy an area of nearly 1 million ha, representing about 7.8 percent of the total cultivable land. Of the area of problem soils, about 68.75 percent (660,000 ha) comprises saline and alkaline soils, although most of them are currently under cultivation. The remaining problem soil area comprises acid sulphate, degraded, peat and swampy soils. Therefore, saline and alkaline soils are the predominant problem soil in agriculture. An anticipated effect of global warming is an increase in area affected and severity of salt stress, both in coastal and inland ecosystems of Myanmar. In coastal areas, an increase in salt intrusion has already been observed in low-lying areas of Ayeyarwady, Yangon and Rakhine and Tanintharyi Regions. In delta regions of Myanmar, sea water penetrates deeper the rivers and streams so that the problem of salinity of irrigation water occurs. This is one of the severe problems for rice production in Myanmar.

There is fresh water in the upper part of delta in the monsoon season (May to September) while in the southern part it becomes brackish water (Land Use Division, DOA, 2014). Farmers in the saline intrusion area of delta traditionally use saline and flood tolerance local varieties such as Ann-awar-bo, Let-yone-gyi and Nga-sein-gyi. Only the minimum inputs are applied due to the high risk of crop failure by storms and floods. Yields are as low as 30-40 bsk/ acre with a long duration of more than 150 days. They are mostly consumed by local communities and have a sustainable market.

In the inland area of central dry zone, saline and alkaline stresses occurred due to the underground water and irrigation water to grow rice. The local saline tolerance varieties are such as A-chun, Kun-wah and Nga-sein. There have been no crop improvement activities of these local varieties, they are degraded and low purity, producing very low yield. Under the TNA project, the production of improved salt tolerance rice varieties and technology dissemination will be conducted through "Farmer Participatory Seed Multiplication (FPSM)" technology.

Current status of the technology

Salinity tolerance rice (STR) varietal improvement program has been developed by conventional and advanced methods in DAR. Some programs had already released salt tolerance varieties and some are ongoing trails by Rice Section and Biotechnology Section of DAR. Nowadays, Marker Assisted Selection (MAS) is taking part in crucial role in the rice and other important crops breeding program in DAR. Nine salt tolerance rice varieties are already released by DAR (DAR, 2019). One of the prominent breeding programs of Biotechnology section has successfully developed the "Sin-thwe-latt" variety accompanied with multiple traits such as tolerance of salinity, submergence and bacterial leaf blight and aroma. Current status of the technology has not well developed, mainly because of limited human resource and finance.

In the both salt affected areas, the farmers are still using the local varieties which produce very low

yield and quality. As a component of the technology, the selection of farmer's traditional varieties will also be conducted. They will be multiplied under the certified seed program and distributed again to the salt-affected areas. The Farmers' field School (FFS) and demonstration plots will be conducted to provide the cultivation techniques to the local farmers. The training program will be designed in accordance with the growth stages of rice and held about five (5) times from sowing to harvesting in a season.

The following steps include in the improvement programs of saline and alkaline tolerance rice varieties:

(1) Screening Myanmar Germplasm for saline and alkaline tolerance varieties
(2) Two Molecular Marker Assisted Breeding programs will be conducted for saline and alkaline tolerance varieties with high yield and good quality.

1.4.2 Identification of barriers for "Salinity tolerance rice varieties" technology

The technology is categorized as a "Consumers good" and the detailed market map was described in Annex III (A). The following barriers were identified and categorized by the consultants through expert knowledge, literature review, and consultation with stakeholders and Adaptation TWG during brain storming sessions of a series of workshops (Table1.10). The logical problem analysis was described in the Problem Tree of Annex III (B).

In addition, to gather more information on BA and measures to address the barriers for Salinity tolerance rice technology, a KII was organized on 23 March, 2020 with the technology experts in Biotech Research Unit of MOE and Agriculture Research Farm (MOALI) in Kyaukse Township. These experts have been conducting the research on STR varieties in the laboratory and field condition. List of participants were shown in the Attachment VI.

Table 0.10 Categorization and description of barriers for "Salinity tolerance rice varieties"

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
Economc and Financial	Cost	Inadequate financial resources	• Seed prices were not much high but more inputs are required to produce higher yield. Newly produced rice seeds were distributed free of charge to encourage the farmer to use them. • The subsidiary systems/ cost sharing for other inputs will help farmers to adopt the technology,
		Limited agricultural credit and loans	• New rice seed varieties are not more expensive but it requires more inputs (fertilizers, weeding, pesticides), • MADB gives agriculture seasonal loans only for major crop production of farmers who have registered lands with Land Use Certificates; saline affected lands are generally along the streams, estuaries and near the mangrove forests and most of them were not officially registered, • MADB loan for one acre of rice production of registered land is 15,000 Kyats, which covers about half of the actual production cost.

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
Non-financial	Policy, legal and regulatory	Limited policies encouraging for the use of stress tolerance seeds for farmers	• Agriculture policies mainly encourage rice production of quality and high yielding varieties (HYV) for export and domestic consumption, and less emphasize on stress tolerance rice varieties, such as saline, flood, drought tolerance rice varieties, • There is very few integrations of climate change considerations in the future agriculture development plans, • Delay process for intellectual property rights and seed registration discouraging the seed producing farmers and companies, • Low effectiveness for the operationalization of existing rules and regulations for use of pure rice seeds,
	Technical	Inefficiency in seed production, and distribution system	• For the production of new/ improved salt tolerance rice seeds require advanced technology and facilities and qualified technicians and experts, all are limited in Myanmar, • More complexity to produce rice seeds than rice grains; therefore, a few numbers of farmers are interested in producing seeds,
	Institutional and organizational capacity	Weak in institutional and organizational capacity	• Inadequate technicians and staff for the extension services, • Insufficient seed production, distribution and delivery systems of DOA and Seed Division to cover the saline affected areas, • Inadequate physical infrastructures, for seed processing, seed dryers and storage for the production of pure seeds, etc.
	Research and development	Limited research programs for saline tolerance rice varieties	• Low institutional capacity on agricultural research, on the production of salt tolerance rice varieties, • Large amount of research funds and long-term research required to release a new STR variety, • Priority is given more to release of new varieties of Quality rice and HYV, • Insufficient funds for Agriculture Research Institutions,
	Information, awareness and	Limited communication and extension	• Farmers generally have low access to information about the new technology,

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
	networking	approach	• Low adoption rate due to the limited communication and extension approaches, • Market failure due to the uncertainty and low demand for seeds, • There is poor networking with farmers and producers of rice value added produce (e.g., rice vermicelli, snacks and cakes from local rice varieties),
	Farmers' Skills	Limited farmers' skills for the technology	• inadequate training on seed multiplication technology, • Lack of early involvement of farmers in rice variety improvement programs,
	Social, Cultural and Behavioral	Low preference of improved new varieties	• Resource poor farmers: Low capacity for high inputs of fertilizers and intensive management practices for improved varieties, • Farmers prefer their locally existing varieties which require low inputs, • Farmers easily access unreliable seed supplies (farmers-to-farmers contact),

Screening of barriers

The barriers were then screened in order to identify their relative importance and separate key and non-key barriers for the transfer, adoption and diffusion of the technology. This was done through discussion and brainstorming sessions with stakeholders via online meetings. The zoom meetings were held on 16 June 2020; separately organized for each technology of three technologies for agriculture sector. All participants reviewed all documents related with BA of the "Salinity tolerance Rice" technology and discussed applying the knowledge of experts and stakeholders. The BA processes including screening stage followed the similar steps with the previous technologies, such as applying voting method for screening. The long list of draft barriers was described in Attachment III (C). It was recorded that in the first stage, five (5) economic and financial barriers, eighteen (18) non-financial barriers, including four (4) farmer level barriers were listed. After assessing the long lists of random barriers, the categorized identified barriers were screened according to their most relevance in the adoption and diffusion of technology by using a simple voting method. The similar methods and process were undertaken as described in the previous technologies. The consensus was reached for the barriers identified and it was also approved by all Adaptation TWG.

The following barriers were identified as the significant barriers that need to be addressed in order to enhance the transfer, adoption, and diffusion of the technology in the saline areas of Dry zone and delta and coastal regions of Myanmar.

- Inadequate financial resources; Limited credit and loans
- Inadequate policies which encourage to use the STR varieties
- Inefficient technology in seed production and distribution system,
- Weak institutional and organizational capacity

- Limited research programs
- Limited communication and extension approach
- Limited farmers' skills, low preference of improved new varieties

1.4.2.1 Economic and financial barriers

The main identified economic and financial barrier to adoption and diffusion of STR varieties is inadequate financial resources. Lack of agricultural credit and loans make low affordability among rural farmers. It causes the lack of available capital to buy seeds and inputs. These hinder the adoption of STR technology as described in (Table 2.11).

The released improved salt tolerance rice varieties are not more expensive than the local varieties, and as a matter of facts, the government distributes them as free of charge for the technology distribution. However, more proper cultivation practices (use of chemical fertilizers, weeding, water management, etc.) are required and therefore, more costly than the conventional methods. This is one of the main reasons why farmers are less interested in the use of improved STR varieties. In addition, the released STR varieties were very few amounts and did not cover many salt affected areas.

Since the STR technology is a market good, the economic and financial barrier was evaluated using a financial calculator to assess NPV, IRR for the technology. Farmer participatory STR seed multiplication will be carried out with the target growing area of 6,000 acres in the delta and 4,000 acres in central Myanmar. After two years of seed multiplication, the STR seed production / multiplication and distribution of the extension activities for these targeted sown areas will be carried out by the project for three more years. For those two project sites (Ayayarwaddy and Dry zone), the initial investment cost will be 947,000 USD for the participatory seed multiplication and extension (described in excel file attached). Production of STR varieties and technology dissemination will be conducted through "Farmer Participatory Seed Multiplication (FPSM) Phase" within 4 years. The STR coverage of 10,000 acres will start from 3rd year and the assumption was made up to 6 years (4 years of application STR technology). The calculation results show that NPV at 8% discount factor is 380,617.40, BC 1.07 and IRR 44%. The detail calculations are shown in the Attachment VIII.

Table 0.11 Decomposition of economic and financial barriers for "Salinity tolerance rice variety" technology

Barrier dimension	Main barrier	Elements of a barrier
Cost	Inadequate financial resources	• Limited access to financial resources by farmers for adoption of new improved varieties, • Limited funding sources of national and international organizations, • Limited loans with low interest rates of for private investors,
	Limited credit and loans	• Interest rates are high, both from Government banks and private banks, • No specific credit system with low interest, in general

1.4.2.2 Non-financial barriers for "Salinity tolerance rice variety" technology

The main identified non-financial barrier to adoption and diffusion of STR technology is related to market failures. The barriers of further analyzed through decomposition as shown in (Table 1.12).

The elements of this barrier are also associated with unreliable supplies due to lack of functional markets in saline affected areas; uncertainty on the demand for seeds; low seed demand; poor infrastructure and etc.

Table 0.12 Decomposition of non-financial barrier for "Salinity tolerance rice variety"

Barrier dimension	Main Barriers	Elements of a barrier
Policy, legal and regulatory	Inadequate policies encouraging for the use of stress tolerance seeds for farmers	• Inadequate policies encouraging use of good quality seeds for farmers, • Very few integrations of climate change considerations in the future agriculture development plans, • Limited policies which encourage research and development for the salinity tolerance rice variety improvement program,
Technical	Inefficiency in rice seed production and distribution system	• Limited number of trained extension workers and farmers for rice seed production,
Institutional and Organizational Capacity	Weak in institutional and organizational capacity	• Weak in extension services, and limited institutional capacity for the distribution of the technology, • Inadequate skills, trainings and education for the technology of variety development program in agriculture universities and research institutions,
Research and development	Limited research programs for saline tolerance rice varieties	• Very low national research fund in the national agriculture budget, • A few trained staff, and technicians, limited facilities and infrastructure at DAR and agricultural institutes and universities, • Very few institutions and organizations for rice research in Myanmar.
Information, awareness and networking	Limited communication and extension approach	• Low information access of farmers to the new technology, • Poor market status for quality /pure rice seeds including saline tolerance rice varieties, • Network failures: limited collaboration between DAR, Extension workers of DOA and other stakeholders (private seed companies, contract seed producing farmers), • Poor networking with farmers and producers of rice value added produce,

Farmers' Skills	Limited farmers' skills for the technology	• Inadequate training on seed multiplication technology,
Social, Cultural and Behavioral	Low preference of improved new varieties	• Farmers prefer their local /conventional salt tolerance varieties which require low inputs and less management although they give low yields.

1.4.3 Identified measures for "Salinity tolerance rice variety" technology

The process of identification of measures was undertaken by the consultants and stakeholders during a series of stakeholder consultation workshop. These measures were also evaluated by the Adaptation TWG and TNA team. During the process, application of the knowledge and literature review including market chain analysis of the consultant combined with the stakeholders' experiences and advice, the measures were identified. This has been done only for the starter problem which is an economic and financial measure. The methodology used to determine measures for main barriers identified was reformulating all the problems as positive statements and developing an "Objective / Solution Tree" (Annex III (C)).

The identified measures for addressing the barriers include provision of agricultural credit and loans to farmers; sufficient allocation of funds to the research institutions, establishing reliable supplies of inputs, functional seed market and efficient seed production and education on seed multiplication and awareness campaigns for the technology. The others are - improving communication and extension techniques; involvement of farmers in seed production; improving agricultural research, and timely release of varieties to the affected areas.

1.4.3.1 Economic and financial measures

The economic and financial measures are - provision of sufficient capital to the research institutions and seed producing farms, agricultural credit and loans to farmers and provision of affordable capital for applying new rice seeds. Seeds costs were not much high but to produce more yield, the inputs (chemical fertilizers, pesticides, etc,.) were required. The measures were analyzed using an objective which gives the measures to overcome the root cause barrier and the resultant effects.

1.4.3.2 Non-financial measures

Non -financial measures include improvement and upgrading of human resources for the rice seed production skills involving capacity building for both farmers and technicians. Enhancement of information and awareness will promote use of improved and new STR varieties. Taking into account the farmers' perception of reluctance of adoption of a new rice variety, the training on awareness raising will reduce social and cultural barriers and enhance community participation. It will also include providing adequate trainings to government staffs and farmers for seed production and multiplication techniques for the local farmers. It is expected that local communities will adopt the technology if measures for provision of credit facilities with low interest rates and improved institutional and organizational capacity are taken place.

1.4.4 Key barriers and measures identified for the "salinity tolerance rice varieties" technology

Barriers and measures for effective technology transfer and diffusion were identified through an extensive consultative process including literature reviews and expert inputs. The outcomes (measures) were validated through zoom meetings sharing the national and international experiences. These barriers and measures are discussed below under categories of economic and financial, and non-financial measures.

The financial measures include such factors as "Explore the international donor funding, Access the national and international investment, Provision of special credit and loans, Subsidize the cost of

production in the project phase". Regarding non-financial barriers, the measures are Improve policies and guidelines, provide trainings and education, Strengthen capacity of related organizations, Provision of sufficient fund and infrastructure to the research institutions and etc. The detail enabling measures were described in Table 1.13.

Table 0.13 Key barriers and measures identified for "Improvement of salinity tolerance rice varieties in coastal and inland salinity areas of Myanmar"

Barrier dimension	Main Barriers	Measures Identified
Economic and Financial Barriers		
Cost	High cost for the farmers for cultivation of new seeds, High cost for plant breeding program	• Explore the international donor funding, such as GEF, GCF, LIFT, etc., • Access the national and international investment on the technology, collaboration with foreign universities,
		• Provision of special credit and loans to farmers • Subsidize the cost of production in the initial years of technology introduction,
Non- Financial Barriers		
Policy, legal and regulatory	Limited policies which encourage the use of improved salinity tolerance rice seeds	• Improve policies and guidelines for technology development and transfer, • Support policies for long-term research,
		• Formulate and enact appropriate legislations and regulations on climate resilient agriculture, • Integration of climate change into the future development plans,
Technical	Limited training and education for technology development	• Provide trainings and education of the technology to the staff of DOA, Seed Division and farmers in salt affected areas,
Institutional and organizational capacity	Weak functioning of organizations and institutions	• Training to strengthen capacity of related organizations - DOA, agriculture universities, and colleges and research institutions, • Provide financial and technical supports to strengthen skills and education for technology development and transfer, • Build a strong collaboration among the related government organizations, and other stakeholders (Private seed companies, contract with seed producing farmers),

Barrier dimension	Main Barriers	Measures Identified
Research and development	Insufficient research work for the technology	• Provision of sufficient capital and infrastructure to the research institutions and seed producing farms; • Allocate sufficient research fund; • Upgrade institutional and organizational research capacity;
Information, awareness and networking	Limited knowledge of extension staff and farmers	• Encourage networking with farmers and producers of rice value added produce, Create contract farming system, • Establish functional markets; Strengthen market system support and financial service, • Conduct demonstration plots to disseminate the technology and its benefits.

1.5 Linkages of the barriers identified

Barriers to technology transfer and diffusion on climate change adaptation are unlikely to function independent of one another. Therefore, analyzing barriers in isolation will be less productive because such an approach tends to overlook more holistic and potentially more efficient opportunities to address their combined effects. The linkages between different barriers of the three prioritized technologies in the agriculture sector are analyzed so as to ensure maximizing synergies and optimize the benefits of recommended measures.

An approach of more holistic will bring about potentially more efficient opportunities to address their combined effects. Most of the barriers and measures to overcome barriers are technology specific and fall within broad categorization for barriers. However, close examination reveals some common elements among them.

It was noted the high cost was common to all three technologies as a barrier to the diffusion of technology. The root cause was the inability to have a credit facility which would assist the targeted farmers and technology developers to venture into the integrated production system. Regarding non-financial barriers, the common key barriers are limited policies and regulations which encourage the technology adoption. The inadequate instructional capacity, research and development activities due to the lack of fund and staff numbers were found to be key constraints for all technologies. Similarly, the barriers of low acceptance by the communities were true to all technologies. Therefore, providing awareness raising and trainings with demonstration plots is required to overcome the barriers on "high efficiency irrigation method, conservation farming and improved salt tolerance rice varieties.

1.6 Enabling framework for overcoming the barriers in the Agriculture Sector

It was noted that some common barriers address two or more of the prioritised technologies. Enabling measures are more technology specific at a detailed level. The technology specific enabling measures for the three common barriers are summarized in the Table 1.14. The barriers common to all technologies are: Inadequate Financing, Weak institutional capacity, limited policy framework encouraging the technology diffusion, Inadequate research and development. The enabling measures are – Set up financing mechanisms, Upgrade the institutional capacity, Establish subsidy schemes, Establish consultative mechanisms with the stakeholders, Support development of producer associations and Increase support to public and private research and development institutions.

Table 0.14 Enabling measures for the common barriers in Agriculture Sector

Common barriers	Technologies affected	Measures to overcome key barriers
Inadequate Financing	1, 2, 3	• Set up financing mechanisms for specific technology packages, • Introduce incentive packages, Establish subsidy scheme
Weak institutional capacity	1, 2, 3	• Upgrade institutional capacity,
Limited policy framework	1, 2, 3	• Set up policies and guidelines which are directly or indirectly encourage the use of technology • Support development of rice seed producer associations
Inadequate R&D	1, 2, 3	• Increase support to public and private R&D institutions

Note: 1 = Solar powered drip Irrigation; 2 = CA; 3 = Salinity Tolerance Rice technology

CHAPTER 2: WATER RESOURCE MANANGEMENT SECTOR

Myanmar is blessed with large water resources within the national borders and a number of trans-boundary and border rivers. A low number of 5% is being stated as the actual utilization rate of available fresh water. This implies ample availability, where the demand for water use is expected to grow with economic development and population increase (IWRM, 2014). The Ayeyarwady and the Chindwin Rivers are the main arteries of the country, running north-south, and important sources for navigation, irrigation and hydropower of the country. However, in the face of climate change, rainfall is unevenly distributed across the country over the seasons, leading to floods, flash floods and also to water shortages and droughts.

Under the TNA process, three water related adaptation technologies were prioritized with the application of MCA tool through the brainstorming efforts of several consultative stakeholders and Adaptation TWG meetings. The technologies were – (1) Renovation and improvement of village ponds and tube wells for better livelihoods in central Dry Zone, (2) Technology for flood disaster risk reduction in Ayeyarwady delta and (3) Drinking water purifying technology in remote villages.

Barriers anticipated for the implementation of these technologies consist of institutional capacities constraints, including research and information management, lack of climate change considerations in existing policies and strategies, weak law enforcement and limited financial resources to overcome high rural poverty prevalence. A number of measures / solutions are proposed for each technology, ranging from promoting research and information management to the strengthening of the roles, responsibilities and capabilities of the key institutions / ministries concerned.

2.1 Preliminary targets for technology transfer and diffusion

Myanmar has launched the first National Strategy and Investment Plan (2016-2030) for Rural Water Supply, Sanitation and Hygiene (WASH) in schools and in health facilities in 2016. The National Water Policy (NWP), 2014 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. Regarding with country's specific applicability and potential, the selected technologies are in line with the NWP of Myanmar, which is the first integrated water policy for the watersheds, rivers, lakes and reservoirs, groundwater aquifers and coastal and marine waters. Myanmar's Water Vision also 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 first and third proposed technologies of TNA adaptation are to address safe water supply for domestic consumption, and are concerned with the section of rural water supply and the rural health care of Department of Rural Development (DRD), under the MOALI. The second prioritized technology is to address the disaster management, particularly flood for the river basin areas of the delta of Myanmar. The technology is related with IWUMD (Irrigation and Water Utilization Management Department) of MOALI. Therefore, the implementation of technologies in "water resource management" sector requires joint commitments of two departments, namely DRD and IWUMD, under the MOALI.

Preliminary target for the proposed technologies aimed at reducing the drinking water scarcity in the dry zone while disaster risks management for floods in the river basin areas of Ayeyarwady delta which happens more often under the climate change. All technologies will be implemented through community participatory activities and they are briefly described below.

(i) For technology 1, it is proposed that in each village of targeted sites, 1 or 2 village ponds will be renovated while 3 -5 deep tube wells will be set up; some for new installation and the old ones which are not in operation will be repaired as necessary. The "Recharge Shaft" will also be installed wherever possible. The number of project

site is 10 villages each in 2 townships, namely Myingyan and Nwahtogyi Townships of Mandalay Region. The project will cover 20 villages with the beneficiaries of more than 20,000 households. The project will help rural development in the dry zone and it will be conducted within a period of seven years. Moreover, the preliminary target for shallow tube wells as a drought intervention for domestic water supply is introduction of 100 hand pump boreholes/tube wells in the dry zone where suitable hydrogeological conditions are available. The project will be completed within a period of seven years**.**

(ii) Flood control with structural and non-structural counter measures will be introduced to prevent the disaster and reduce socioeconomic losses. Flood inundation maps will be produced for flood risk management. The effectiveness of existing counter measures will also be examined for design return period flood events. The new additional countermeasures will be developed for future disaster risk reduction plan. It will reduce the flood inundation depth and duration depending on the selection of effective countermeasures. The project site was proposed along the Ayeyarwady River in Hinthada Township. The proposed project includes the construction of 3 m levee along the left or right river bank, and the channel modification in the main river combination with dredging in the tributaries. The channel widening in the main river stream combination with dredging in the tributaries will reduce the large area from flooding. It includes river channel widening for 150m and tributaries widening for 80m and 30m in the downstream area where more inundation occurred. Estimation of damage by flooding will be conducted for flood mitigation measures and it needs long term flood control plans and emergency management.

(iii) The technology on "Drinking water purifying technology in remote villages" will be targeted in the rural area with the most serious impurity of drinking water problem, such as delta area of Ayeyarwady and Yangon Regions. Water purifying plants for village level will be installed to improve the health and quality of life through sustainable access to safe drinking water. In order to achieve these targets, the stakeholders include policy makers in related government ministries and departments. Other players include manufacturers of technology components, wholesalers and retailers, technicians and experts in rural water management sector. The implementers including women and youth groups at local level, CBOs and NGOs dealing with water issues at local and national levels and community leaders will be key players in the transfer and diffusion of the technologies in the water sector.

2.2 Barrier analysis and possible enabling measures for technology on "Renovation and improvement of village ponds and tube wells for better livelihoods in Myanmar Dry Zone"

2.2.1 General description of the technology

Village ponds/ tanks get water from surface water bodies, runoff and from direct rainfall. Over the centuries, these ponds have acted as insulation against droughts, helped in recharging groundwater, functioned as a source of multiple uses for the village community (drinking water, household use, water for livestock and wildlife, fishing, etc.). Restoration/rehabilitation of silted or damaged village ponds in vulnerable areas will contribute to adaptation for climate change by diversification of water

supply, storm water control and groundwater recharge. Many of these facilities were constructed decades ago, and many were abandoned and not functional these days. The main cause was the limited budget for maintenance of government and local communities. It was compounded by the climate change impact (drought and floods) which often damaged theses infrastructure. People usually repair their ponds with their collective efforts every year before the rainy season starts. They usually did, as an ad hoc repair, raising bunds and clearing the silts of the spillways of ponds/ tanks. Groundwater extraction became common in Myanmar since 1990s and boreholes/ tube wells were dug for village level (community) and for individual household level across Myanmar. The highest numbers of tube wells are found in central dry zone area of Ayeyarwady and Chindwin river basins where the water aquifer is sufficient for extraction.

Current status of the technology

Rural villages of dry zone and many other areas traditionally possess communal village pond/tanks, at least 2-3 numbers in each village. Most of them can accommodate for drinking and household water use for the whole village while some for irrigation. Tube wells for underground water for irrigation were recorded as 12,258 facilities, (including ground water facilities of 7,734 deep tube wells and 4,524 shallow tube wells) were completed covering the beneficial area of 65,695 ha across Myanmar (DAP, MOALI, 2014). The largest numbers found in Mandalay, Sagaing and Magway Regions. The responsible department for irrigation is IWUMD of MOALI.

In the past (during 1952 to 1995), underground water facilities (Tube wells) were constructed by the Agriculture and Rural Development Corporation (ARDC) under the Ministry of Agriculture and Forestry (MOAF). About 80% of the underground water facilities were installed during that period. After 1995, Water Resource Utilization Department (WRUD) was established under the Ministry of Agriculture and Irrigation (MOAI) and it took the responsibility of underground water facilities. The total tube wells were 34,479 numbers in 2014 supporting the rural population of more than 14 Million. (Source: DAP, 2014)

Technology category and market characteristics

The technology can be categorized as a public good when established at community level and other non-market good category when adopted by individual households. The option taken in this report is community level water harvesting system which is a public good. It contributes to the provision of public benefits and services; the technology is transferred and diffused under nonmarket, governments, public or nonprofit institutions, international donors or NGOs.

For the marketing, there are qualified registered organizations / private company for construction of boreholes where the contractor providing all labor, transport, tools, equipment and materials and other components. The contractor has to ensure successful implementation of all stages of the construction including locating sites for drilling and construction of the boreholes. Moreover, it includes all related subsidiary activities such as installation of pumps, chemicals and biological water quality testing, chlorination, etc.

2.2.2 Identification of barriers for the technology on "Renovation and improvement of village ponds and tube wells"

For the initial step of the process, the consultant conducted a desk study of policy papers and other appropriate documents to identify the reasons why the technology is not currently in widespread use, and why neither the private nor public sectors have invested significantly in it. The study was supplemented by interviews with experts and stakeholders. It also included available relevant assessments. The barriers were randomly identified by the consultants through literature review and expert knowledge and consultation with the stakeholders and Adaptation TWG during workshops and brain storming sessions. The processes of BA, such as identification of barriers, barrier screening and etc. were similar to the processes described in the Agriculture Sector of Chapter 1. In addition to

the online meetings, to access more information for barrier analysis and enabling measures, the consultant organized the (KII) and meetings with high level staffs. The meetings were arranged to discuss with Directors and Deputy Director General of relevant government departments of IWUMD and DZGD, Mandalay Region on 13 May, 2020 and 5 June 2020, respectively. The participants of KII were presented in Attachment IX (A) and (B).

Two levels of barriers were identified and categorized as "Economic and financial", such as high initial cost, inadequate access to financial resources, and "Non- financial", such as technology needs, insufficient capacity among the local community, Environmental impacts and climate change, etc., (Table 2.1).

Table 0.1 Categorization and description of barriers for "Renovation and improvement of village ponds and tube wells"

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
Economic and Financial	Cost	High initial cost of renovation and maintenance	• High price of construction materials; high transaction costs, • The construction machines such as excavator, bulldozer, etc., are imported and expensive, and the hiring costs are high accordingly, • Local communities cannot afford the technology without any funding support,
		High rate of loans and credits for technology developers	• Limited effective credit and loan systems for developers and producers,
Non-financial	Policy, legal and regulatory	Limited legal and regulatory framework for water management for rural communities	• Many boreholes /tube wells are widely installed in villages without any regulation and guidelines for the ground water extraction, • "Underground water law" has been recently submitted to the Parliamentary for approval, • In general, the existing policies and guidelines do not include the climate change adaptation consideration, • Limited laws and policies encouraging the proper rural water supply
	Technical	Low Technology knowledge and skills	• The community has limited technical knowhow for renovation, improvement and maintenance of the ponds and tube wells, • Data on underground water resources is not adequate and updated, • Poor standards, codes for certification for village pond and tube wells,

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
	Institutional and organizational capacity	Limited institutional and organizational capacity	• In general, the related government institutions DRD of MOALI, Ministry of Health and Sports (MOHS), and Ministry of Education (MOE) have insufficient human resources in the field of hydrology, groundwater, etc.
	Research and development	Weakness in research for the proper development and adoption of the technology	• Inadequate assessments on ground water quality and availability, and hydrogeology of various sites across the country, • Inadequate feasibility study for the hydrology and ground water access of the country, • Limited groundwater survey equipment, exploration machines and monitoring equipment
	Information and awareness	Inadequate information and knowledge related with the technology	• The community has limited knowledge of the safe and clean water and Water scarcity in future climate change scenario, • Limited knowledge how to renovate or repair the facilities which are not in working condition,
	Farmers' skill	Limited skills for maintenance and repair of the existing water supply facilities	• Long time lack of maintenance due to the technical and financial constraints, • When the facility is in failure, very few community people can fix the facility up.
	Social and cultural	Farmers' weak participation in the technology	• Lack of sense of ownership of the technology, • Weak community organizations and limited participation,

Screening of barriers

Barrier identification resulted in a long list of barriers gathered from various documents, interviews and/or the open-minded and nonselective recording of all ideas suggested by workshop participants. The draft long lists of barriers for three technologies were described in the Attachment X (A), (B) and (C). When all the conceivable barriers have been identified, they need to be screened according to their significance. The brief meeting notes of the discussions held regarding screening of barriers for Water Sector (on 17 June 2020 – Zoom meeting) were presented in Attachment XI. Then, the feedbacks and comments on the draft BA-EF Report were given by the various stakeholders through E-mails to ECD. Brief notes from these comments were described in the Attachment XII for the Water Sector.

During the stakeholder meeting, the participants argued for and against the listed barriers and the agreement was reached by consensus or majority for each barriers. The process was done to identify

(1) the essential barriers – the barriers which definitely need to be addressed for technology transfer and diffusion to occur;

(2) the non-essential barriers – to be discarded and subsequently ignored. A simple voting method was used for screening; the long list of barriers was sorted into key and non-key barriers, thus keeping the focus on the objective of the transfer and diffusion of the technology.

In this way, the categorized identified barriers were screened according to their significance in the adoption and diffusion of technology. The main barriers are identified, which definitely needs to be addressed for effective transfer and diffusion of the "Renovation and improvement of village ponds and tube wells" technology. This step was done through brainstorming and discussion sessions with stakeholders and Adaptation TWG in a series of workshop. Then, it was reviewed by the TNA Team. The following barriers were selected for further analysis:

- High cost of renovation and maintenance
- Limited legal and regulatory framework for water management
- Low human resource capacity and facilities for extension services
- Insufficient research funds
- Lack of trainings and workshops for the technology dissemination

2.2.2.1 Economic and financial barriers

The screened barriers were decomposed through discussion to check whether some barriers are actually composed of some of the other barriers, or whether one barrier is just more concrete. Economic and financial barriers were identified as key and decomposed in two levels: high cost of renovation, and resource poor communities (Table 2.2). Villagers can only contribute labor and manpower to the construction of village ponds, hand dug wells and tube wells. Even when construction costs are fully borne by donors, there are cases that villagers will be unable to fund spare parts for future maintenance and repairs. It explained the prevalence of low quality/ low maintenance tube wells and village ponds in rural Myanmar. Decomposition of the economic and financial barrier revealed that the high cost of initial installation and renovation is associated with high cost of the construction and there are very few local technicians and constructers which create more cost for communities. The detailed logical problem analysis was described on barriers for this technology in the Problem Tree of Annex IV (A).

Table 0.2 Decomposition of economic and financial barriers for "Renovation and improvement of village ponds and tube wells"

Barrier dimension	Main Barrier	Elements of a barrier
Economic and Financial	High cost of renovation and maintenance	• High cost of labors, high hiring cost of heavy machinery, • Limited access to financial support for investment and maintenance, • Inadequate national and international funds

	Resource poor communities	• Communities cannot bear the cost of renovation/ construction and maintenance cost

After decomposing the barriers, the consultants analyzed the causal relations between the decomposed barriers by looking at the main barrier or the starter problem, which is high cost of initial installation. The casual relationship was done by looking at root causes of barrier and the effects of barriers on the communities. The analysis showed that the high cost of initial installation of the technology is due to cost of components of construction as a result of high cost of credit facilities, inadequate credit facilities and high interest rates of the developers.

2.2.2.2 Non-financial barriers

One of the main non-financial barriers is the limited legal and regulatory framework for water resource management. The other barriers include technical requirement for planning, installation and maintenance of village ponds and tube wells. Besides, specialized experts' skills for implementation are inadequate. Currently, there are very few trained technicians for this technology in Myanmar. Moreover, inadequate awareness and low education levels of communities are significant constraints for the acceptance of safe and clean water for their daily life. Therefore, awareness trainings for water, sanitation and health issues to communities are required as a basic knowledge. The capacity building of technicians is also required to enable them to adopt and distribute this technology.

Table 0.3 Decomposition of non- financial barriers for "Renovation and improvement of village ponds and tube wells"

Barrier dimension	Main Barrier	Elements of a barrier
Policy, legal and regulatory	Limited legal and regulatory framework for water resource management	• Limited policies and guidelines encouraging the improvement of rural water supply, and health issues, • Limited policies/ laws to control drilling of new boreholes/tube wells which will affect vulnerable aquifers,
Technical	Low technology knowledge and skills	• Limited local experts and technicians, • Limited standard requirements and feasibility studies for the technology adoption, • Limited data on underground water resources,
Institutional and organizational capacity	Limited institutional and organizational capacity	• Low human resource capacity and facilities for extension services of related departments and ministries, • Inadequate assessments on ground water quality and availability, and hydrogeology of various sites across the country,
Research and development	Weakness in research and development activities	• Very few research institutions, and insufficient technicians, • Inadequate research funds, • Weak in survey research status of aquifers in dry zone and across the country,

Barrier dimension	Main Barrier	Elements of a barrier
Information and Awareness	Inadequate information and knowledge related with the technology	• Few trainings and workshops for the technology dissemination (safe and clean water and future climate change scenario, etc.,) in rural area,
Farmers' skill	Limited skills for maintenance and repair of the existing water supply facilities	• A few technicians for maintenance and repair (e.g. failure of tube well),
Social and cultural	Farmers' weak participation in the technology	• Lack of sense of ownership of the technology, not value the benefit of safe drinking water in some cases

2.2.3 Identified measures of "Renovation and improvement of village ponds and tube wells"

The process of identification of measures was undertaken by the consultant and stakeholders during a series of stakeholder consultation workshop. These measures were also evaluated by the Adaptation TWG and the TNA team. During the process, application of the knowledge and literature review including market chain analysis of the consultant combined with the stakeholders' experiences and advice, the measures were identified. This has been done only for the starter problem which is an economic and financial measure. The key barriers for transfer and diffusion of the technology and the enabling measures to overcome these barriers are presented in Table2.4.

2.2.3.1 Economic and financial measures

The measures were analyzed using an "objective tree" which gives the measures to overcome the root cause barrier and the resultant effects. The key barriers and solution measures were presented in the "Objective Tree or Solution Tree" in Annex IV (B). Economic and financial measures should be put in place to reduce interest rates and increase credit facilities leading to adequate credit for the entrepreneurs and constructers. If measures to train more technicians are undertaken, it will result in more specialized manpower leading to more service delivery. This will contribute to lowering the cost of initial installation and construction. The implementation of these measures will result in more number of villages under this technology.

2.2.3.2 Non-financial measures

Non-financial measures include development of human skill involving capacity building for both farmers and technicians. Enhancement of information and awareness will promote the knowledge of water, sanitation and health of the rural communities. It will, in turn, reduce social and cultural barriers and enhance community participation. The enabling measures for the inadequate Government commitment includes to pursue the government to increase the budgetary allocations for the rural development programs and provide assistance to the responsible agencies to promote for consuming of safe and clean water for rural community. Awareness programs for senior management of the respective organizations to enable appreciating the need for the rural health.

2.2.4 Key barriers and measures identified for the "Renovation and improvement of village ponds and tube wells"

Barriers and measures for effective technology transfer and diffusion were identified through an extensive consultative process including literature reviews and expert inputs. The outcome was validated using zoom meetings, sharing the national and international experiences to overcome these barriers. These barriers and measures are described below (Table 2.4) under categories of economic & financial and non-financial measures.

Table 0.4 Key barriers and measures identified for the "Renovation and improvement of village ponds and tube wells for better livelihoods in Myanmar Dry Zone"

Barrier dimension	Main Barriers	Measures Identified
Economic and Financial		
Cost	High capital cost	• Obtain funds / loans/ grants from national and international donor agencies such as the World Bank, ADB, LIFT, IFAD etc., • Take appropriate steps to reduce the investment (capital) cost through reducing cost of equipment and construction - partially community contributions in terms of labor,
	High interest rates of loans for importers/producers of constructers	• Establish a low interest loan scheme for importers/ producers of construction of the rural development programs
Non- financial		
Policy, legal and regulatory	Lack of policies/ laws to control drilling of boreholes affecting vulnerable aquifers	• "Underground water law" has recently submitted to the Parliamentary for approval, • When the "Underground water policy, law and its rules and instructions are released, people are encouraging to strictly follow them, for implementing this technology, • Set up more laws and policy encouraging the rural water supply and health improvement,
	Limited policies and guidelines encouraging health, water and sanitation	• Pursue the government to increase the budgetary allocations for the rural water development programs, • Set up the policy guidelines to promote the community health and prevent the water borne diseases, • Formulate laws/guidelines for safe and sustainable use of ground water,
Technical	Lack of standards, codes and certification for the adoption of technology	• Formulate a mechanism for establishing standards, codes and certification systems for village ponds and tube wells, • Improve and update the data on underground water resources

Institutional and organizational capacity	Limited institutional and organizational capacity	• Recruit the qualified staffs and technicians, • Provide trainings and higher education studies, • Make adequate assessments on ground water quality and availability, and hydrogeology of various sites across the country,
Research and development	Limited research and development activities	• Allocate additional funds for supporting the research, • Promote R & D on ground water quality and hydrogeology of various sites for suitability assessment,
	Very few research institutions,	• Initiate research institutions, training centers for the technology
Social and cultural	Weak involvement of community in the technology implementation and maintenance	• Strengthen Farmer Organizations and increase involvement of farmers starting in planning and decision-making stage, • For the sense of ownership, make labor contribution from the community, and form Water user groups for the facilities for long term maintenance, • Create employments during construction period and payments for communities (Food for work program),

2.3 Barrier analysis and possible enabling measures for "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

2.3.1 General description of the technology

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

Coastal areas are flooded by storm surges combining with high tides and large wave events at sea, resulting in waves over-topping flood defenses 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 with large catchment areas. The increase in flow may be the result of sustained rainfall, rapid snow melt, monsoons, or tropical cyclones. 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 outdated 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.

Current status of the technology

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 the 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 died after heavy rain triggered a massive landslide in Paung Township, Mon State.

The Coastal dikes were constructed in coastal regions in Rakhine State, Ayeyarwady and Sittaung delta, Mon State and Tanintharyi Region for flood management. There are, currently, 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 of in the river, which occurs as a result of deforestation in catchment area. Continuous and gradual rising of river bed level would entail the raising of dikes. Myanmar government has limited funding for strengthening, rehabilitation and maintenance of these embankments. The condition is exaggerated by the occurrence of floods and cyclone with more intensity and frequency in the face of climate change. These conditions necessitate both raising and strengthening of the existing embankments in an urgent manner. Similarly, new installation of embankments is required for the long-term disaster risk reduction.

For the flood risk management in river basin areas of Myanmar, renovation and repair work of existing dikes in Ayeyarwady Region will be conducted. For the flood protection, investigation is needed to determine the weak portions of the dikes for rehabilitations and appropriate maintenance measures. The possibility of overtopping of embankment increases. The project may take a long time of implementation (about ten years).

2.3.2 Identification of barriers for the "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

The barrier identification and the screen processes were done in the same procedures as in the previous section of agriculture sector. The barriers were randomly identified by the consultants through literature review and expert knowledge and consultation with the stakeholders and Adaptation TWG, and through the brain storming discussion during the consultation workshops. Two levels of barriers were identified as "Economic and financial", such as high initial cost, inadequate access to financial resources, and "Non- financial", such as technology needs, insufficient capacity among the local community, institutional capacity, research and development, etc., (Table 2.5).

Table 0.5 Categorization and description of barriers for "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
Economic and financial	Cost	Huge investment and maintenance costs,	• Huge investment for construction of infrastructure for protection of floods dykes/ embankments, polders, • Incremental costs to adapt to climate change, • High cost of construction materials, high price of labor cost,

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
			• Limited Natural Disaster Management Fund, and limited support from national and international donor,
Non - financial	Policy, legal and regulatory	Limited laws policies and guidelines which encourage Flood Disaster Risk Management (DRM)	• Limited implementation of existing Natural Disaster Management Law (2013) and Myanmar Action Plan on Disaster Risk Reduction (MAPDRR) (2017), • Limited national disaster management activities to meet the Myanmar National Framework for Community Disaster Resilience, • Weak integration of DRM in the future development plans and project, • Limited regulations and an appropriate modality for the river basins management and flood disaster protection,
	Technical	Low level of technology	• Insufficient data and information to identify areas at risk of flooding, and consequently to improve flood risk management and disaster preparedness, • Limited "Hazard and risk assessment and mapping" in hazard prone areas
	Institutional and organizational capacity	Weakness in institutional capacity,	• Insufficient database on water resources and river basin environment, • Limited social, economic and environmental impact assessments when building sea dykes, • Weak collaboration among the lead ministries, such as MOSWRR, MOH, MOALI, DMH and etc.
	Research and development	Limited research and development activities	• Insufficient observation data or long-term research on natural conditions (wind, storm, tide or sea-level rise, etc.), • Low research activities on flood disaster management, flood disaster impact assessment, etc.
	Information and awareness	Poor information on water related	• Community has very low information and awareness on DRM processes,

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
		hazards	• Limited understanding of water related hazards under the climate change, • Inadequate community awareness of flood preparation and avoidance,
	Social and cultural and people participation	Communities weak participation in DRM processes	• Weak community organizations and limited participation of the community in the technology adoption,

Screening of barriers

The categorized identified barriers were screened according to their significance in the adoption and diffusion of technology. The main barriers are identified, which definitely needs to be addressed for effective transfer and diffusion of the "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar". The long list of barriers before screening process was described in the Attachment VIII. This step was done with a simple voting method through brainstorming and discussion sessions with stakeholders and Adaptation TWG in a series of workshop. Then, it was reviewed by the TNA Team. The following barriers were selected for further analysis:

- Huge cost of new installation or renovation and maintenance,
- High requirement of technology and trained experts
- Limited laws, policies and guidelines
- Low level of technology related with hydrology and flood risks
- Weakness in institutional capacity
- Limited Research and development activities

2.3.2.1 Economic and financial barriers

The screened barriers were decomposed through discussion to check whether some barriers are actually composed of some of the other barriers, or whether one barrier is just more concrete. Economic and financial barriers were identified as key and decomposed in two levels (Table 2.6). Decomposition of the economic and financial barrier revealed that the high cost of initial installation and renovation is associated with high cost of the construction and inadequate access to financial resources.

The cost of deployment and application of technology depends on cost databases, construction coordination model of river basin management, training, labor. Incremental costs to adapt to climate change will also be high depending on the adverse impacts of climate change. Sea dikes were constructed in a large scale in Myanmar in 1990s but they have been degraded in many parts ever since. Currently, Myanmar has more than 2000 km of sea dikes embankments of which many passages have deteriorated that need strengthening. The flood protected sea dikes and embankments were constructed in Ayeyarwady Region, Yangon Region, Rakhine State and Mon State (DOP, 2019).

Table 0.6 Decomposition of economic and financial barriers for "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

Barrier dimension	Main barrier	Elements of a barrier
Cost	Large investment and maintenance costs	• High construction materials, hiring machineries, and high labor cost and high labor requirement, • Limited credit facilities for developers
	Inadequate access to financial resources	• Limited government budget, Natural Disaster Management Fund, • Limited access of contribution and donation from foreign countries, international organizations and external regional organizations,

After decomposing the barriers, the consultants analyzed the causal relations between the decomposed barriers by looking at the main barrier or the starter problem, which is high cost of initial installation. The casual relationship was done by looking at root causes of barrier and the effects of barriers on the communities. The analysis showed that the high cost of initial installation of the technology is due to cost of components of construction materials as a result of high cost of credit facilities, and high cost of labor, etc. The detailed logical problem analysis was described on barriers for this technology in the Problem Tree of Annex V (A). Based on this, the root causes were identified by decomposing each barrier shown in the following tables.

2.3.2.2 Non-financial barriers

The main non-financial barrier is technical requirement for planning, installation or renovation of existing embankments and dykes. They also include high qualified experts' skills for implementation. Currently, there are very few trained technicians and academician in research and development for this technology in Myanmar. Besides, inadequate awareness and low education levels related with the technology are the major constraints for maintenance and sustainable use of the technology. The non-financial barriers also include the limited implementation and enforcement of existing Natural Disaster Management Law and MAPDRR. The awareness trainings for DRR and DRM technologies to communities and the capacity building of technicians are required to enable them to adopt and distribute this technology. The decomposition of non- financial barriers was shown in Table 2.7.

Table 0.7 Decomposition of non- financial barriers for "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

Barrier dimension	Main barrier	Elements of a barrier
Policy, legal and regulatory	Limited laws, policies and guidelines which encourage flood Disaster Risk Management (DRM)	• Limited implementation and enforcement of existing Natural Disaster Management Law and Myanmar Action Plan on Disaster Risk Reduction and National Framework for Community Disaster Resilience, • Limited policies/ laws to control and maintenance of existing polders and dykes, • Inefficient enforcement of national policies related with the DRM processes

Barrier dimension	Main barrier	Elements of a barrier
Technical	Low level of technology related with hydrology and flood risks under climate change	• Limited technological knowledge and low education levels related with the technology • Inadequate "Hazard and risk assessment and mapping" to identify areas at risk of flooding, and consequently to improve flood risk management and disaster preparedness, • Insufficient database on water resources and river basin environment,
Institutional and organizational capacity	Weakness in institutional capacity for the technology implementation	• Insufficient numbers of technicians, experts and extension agents, • Weak collaboration and networking among the lead ministries,
Research and development	Limited Research and development activities	• very few trained technicians and academician in research and development • Insufficient observation data or long-term research on natural conditions (wind, storm, tide or sea-level rise, etc.), and water related hazards, • Limited updated infrastructures and facilities for conducting related research, • Inadequate staff and research funds for the technology,
Information and awareness	Poor information on water related hazards	• Very few trainings and awareness raising activities to the community, • Poor accessibility for information on rainfall and weather data at the village level,
Social and cultural and people participation	Weak community organizations and limited participation of local community	• Limited participation of communities in planning, decision making and implementation of project activities, • Weak networking among government organizations and private sectors, LNGOs and INGOs and the local community,

2.3.3 Identified measures of "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

The process of identification of measures was undertaken by the consultants and stakeholders during a series of stakeholder consultation workshop. These measures were also evaluated by the Adaptation TWG and the TNA project team. During the process, application of the knowledge and literature review including market chain analysis of the consultant combined with the stakeholders' experiences and advice, the measures were identified. This has been done only for the starter problem which is an economic and financial measure.

2.3.3.1 Economic and financial measures

The measures were analyzed using an "Solution Tree" which gives the measures to overcome the root cause barrier and the resultant effects (Annex V (B)). Economic and financial measures should

be put in place to reduce interest rates and increase credit facilities leading to adequate credit for the entrepreneurs and constructers. The internal and external funding agencies will be approached for long term loans and grants. For the human power development, the post graduate programs will be introduced for specialized subjects, such as hydrological hazards and flood DRM, leading to more human resource development and improved service delivery. The adequate funds for research and development programs related with flood disaster will be set up.

2.3.3.2 Non-financial measures

Non-financial measures include development of human skill involving capacity building for both communities and technicians. Enhancement of information and awareness will promote the knowledge of hydrological hazards of the rural communities. It will, in turn, mitigate the social and economic losses and enhance community resilience to disasters.

2.3.4 Key barriers and measures identified for the "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

Barriers and measures for effective technology transfer and diffusion were identified through an extensive consultative process including literature reviews and expert inputs. The outcome was validated using zoom meetings, sharing the national and international experiences to overcome these barriers. These key barriers and measures are discussed below (Table 2.8) under categories of economic and financial and non-financial measures.

Table 0.8 Key barriers and measures identified for the "Technology for flood disaster risk reduction in Ayeyarwady delta of Myanmar"

Barrier dimension	Main barrier	Measures identified
Economic and Financial Barriers		
Cost	High capital and maintenance cost	• Set sufficient national budget for DRM. • Explore the contribution and donation from foreign countries, international organizations and external regional organizations, • Access to the contributions and donations of local bodies, well-wishers in local and foreign, civil societies and other non-government organizations, • Increase International collaboration for DRM, • Obtain loans and grants from international funding agencies such as GEF, GCF, ADB, WB etc.
Non- Financial Barriers		
Policy, legal and regulatory	Inadequate laws policies and guidelines which encourage Disaster Risk Management (DRM)	• Formulate the relevant laws and regulations for DRM, • Set up policies/ laws encouraging to construct new infrastructure, renovation and maintenance of existing polders, embankments and dykes, wherever required,
	Inefficient enforcement of national DRM law, action plan and framework	• Implement the existing Natural Disaster Management Law and action plans more effectively and efficiently,

Barrier dimension	Main barrier	Measures identified
		• More active implementation of the pre-disaster stage of the flood disaster
Technical	• Low level of technology related with hydrology and flood risks	• Introduce and implement "Flood hazard assessment and mapping", to identify areas at risk of flooding, and consequently to improve flood risk management and disaster preparedness, • Improve database on water resources and river basin environment,
Institutional and organizational capacity	Weak institutional capacity for the technology implementation Insufficient numbers of technicians, experts and extension officers	• Promote institutional and organizational capacity by financial and human development support • Recruit the staff and upgrade their capacity by giving trainings and further graduate studies, majoring the DRM technology, • More actively engagement in the DRR Working Group, • Carry out better improvement on early warning system of natural disaster,
	Weak collaboration among related ministries and organizations	• Promote collaboration among related ministries and organizations for the success of DRM,
Research and development	Limited research and development activities for the technology	• Improve understanding on hydrology by promoting R & D, • Promote R &D on flood occurrence and survey data and analysis, • Encourage research activities on flood disaster management, flood disaster impact assessment, etc.,
Information and awareness	Poor understanding of water related hazards of the community, Poor accessibility for information on rainfall and weather data	• Enhancing the community awareness of flood preparation and avoidance, • Dissemination of flood warning to local levels in time, • Encouraging public participation in monitoring, management and resolution of flooding, • Improve information and data dissemination policies of DMH,

2.4 Barrier analysis and possible enabling measures for "Water purifying technology in remote villages in Myanmar"

2.4.1 General description of the technology

In many rural villages, multiple sources are used to access domestic water supplies seasonally. Drinking water is primarily accessed from wells and ponds. Village ponds often dry out early in the dry season and villagers will then revert to more reliable subsurface supplies. Substantial gains have

been made in developing safe water supplies since the mid-1980s, when only one-fifth of village domestic supplies were derived from tube wells, but unprotected shallow dug wells are still a relatively important source of water within villages. The high mortality rate of children under 5 years old (38 per 1,000 live births) is partly attributed to waterborne diseases from unprotected sources (IWMI, 2015).

In the Ayeyarwady delta where rainfalls are fairly high, rainwater harvesting is common for individual households and stream water, village ponds and hand dug wells are traditional practices of many rural areas. The surface water, such as creeks and rivers, shows high turbidity while the groundwater is limited due to the high contamination of arsenic in some areas. of Ayeyarwady Delta area. In this region, problems may range from arsenic and iron contamination in groundwater to pesticide residue and fecal bacteria contamination and concentrating in open ponds. Storage of rainwater was mainly done in small capacity, storing in jars to meet several days or weeks of domestic consumptions. Improved rainwater harvesting technology in large scale are seen mostly in schools, monasteries and health centers of rural villages introduced in a few decades ago, funded by NGOs, UNDP and several other development partners. When the rainwater is used up, the river water is pumped into these containers for siltation.

Status of technology in country

The drinking water source of most urban people is bottle/ purified 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. Some NGOs and INGOs donated the medium and large-scale water purifiers to the several villages in Ayeyarwaddy regions after the devastation of Cyclone Nargis in 2008. Water purifier plants were installed in several villages in Pyapon and Mawlamyaing Kyun Townships of Ayeyarwaddy Region by local NGOs supported by the development funding agencies. For example, the FREDA (Forest Resource Environment Conservation and Development Association), a local NGO constructed three water purifying plants in Pyapon Township in 2014 - 2016. The villagers can access the purified water at a cheap price, with a share for the fuel cost of the operation.

Water purifying plants for village level will be introduced to improve the health and quality of life through sustainable access to safe drinking water.

In order to achieve these targets, the stakeholders and players include policy makers in related government ministries and departments. Other players include manufacturers of technology components, wholesalers and retailers, technicians and experts in water and irrigation sector. The implementers including women and youth groups at local level, CBOs and NGOs dealing with water issues at local and national levels and community leaders will be key players in the transfer and diffusion of the technologies in the water sector.

2.4.2 Identification of barriers for the technology on “Water purifying technology in remote villages

The barriers were randomly identified by the consultants based on the literature review and expert knowledge and consultation with the stakeholders and Adaptation TWG during workshops and brain storming sessions. Two levels of barriers were identified as “Economic and financial”, such as high initial cost, inadequate access to financial resources, and “Non- financial”, such as technology needs, resource poor and limited information and knowledge among the rural community, etc. The result of categorization and description of barriers description were described in Table 2.9.

Table 0.9 Categorization and description of barriers for "Drinking water purifying technology in remote villages"

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
Economic and Financial	Cost	• High cost of installation and maintenance, • inadequate access to financial resources •	•High cost of construction materials, high price of imported materials, high transaction costs, high labor cost, •High operation cost of diesel where the national electricity is unavailable, •Limited financial support, •Inadequate credit and loan for community to construct the infrastructure by the village community, •The interest's rates of government's banking loans or cooperate with local banks are 15%, in general. The entrepreneurs want to access loan with their affordable interest rates is less than 10%.
Non-Financial	Law, policy and regulatory	Limited policy and guidelines to support the health, water and sanitation	• Limited laws/ guidelines to encourage the consuming of safe and clean water in rural areas, • Very few policies and regulations for prohibition of use of unsafe water for the community (e.g., contaminated with Arsenic, salt and impurity with water borne diseases, etc.)
	Technical	Limited technology for installation and maintenance	• Few technicians for the technology, • The community has limited technical knowhow for repair and maintenance of the water purifying plants
		Lack of standards of the water purifying plant and facility	• Lack of standards, codes for certification for water purifiers
	Institutional and organizational capacity	Weak in institutional and organizational capacity	• Low capacity for the extension services, • Insufficiency in capacity of related ministries and departments for the technology dissemination (such as MOHS, MOALI, MOE, etc.)
	Research and development	Limited research programs for safe water supply in village community	• Low institutional capacity on research and development, • Low researches on Arsenic / salt contamination in ground water and water borne diseases of surface water, • A few numbers of research institutions and laboratories for the water quality test,
	Information and Awareness	Limited awareness of community on safe water and	• The technology has been used in urban areas but it is not widely utilized in rural villages,

Barrier Category	Barrier dimension	Main Barrier	Barrier Description
		health issues	• Insufficient awareness of the technology, • Inadequate information and knowledge of the advantages of safe and clean water, • Low awareness of environmental issues of surface water polluted by agro-chemicals, drinking water scarcity and impurity,
	Social, Cultural and Behavioral	Low preference of good /purified water	• Due to the very low knowledge on health issues, rural communities do not value the safe drinking water. They prefer their conventional source of water, such as ponds, wells and streams, • Many villagers are not accustomed to the taste and smell (Chlorinated water) of the purified water,

Screening of barriers

The barrier identification and screening processes were done in the same way as mentioned in the previous technologies. The long list of barriers for screening was described in the Attachment VIII. The categorized identified barriers were screened according to their significance in the adoption and diffusion of technology. The main barriers are identified, which definitely needs to be addressed for effective transfer and diffusion of the "Water purifying technology in remote villages". This step was done through brainstorming and discussion sessions with stakeholders, Adaptation TWG and the national TNA Team in a series of workshop. The following barriers were selected for further analysis:

(i) High cost of installation and maintenance
(ii) Human skills requirement for installation and monitoring the technology
(iii) Inadequate extension services for water, sanitation and health issues in rural areas

2.4.2.1 Economic and financial barriers

The screened barriers were decomposed through discussion to check whether some barriers are actually composed of some of the other barriers, or whether one barrier is just more concrete. Economic and financial barriers were identified as key and decomposed in two levels (Table 2.10). Decomposition of the economic and financial barrier revealed that the high cost of initial installation is associated with high cost of the construction and there are very few financial sources with reasonable interest rates for the developers and dealers of the technology. In addition, insufficient local technicians for the technology create more cost for communities. The detailed logical problem analysis was described on barriers for this technology in the Problem Tree of Annex VI (A).

Table 0.10 Decomposition of economic and financial barriers for "Drinking Water purifying technology in remote villages"

Barrier dimension	Main barrier	Elements of a barrier
Cost	High cost of initial installation and maintenance	• High cost of the construction and high cost of technology components, most of which are imported,

Barrier dimension	Main barrier	Elements of a barrier
		• There are very few local technicians which create more labor cost,
	Very few financial sources for developers and dealers	• Lack of access to financial support for initial investments, • Inadequate credit and loan for community to construct the infrastructure by the village community, • A few local investments in rural areas, • Limited formal financial service providers such as SME loans and microfinance,

After decomposing the barriers, the consultants analyzed the causal relations between the decomposed barriers by looking at the main barrier or the starter problem, the high cost of initial installation. The casual relationship was done by looking at root causes of barrier and the effects of barriers on the communities. The analysis showed that the high cost of initial installation of the technology was due to cost of components which are imported. As a result, the rural communities are not interested in introducing the technology, unless they can access the financial support.

2.4.2.2 Non-financial barriers

One of the main non-financial barriers is technical requirement for planning, installation and maintenance of village level water purifier plants. They also include the requirement of experts' skills for operation and maintenance. Besides, inadequate awareness and low education levels of community are significant constraints for the acceptance of safe and clean water for their daily life. There are also limited policies and guidelines to support the health, water and sanitation for rural communities. Awareness trainings for water, sanitation and health issues to communities are required as a basic knowledge for the technology adoption.

Table 0.11 Decomposition of non- financial barriers for "Drinking water purifying technology in remote villages"

Barrier dimension	Main barrier	Elements of a barrier
Policy, legal and regulatory	Limited policy and guidelines to support the health, water and sanitation for rural communities	• Limited policies and regulations for use of safe drinking water (e.g., Prohibition of water contaminated with Arsenic, salt and etc.),
Technical	Weak technology for installation and maintenance	• Very few local experts, technicians and public and private extension agents, • Insufficient standards of water purifying plants and facilities established in the country, • Limited database for the most suitable areas in the country for the technology
Institutional and organizational capacity	Weak institutional and organizational capacity	• Inadequate of extension services, insufficient numbers and facilities of related departments,

		• Weak coordination among the related ministries and departments (MOH, MOE, MOALI- DRD, etc.) for the implementation process.
Research and development	Limited research programs for safe water and health issues	• Very low national research fund, • Very few institutions and organizations that are working for the rural water supply and purified drinking water,
Information and awareness	Low education level information and awareness of rural community	• Poor market status for water purifying plants, • Limited local knowledge of communities for the technology,
Social, cultural and behavioral	Low preference of good /purified water	• Limited participation of communities, • Less sense of ownership of the rural community,

2.4.3 Identified measures of "Drinking water purifying technology in remote villages"

The process of identification of measures was undertaken by the consultants and stakeholders during a series of stakeholder consultation workshop. These measures were also evaluated by the Adaptation TWG and the TNA team. During the process, application of the knowledge and literature review including market chain analysis of the consultant combined with the stakeholders' experiences and advice, the measures were identified. This has been done only for the starter problem which is an economic and financial measure.

2.4.3.1 Economic and financial measures

The measures were analyzed using an "solution tree" which gives the measures to overcome the root cause barrier and the resultant effects (Annex VI (B)). Economic and financial measures, funding agencies should be put in place to reduce interest rates and increase credit facilities leading to adequate credit for the entrepreneurs and constructers. it will result in reduced price, leading to more service delivery. This will contribute to lowering the cost of initial installation and construction.

2.4.3.2 Non-financial measures

Non-financial measures include development of human skill involving capacity building for both beneficiaries and technicians. Enhancement of information and awareness will promote the knowledge of water, sanitation and health of the rural communities. It will, in turn, reduce social and cultural barriers and enhance community participation.

2.5 Key barriers and measures identified for the "Drinking water purifying technology in remote villages"

Barriers and measures for effective technology transfer and diffusion were identified through an extensive consultative process including literature reviews and expert inputs. The outcome was validated using zoom meetings, sharing the national and international experiences to overcome these barriers. These barriers and measures were mentioned below under categories of economic and financial and non-financial measures (Table 2.12).

Table 0.12 Key barriers and measures identified for the "Drinking water purifying technology" in remote villages of Myanmar

Main Barriers	Barrier's elements	Measure identified
Economic and Financial Barriers		
Cost	High cost of initial installation and maintenance	• Obtain financial access and funds from national and international donor agencies. to construct the infrastructure, • Explore local investor, • For the local investors, access the formal financial service providers such as JICA SME Two Step-Loans with interest rates of 5.5 to 10%, eligible for SMEs which are obliged with Small and Medium Enterprises Development Law (2015), • Access to the government's Emerald Green loans and rural development funds for rural villages infrastructure development,
Non- Financial Barriers		
Policy, legal and regulatory	Insufficient policy and guidelines to support the health, water and sanitation for rural communities	• Set up policy and guidelines to encourage to access safe and clean water (e.g., free from Arsenic contamination), • Strict enforcement for health, water and sanitation policy and guidelines
Technical	• Low technology for installation and maintenance rural communities • Few numbers of expertise on this technology	• Produce more qualified technicians on the technology, • Set up the standards of water purifying plant and facility, • Identify and prioritize suitable areas in the country for installation of water purifying facilities
Institutional and organizational capacity	Weak in institutional and organizational capacity	• Promote extension services for the technology • Encourage more collaboration among the related ministries • Recruit the extension staff and facilities
Research and development	Limited research programs for safe water and health issues	• Support research fund for the technology • Establish more institutions and organizations which are working for the rural water supply and purified drinking water • Encourage more research activities such as safe household and drinking water status of the country, (e.g., Arsenic contamination in ground water, etc.)
Information and awareness	Low information and awareness of rural community on safe water and health issues and use of the technology	• Build confidence in technology, • Build an awareness campaign on safe water, health and sanitation issues in rural areas

Main Barriers	Barrier's elements	Measure identified
Social, Cultural and Behavioral	Low preference of good /purified water	• Limited participation of communities, • Increase the sense of ownership of the rural community by organizing them to participate in the project starting from the planning and decision-making stage, • Form the Water User Groups for the long-term operation and maintenance

2.6 Linkages of the barriers identified

Barriers to technology transfer and diffusion on climate change adaptation are unlikely to function independent of one another. Therefore, analyzing barriers in isolation will be less productive because such an approach tends to overlook more holistic and potentially more efficient opportunities to address their combined effects. The linkages between different barriers of the three prioritized technologies in the agriculture sector are analyzed so as to ensure maximizing synergies and optimize the benefits of recommended measures.

An approach of more holistic will bring about potentially more efficient opportunities to address their combined effects. Most of the barriers and measures to overcome barriers are technology specific and fall within broad categorization for barriers. However, close examination reveals some common elements among them.

2.7 Enabling framework for overcoming the barriers in "Drinking water resource management sector"

Some common barriers address two or more of the prioritised technologies. Enabling measures are more technology specific at a detailed level. The main barriers to all prioritized technologies are the huge initial investment requirement, due to the nature of the technologies. Others compounding factors are weak financial supporting mechanisms such as credits and loans systems favoring the investors /developers. Non-financial barriers are limited policy, legal and regulatory, weakness in institutional and organizational capacity, poor research and development activities. For the technical aspect, Myanmar has also limited technical experts and technician for the particular subject matter, such as ground water hydrology, flood disaster mapping and water purification technology. The main reasons for all these barriers are – "limited national and international funds and investors" for the technologies. The following enabling measures are selected to address these barriers -

• Develop bylaws and regulations to implement the National Water Policy including regulations for agricultural production, drainage, groundwater, water users' associations (WUA), and irrigation service fees (ISF);

• There is a serious imbalance of budget allocation under the MOALI- the small amount spent on agricultural research and development (R&D). Increase the budget for research and extension services is an urgent measure to disseminate the technologies successfully.

- Explore donor organizations, in collaboration with international organizations, private and public partnerships of local investors/ developers and user communities
- Develop funds for research, studies, demonstration, training, and extension services of water use management practices,

The technology specific enabling measures for these common barriers were summarized in Table 2.13.

Table 0.13 Enabling measures for the common barriers in the Water Sector

Common barriers	Technologies affected	Measures to overcome key barriers
High capital cost	1,2, 3	(i) Explore additional funds from donor agencies, (ii) Promotion of research on development of low-cost technology, (iii) Create funding sources with low interest rates for the investors and developers,
Limited sustainability	1	(i) Select suitable sites based on hydro-geological conditions, (ii) Improve operation and maintenance practices (iii) Avoid over extraction and allow recharge ground water, (iv) Avoid sites having poor ground water quality,
Limited relevant policies / laws/ regulations	1 1 1,2,3 1, 3	(i) Prepare a clear policy on selection and prioritization of the project sites, (ii) Prepare policy/guidelines for ground water management, (iii) Strengthen institutional capacities to implement existing policies/ legal frame work, (iv) Strict enforcement of relevant environment laws/regulations,
Limited information and awareness	1, 2 1 1,2,3	(i) Promote R & D to collect data on hydrology and information dissemination, (ii) Improve operation and management practices of village ponds and tube wells through awareness raising, (iii) Provide information on assistance to the constructors from rural areas, (iv) Collect the region -wide information related with the technology in the country through surveys and documentation,
No prioritized areas to implement the technology	1, 2	(i) Develop a policy/ strategy for selection and prioritization of village ponds and boreholes for restoration and new installation, (ii) Identify needs and urgency based on Climate change modeling,
Limitations institutional and organizational capacity	1,2,3 1,2,3 1, 2,3	(i) Improve the numbers of staff, staff's capacity and education, (ii) Improve the institutional capacity by increasing extension services,

Common barriers	Technologies affected	Measures to overcome key barriers
		(iii) Improve operation and management practices,
Limited research and development	1,2,3 1,2,3	(i) Promote research and development programs, (ii) Provide necessary funds for R & D to universities for post-graduate studies, and research institutions, (ii) Increase the national budget for research, Upgrade the research facilities and capacity of the staff

Note: 1: The technology for renovation and improvement of village ponds and tube wells, 2: Technology for flood disaster risk reduction in Ayeyarwady delta, and 3: Drinking water purifying technology in remote villages.

2.8 Market maps for the technologies prioritized in the "Water resource management" Sector

Regarding the Market mapping for the three technologies selected in the "water resource management" sectors, all technologies were categorized as "Publicly provided goods". They are transferred and diffused under nonmarket – by the governments, public or non-profit institutions, international donors or NGOs. Therefore, the figures for the Market maps were not mentioned in this BA Report. Instead, the market characteristics of prioritized technologies were described in the below Table 2.14.

Table 0.14 Market maps for the technologies prioritized in the "Water resource management" Sector

Technology	Category /Description	Market characteristics
(1) Renovation and improvement of village ponds and tube wells for better livelihoods in central Dry Zone	• Publicly provided goods: • Contributes to provision of public benefits and services; • Transferred and diffused under nonmarket, governments, public or non-profit institutions, international donors or NGOs;	• Public ownership or joint management with local communities; Serves overall political development objectives, such as poverty alleviation; contribution to MDG; Donor or government funding; • High number of potential consumers; Interaction with existing markets; Maintenance and installer networks in the supply chain; • Small and complicated supply chains with many actors, including producers, assemblers, wholesalers, retailers and end consumers; • Demand depends on consumer awareness and preferences
(2) Technology for flood disaster risk reduction in	• Publicly provided goods contribute to the provision of the public services;	• A limited number of potential sites/consumers;

Technology	Category /Description	Market characteristics
Ayeyarwady delta	• Non-tradable, transferrable and diffused under nonmarket conditions which are primarily diffused through political decisions; • Government institutions, public or nonprofit institutions, NGOs etc., have a direct influence on the diffusion of the technology	• Relatively high capital investment; • Simple market chain; • Demand is profit-driven and depends on demand for the products the capital goods are used
(3) Drinking water purifying technology in remote villages of Myanmar	• "Publicly provided goods / nonmarket goods" since they were destined for the establishment for the village level purifying plants, • Limited standard requirements; • High price of materials since almost all components are imported; • Insufficient legal and regulatory framework; • Limited knowledge on health, water and sanitation in remote areas	• High installation cost; • High price of materials; • Lack of financial incentives; • Difficult accessibility and remoteness

CHAPTER 3: CONCLUSION

The "Barrier Analysis and Enabling Framework for Climate Change Adaptation Technologies" Report looked at the key sectors of Myanmar: agriculture and water resource management. From the results of the first stage of TNA project, the prioritized technologies are solar powered drip irrigation, conservation agriculture and STR varieties in agriculture sector, and renovation of village ponds and tube wells, flood disaster risk reduction and water purifying technology in water sector. These technologies require a considerable amount of time and expense. In this BA-EF stage, barriers for diffusion and adoption of these technologies and measures to overcome them were identified. In spite of the COVID 19 pandemic with the intermitted regulations of travel restrictions and social distancing, the KII, FGD and participatory and consultative virtual meetings were organized as many as possible. By involving government organizations, communities and other relevant stakeholders in all stages of project processes, the barriers were identified and screened; tailored solutions were provided through the consensus of all participants.

These prioritized adaptation technologies in agriculture sector already exist in Myanmar but they are not currently in widespread use, and neither the private nor public sectors have invested significantly in them. It needs certain actions to mainstream, and scale up, ensuring access to technologies for the most vulnerable areas of Myanmar to adapt to climate change. In both sectors, the financial barrier is recognized as the key barrier in all technologies identified. The root cause is high cost of the technology implementation due to the several interrelated factors. Almost all technology components are imported; even many of them (such as agriculture related materials and machinery) are custom duty -free items. However, the prices are still high for the investors and farmers due to the fluctuation of world market prices, exchange rate of Myanmar currency, etc. The situation is compounded by the limited financial supporting mechanisms such as reliable credits and loans encouraging the investment and initiating a new business of a technology. The recommended measures are exploring the international funding agencies for loans or grants (such as the World Bank, ADB, JICA, IFAD, GEF, GCF and etc.). Creating enabling environment of the technologies attractive and easy implementation to the foreign and local investors is another measure. The second key barrier is constraints in related policy, legal and regulatory framework. For example, there are very few agriculture policies and guidelines encouraging directly and forcefully for reduced use of irrigation water, conservation agriculture and use of stress tolerance varieties for the selected technologies adoption.

The same is the case in water sector: there are limited policies for encouraging the proper safe water supply and hygiene in rural areas. Therefore, improvement and update of the current policies, designing robust policies and regulations will be undertaken wherever necessary. More importantly, the climate change consideration should be incorporated and mainstreamed into the current and future national sectoral development plans and strategies. Regarding non-financial barriers, the limited human resources and institutional and organizational capacity are the key hindrance, common to all technologies. The underlying causes are inadequate national budget, staff numbers and their capacity. The measures are suggested for the recruitment of staff, upgrade their quality and supporting with adequate departmental fund so that these technicians and experts will be able to do the research and extension work for the technology dissemination. In addition, building local competence, creating markets, introducing partnerships and collaborations and awareness raising trainings are recommended enabling measures for the widely adoption of prioritized technologies.

By facilitation of technology solutions and improving capacities of Myanmar in agriculture sector, the technologies for less water requirement for cash crop production, sustainable agriculture, stress tolerance rice varieties will improve food security and contribute to additional income of farmers in the long term. Similarly, only when the enabling frameworks for overcoming these barriers are put in place in the water sector, there will be improved water supply, hygiene and livelihoods in rural communities and less impact of seasonal flood disasters, leading to poverty reduction and

diversification of income generating activities. These anticipated outcomes of the TNA project on improved social and economic development in a sustainable way in agriculture and water resource management sectors will bring Myanmar to shift to a climate resilient nation.

List of References

Asian Disaster Preparedness Centre, MOSWRR, 2012. Myanmar Action Plan on Disaster Risk Reduction. Ministry of Social Welfare, Relief and Resettlement

Aung, Tin Myint, 2013. Flood inundation analysis for effective countermeasures in the Bago River Basin. A Master Thesis, Submitted in Partial Fulfillment of the Requirement, For the Master's Degree in Disaster Management, National Graduate Institute for Policy Studies, National University in Tokyo, Japan. August 2013

DOP, 2019. Myanmar Agriculture Sector *in Brief.* Department of Planning. Ministry of Agriculture, Livestock and Irrigation (MOALI), Nay Pyi Taw

GORUM, 2012. Framework for economic and social reforms, policy priorities for 2012-15 towards the Long-term goals of the national comprehensive development plan. Government of the Republic of the Union of Myanmar

GORUM, 2014. Myanmar Integrated Water Resources Management (IWRM) Strategic Study-Research and Analysis, Strategies and Measures. The Government of the Republic of the Union of Myanmar, December 2014

GORUM, 2014. National Water Policy, Government of the Republic of the Union of Myanmar

GORUM, 2016 (a). The National Strategy for Rural Water Supply, Sanitation and Hygiene (WASH), in Schools and WASH in Health Facilities 2016 – 2030. The Department of Rural Development of the Ministry of Agriculture, Livestock and Irrigation, the Department of Public Health of the Ministry of Health and Sports, the Department of Basic Education of the Ministry of Education, The Government of the Republic of the Union of Myanmar, March 2016

GORUM, 2016 (b). National Investment Plan for Rural Water Supply, Sanitation and Hygiene (WASH), WASH in Schools and WASH in Health Facilities 2016-2030. 27. The Government of the Republic of the Union of Myanmar, June 2016. https://www.unicef.org/myanmar/water-sanitation-and-hygiene-wash/rural-water-supply

GORUM, 2017. Myanmar Action Plan on Disaster Risk Management (MAPDRR), 2017 Fostering resilient development through integrated action plan. National Disaster Management Committee, the Government of the Republic of the Union of Myanmar, October 2017

GORUM, 2019 (a). National Environmental Policy (NEP) of Myanmar, the Government of the Republic of the Union of Myanmar, June, 2019 https://www.mm.undp.org/content/myanmar/en/home/library/environment_energy/national-environmental-policy-of-myanmar.html

GORUM, 2019 (b). Myanmar Climate Change Strategy (MCCS) (2018 – 2030), 2019. The Government of the Republic of the Union of Myanmar. http//unhabitat.org.mm › publications › myanmar-climate-change-strategy

INDC, 2015. Myanmar's INDC. Myanmar's Intended Nationally Determined Contribution-INDC (25-8-2015), Ministry of Environmental Conservation and Forestry, The Government of the Republic of the Union of Myanmar.

International Water Management Institute (IWMI). 2015. *Improving water management in Myanmar's dry zone for food security, livelihoods and health.* Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p. doi: 10.5337/2015.213

MNPED, 2011. National Comprehensive Development Plan (2012 – 2031), Ministry of National Planning and Economic Development (MNPED), the Government of the Republic of the Union of Myanmar, 2011

MOALI, 2015(a). Myanmar Climate-Smart Agriculture Strategy. Ministry of Agriculture, Livestock and Irrigation (MOALI), the Republic of the Union of Myanmar, under the joint project of YAU,

CGIAR, IRRI. Sept., 2015, Nay Pyi Taw

MOALI, 2015(b). Myanmar Rice Sector Development Strategy. Ministry of Agriculture, Livestock and Irrigation, International Rice Research Institute (IRRI), The Government of the Republic of the Union of Myanmar, May, 2015. Web: www.moai.gov.mn

MOALI, 2016. Agricultural Sector Policies and Thrusts for Second Five Year Short Term Plan. Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, Myanmar, 2016

MOF, 2017. Integrated Water Resources Management (IWRM) in Myanmar, Norwegian Institute for Water Research, 2017. Ministry of Forestry (MOF), United Nations Environment Programme, Regional Resource Center for Asia and the Pacific (UNEP.RRC.AP) – RAPPORTL.NR.7163-2017

MOALI, 2018. Myanmar Agriculture Development Strategy and Investment Plan (2018-19 ~ 2022-23). The Government of the Republic of the Union of Myanmar, May, 2018. Web: www.moai.gov.mn

MONREC, 2017. National Environmental Policy (NEP) for Myanmar, Ministry of Natural Resources and Environmental Conservation (MONREC), the Government of the Union of Myanmar, 2017

MONREC, 2019. Myanmar Green Economy Policy Framework, Ministry of Natural Resources and Environmental Conservation (MONREC), Final Draft (version 12), 21 February 2019, The Government of the Union of Myanmar, 2019

NAPA, 2012. Myanmar's National adaptation Programme of Actions (NAPA) to Climate Change, National Environmental Conservation Committee (NECC), Ministry of Environmental Conservation and Forestry (MOECAF), and Department of Meteorology and Hydrology, Ministry of Transport, 2012

NWRC, 2014. National Water Policy. National Water Resource Committee (NWRC), the Government of the Union of Myanmar, 2014

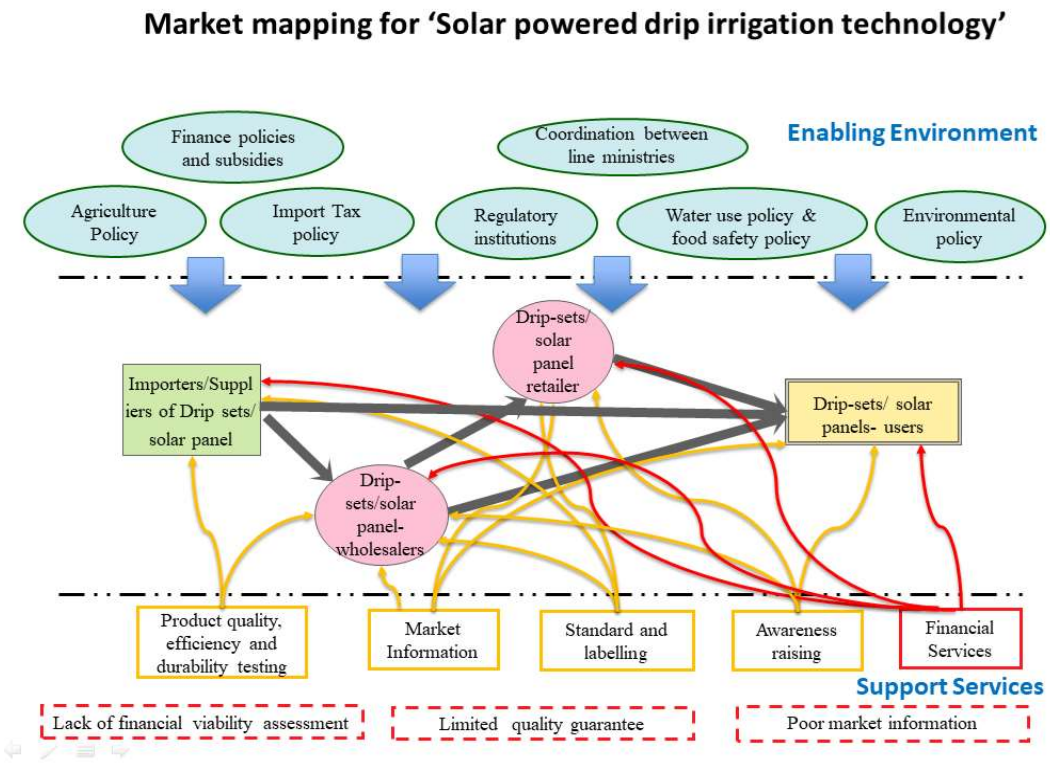
Rowell, B., Soe, M.L, and Khine, T.T., 2011. Low pressure drip irrigation for commercial vegetables in Myanmar, Proximity Designs, Suite 202, Yangon, Myanmar

UNESCAP. 2009. Sustainable agricultural development strategies for the least developed countries of the Asian and the Pacific region, Myanmar prepared by U Myint Thein, Director-General (Retd),

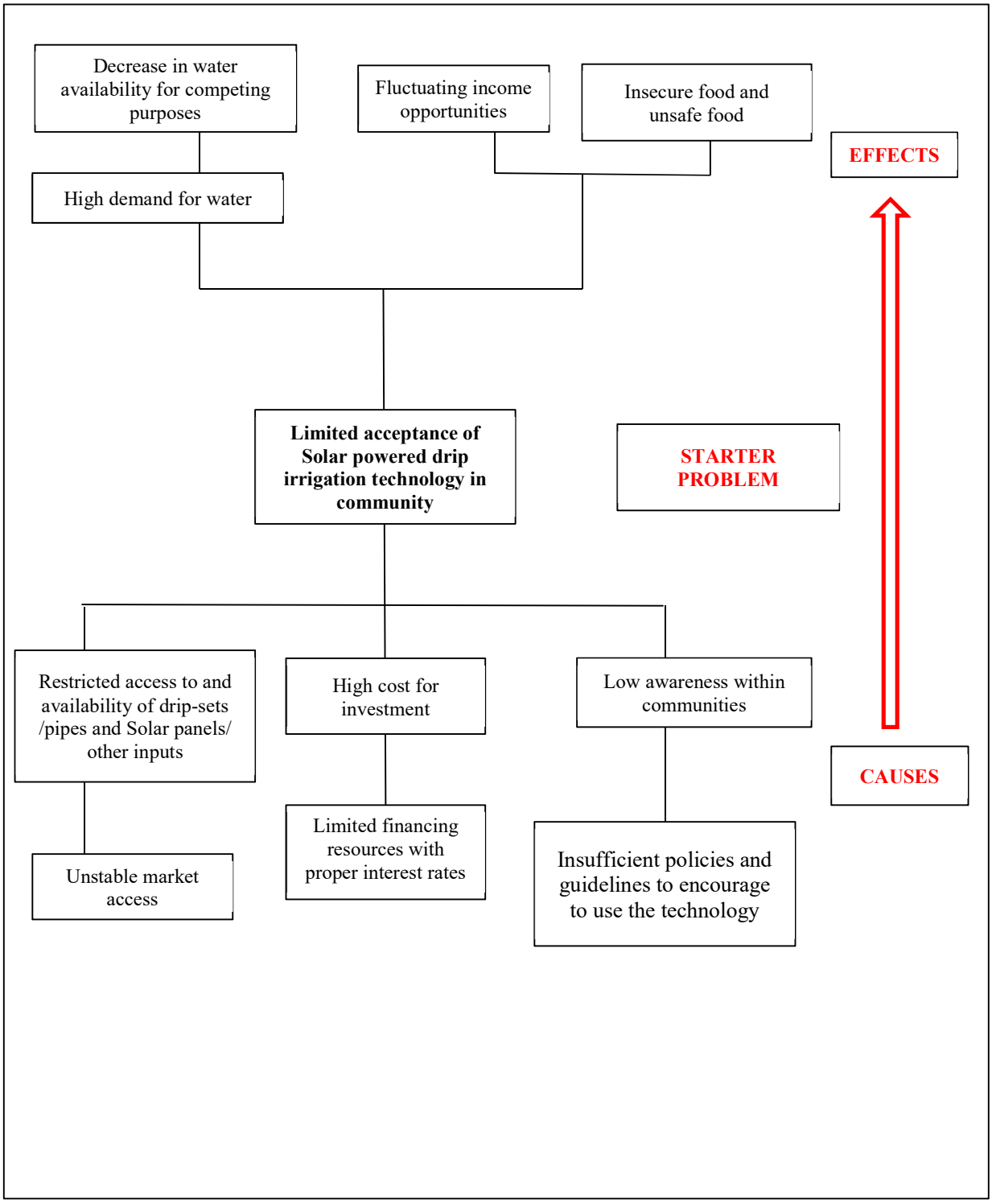
Ministry of Agriculture and Irrigation, Yangon. Retrieved February 2009.Available Source: www.unescap.org/rural/doc/sads/myanmar.

https://arnfinno.wordpress.com/2014/10/11/proximity-designs-helps-450000-farmers-in-Myanmar/. Proximity Designs helps 450,000 farmers in Myanmar.11 October, 2014

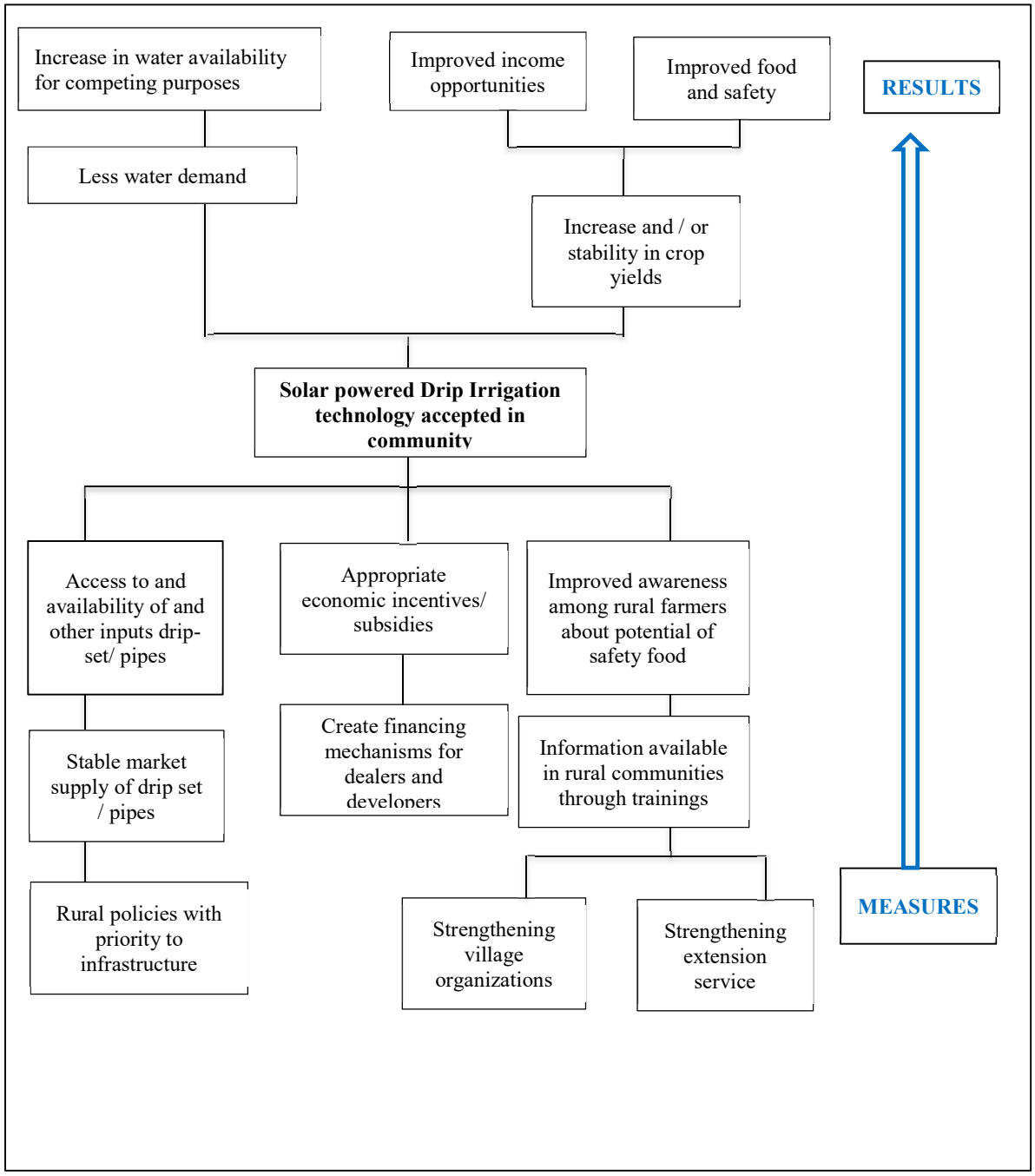
Annex I (A) Market map for "Solar powered drip irrigation" technology



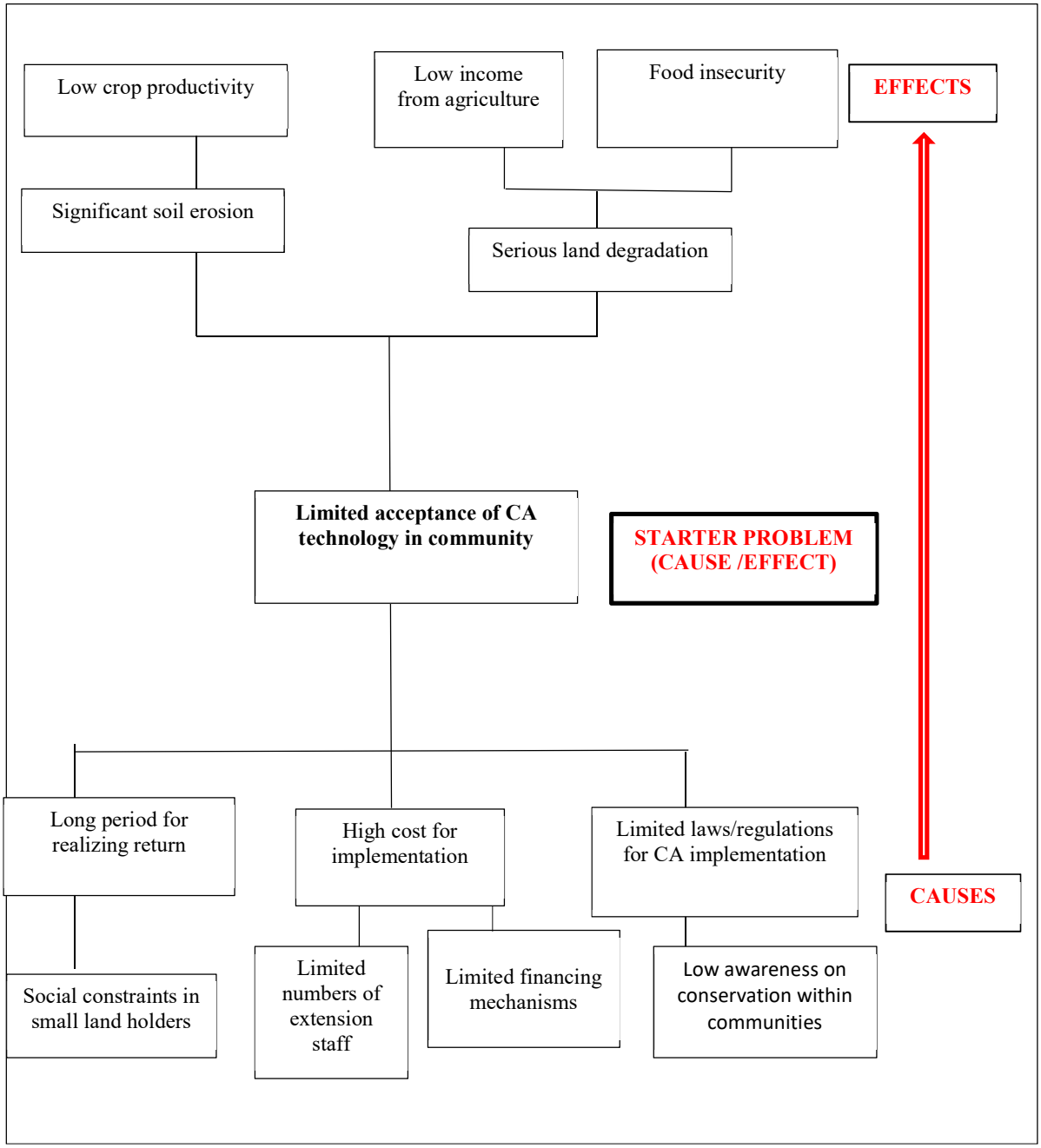
Annex I(B) Problem tree for "Solar powered drip irrigation" technology



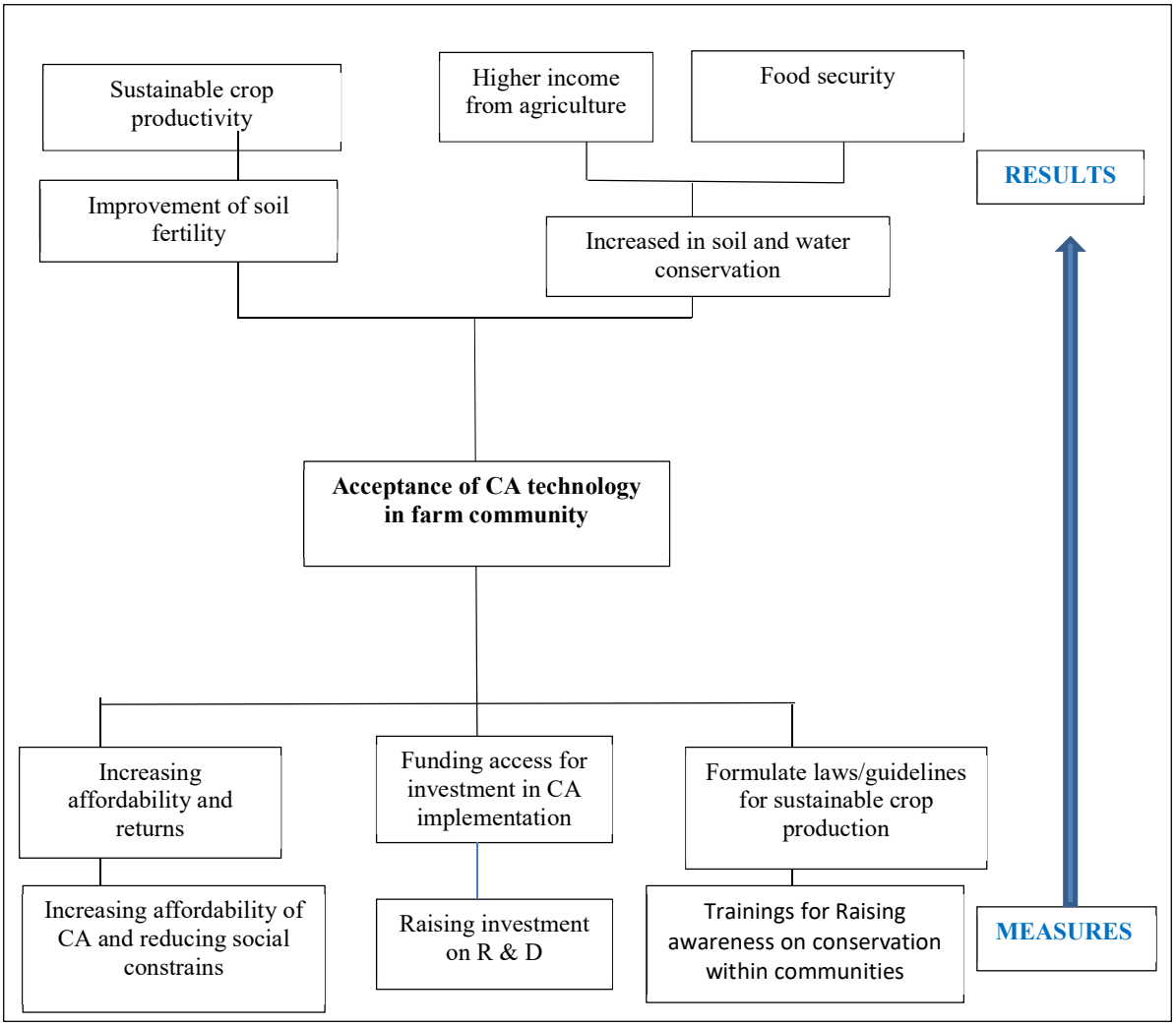
Annex I (C): Solution Tree for "Solar powered drip irrigation" technology



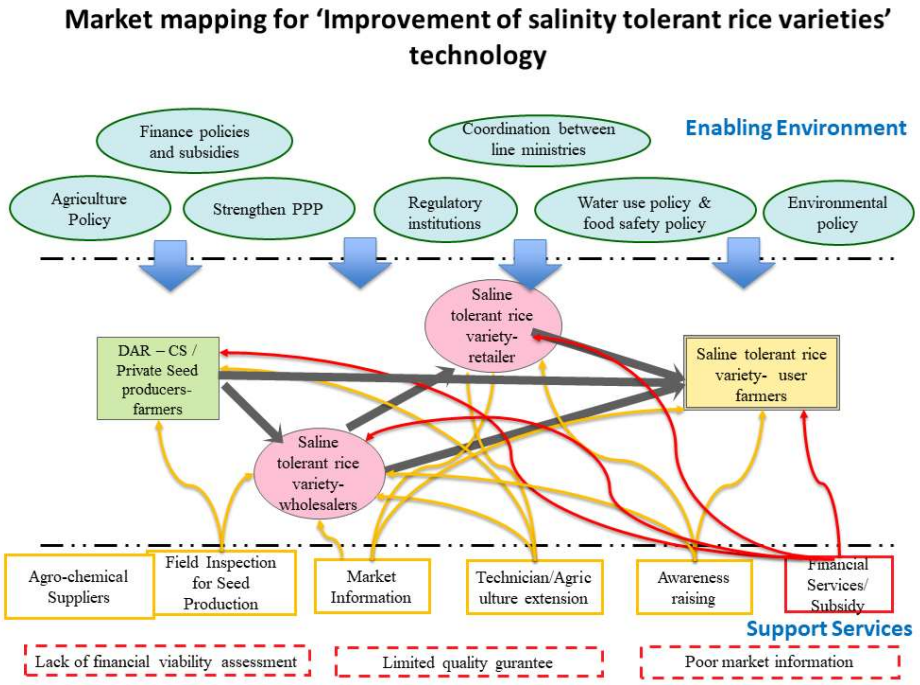
Annex II(A) Problem tree for "Conservation Agriculture" technology



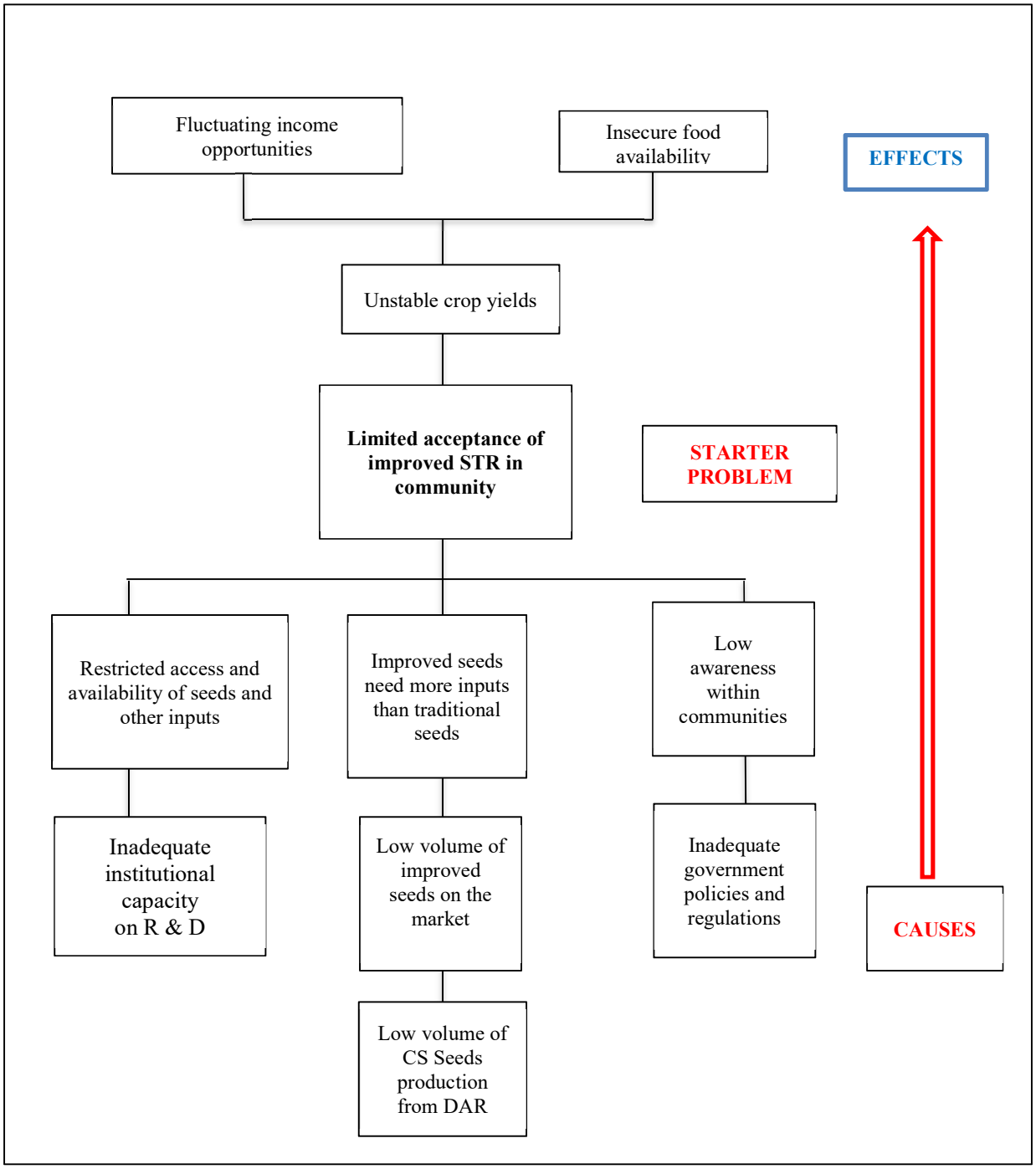
Annex II(B) Solution Tree for "Conservation Agriculture" technology



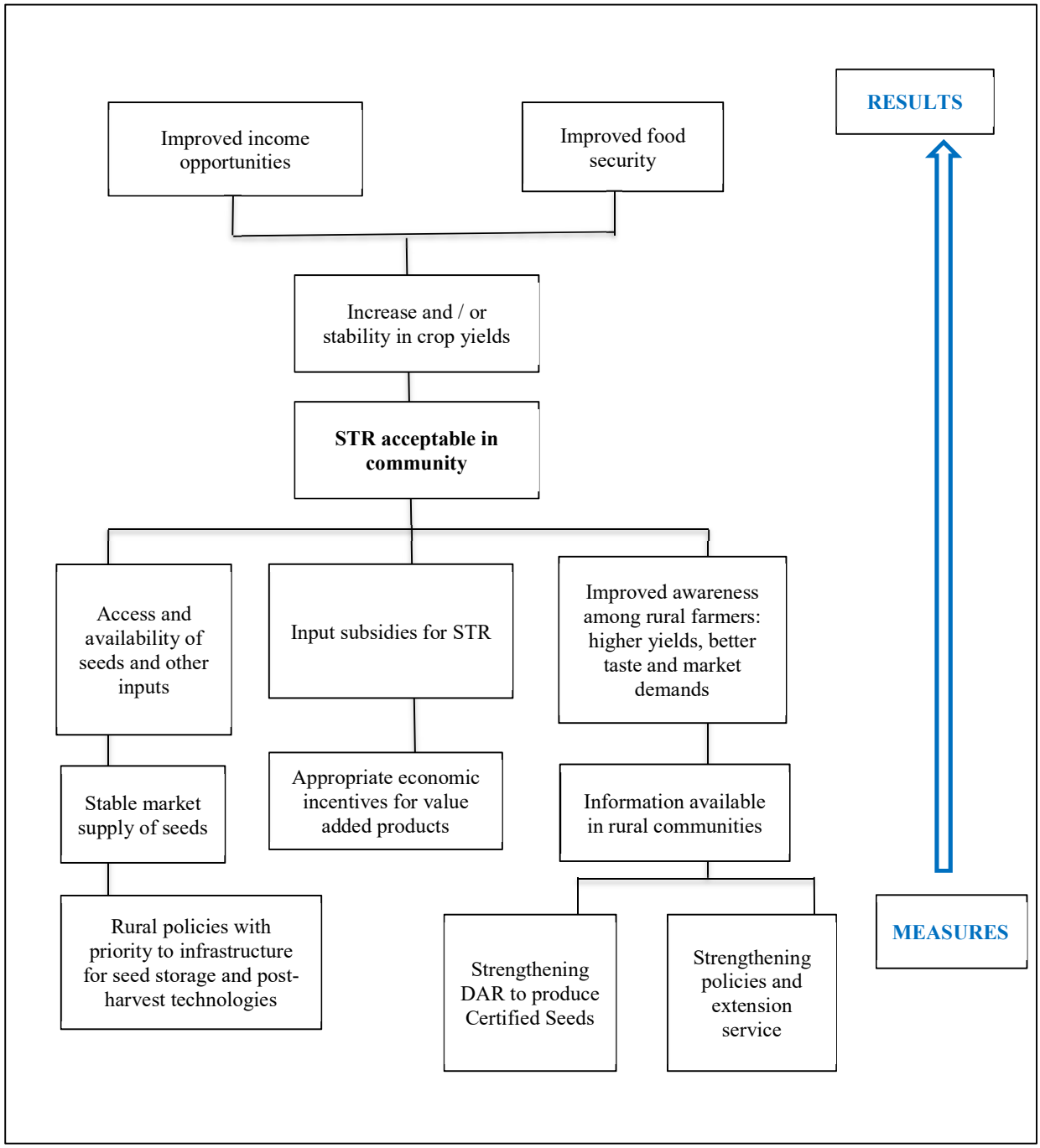
Annex III (A) Market map for "Improvement of salinity tolerance rice varieties" technology



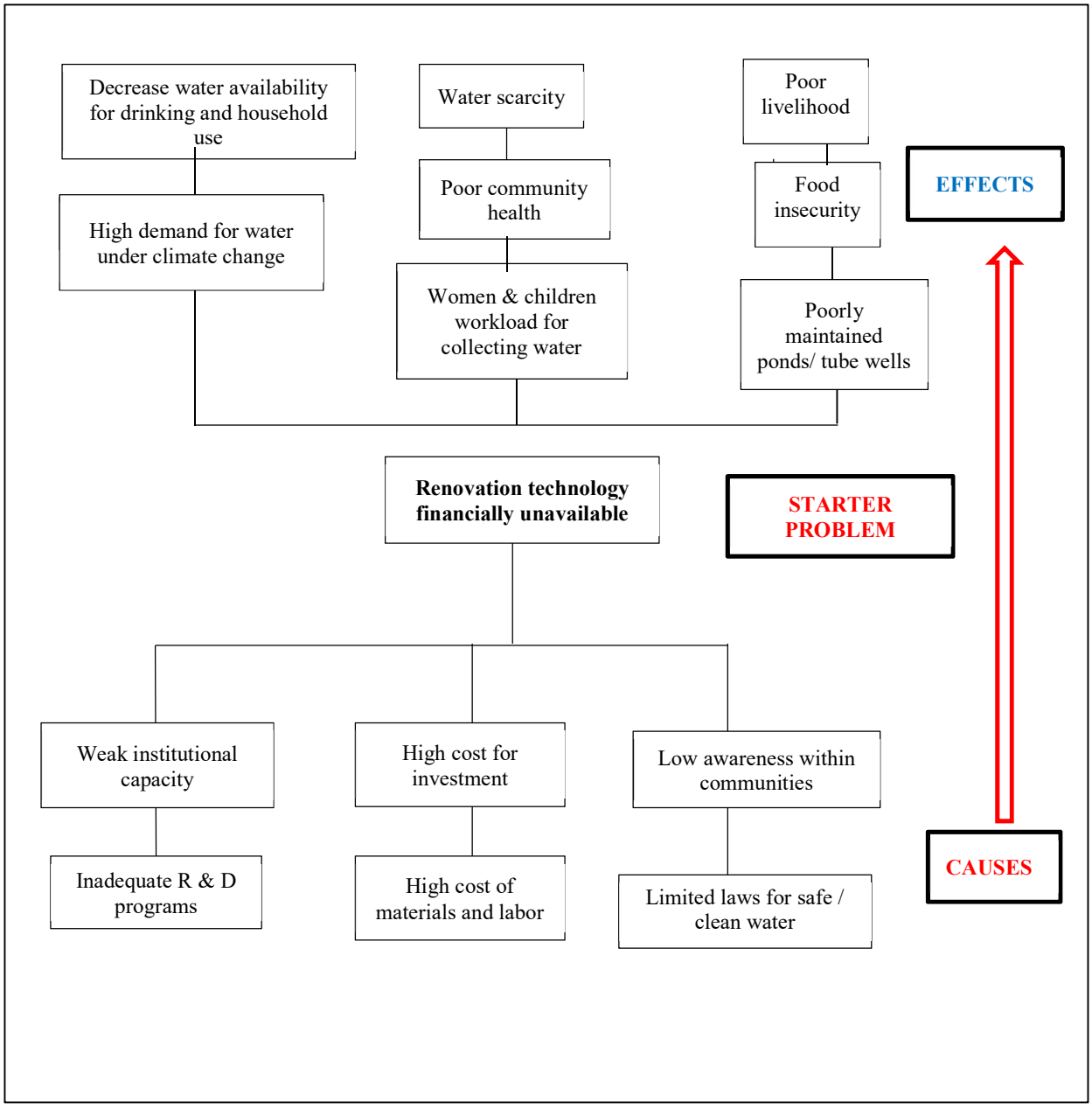
Annex III (B) Problem tree for ” Improvement of salinitytolerance rice varieties” technology



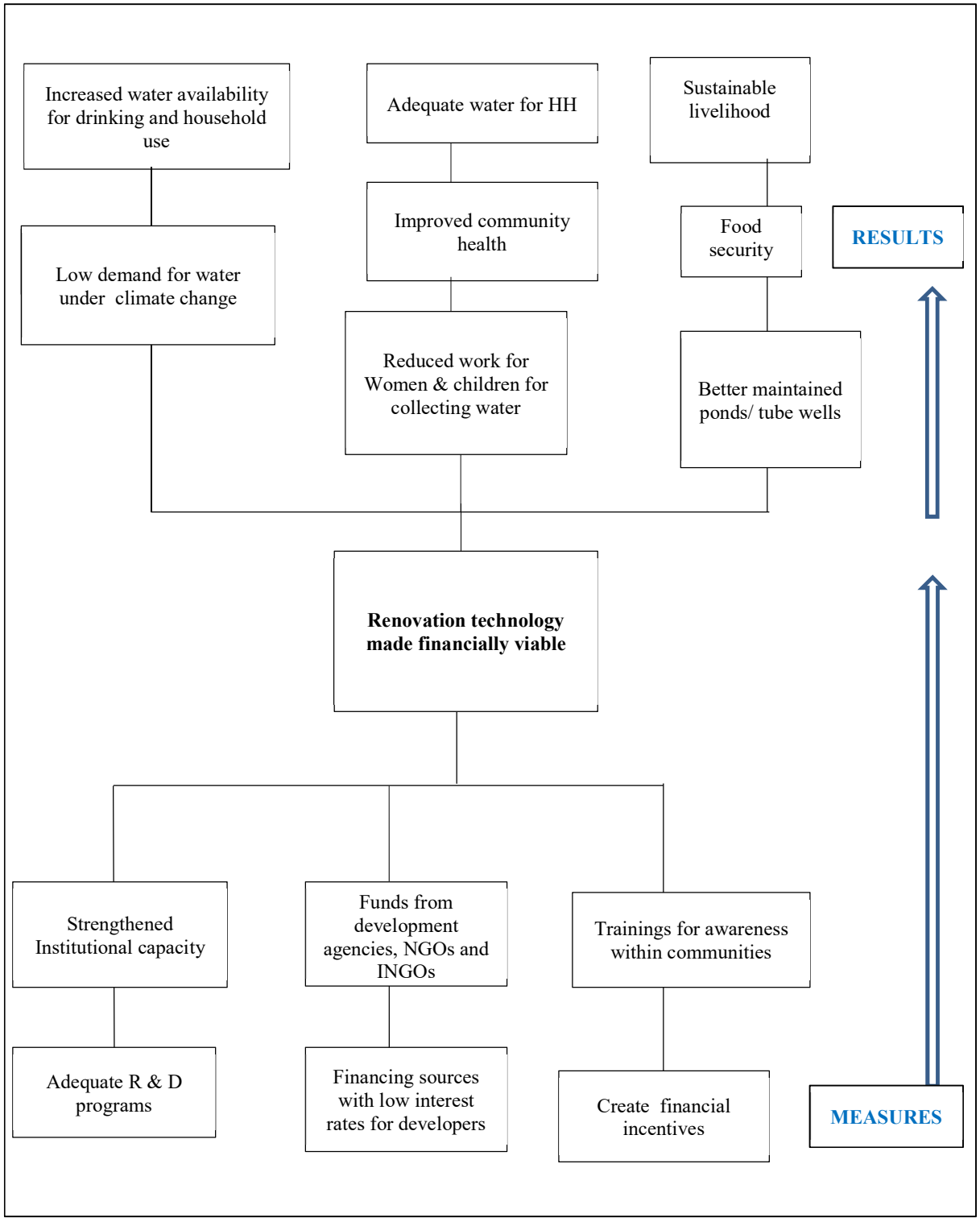
Annex III (C) Solution tree for "Improvement of salinity tolerance rice varieties" technology



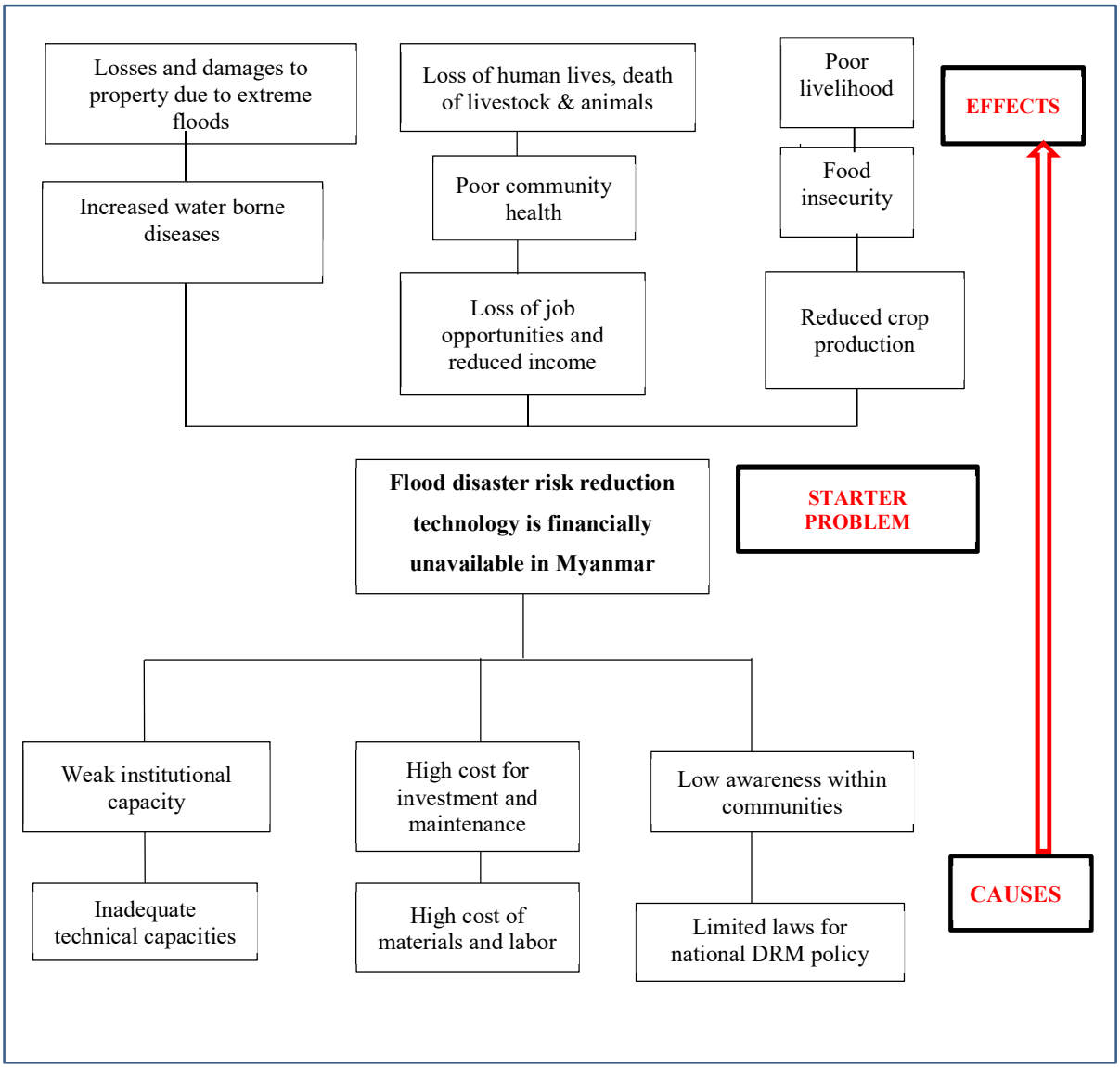
Annex IV (A) Problem tree for "Renovation and improvement of village ponds and tube wells" technology



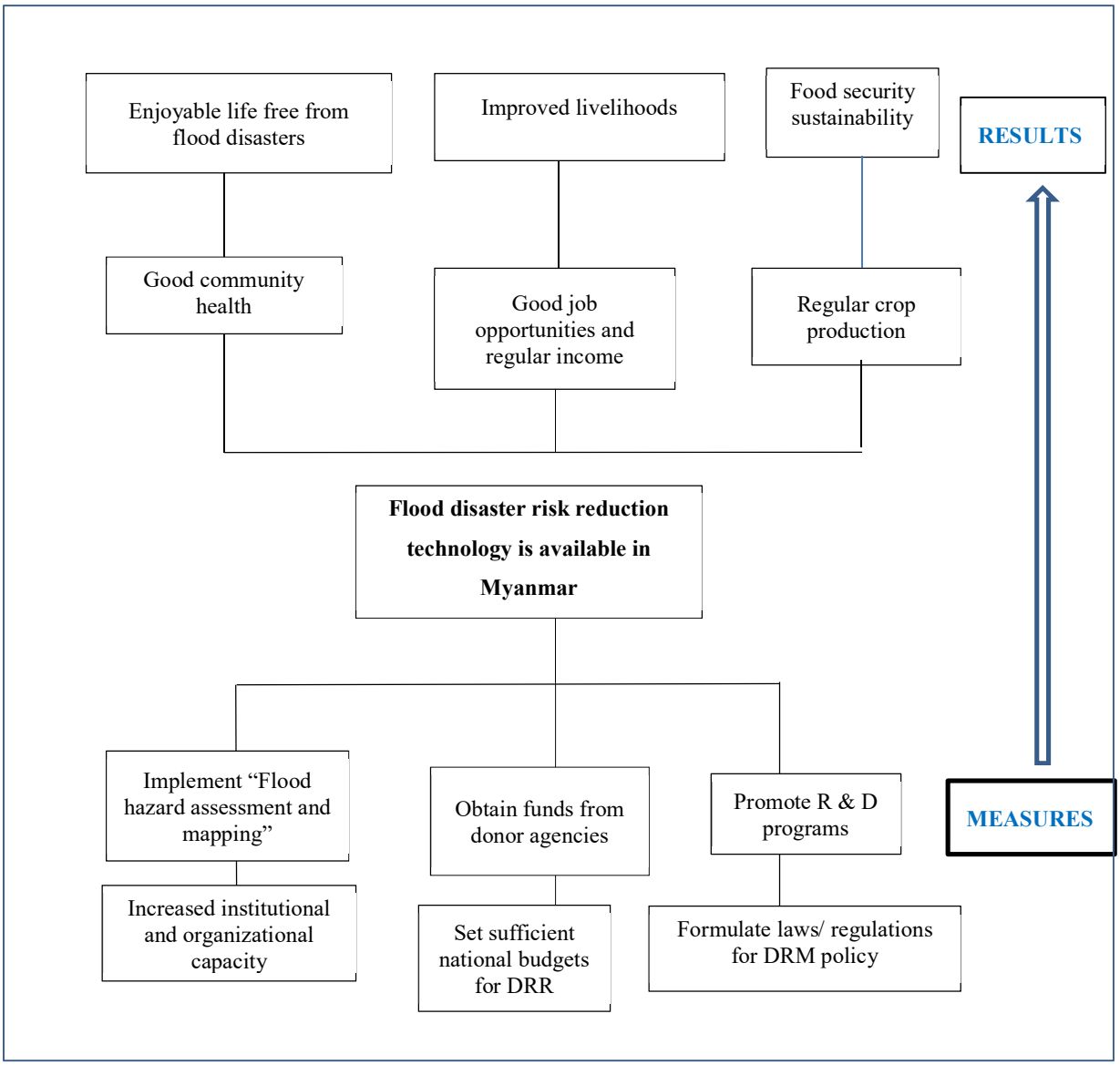
Annex IV (B) Solution tree for "Renovation of village ponds and tube wells" technology



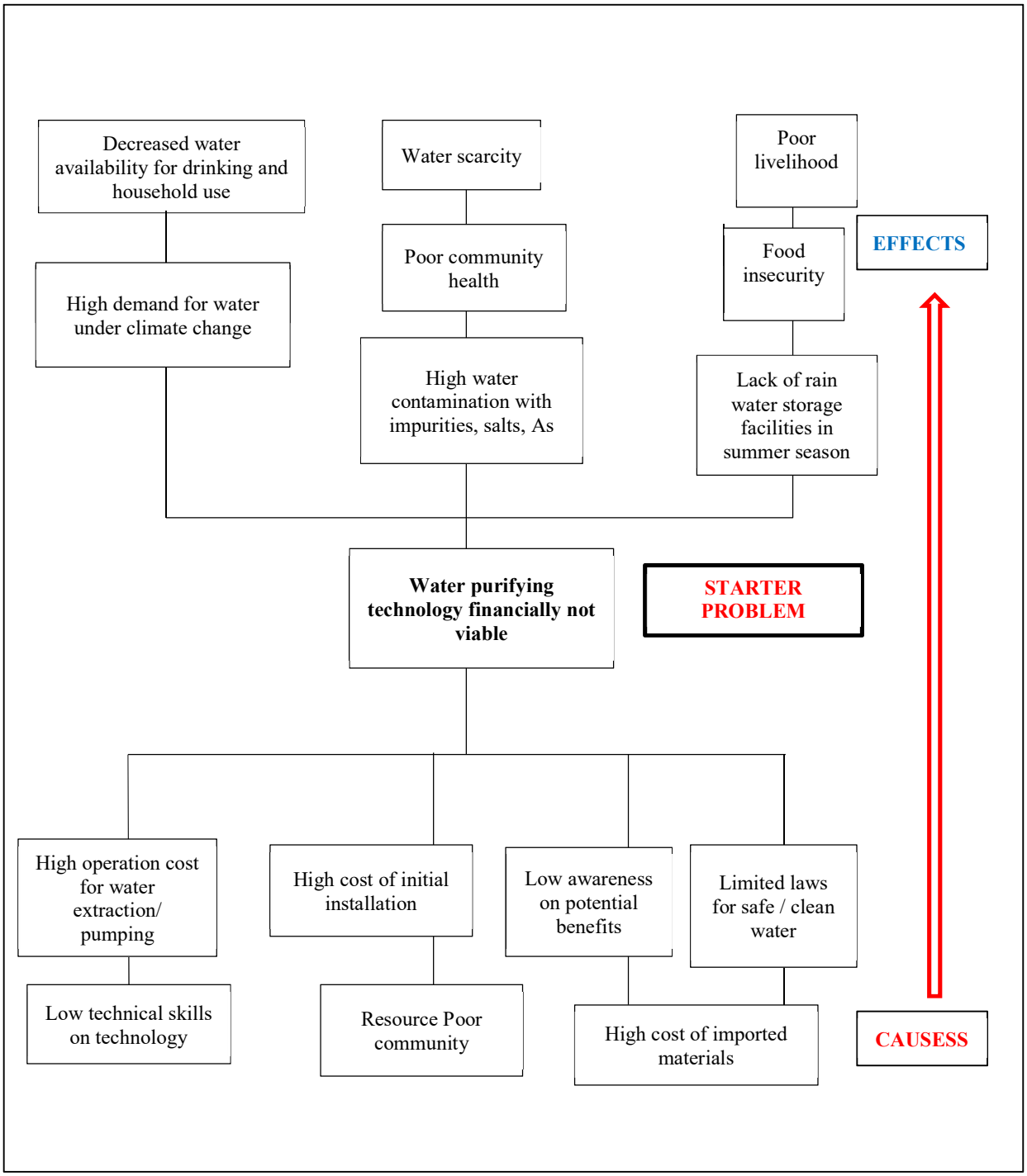
Annex V (A) Problem tree for "Flood disaster risk reduction " technology



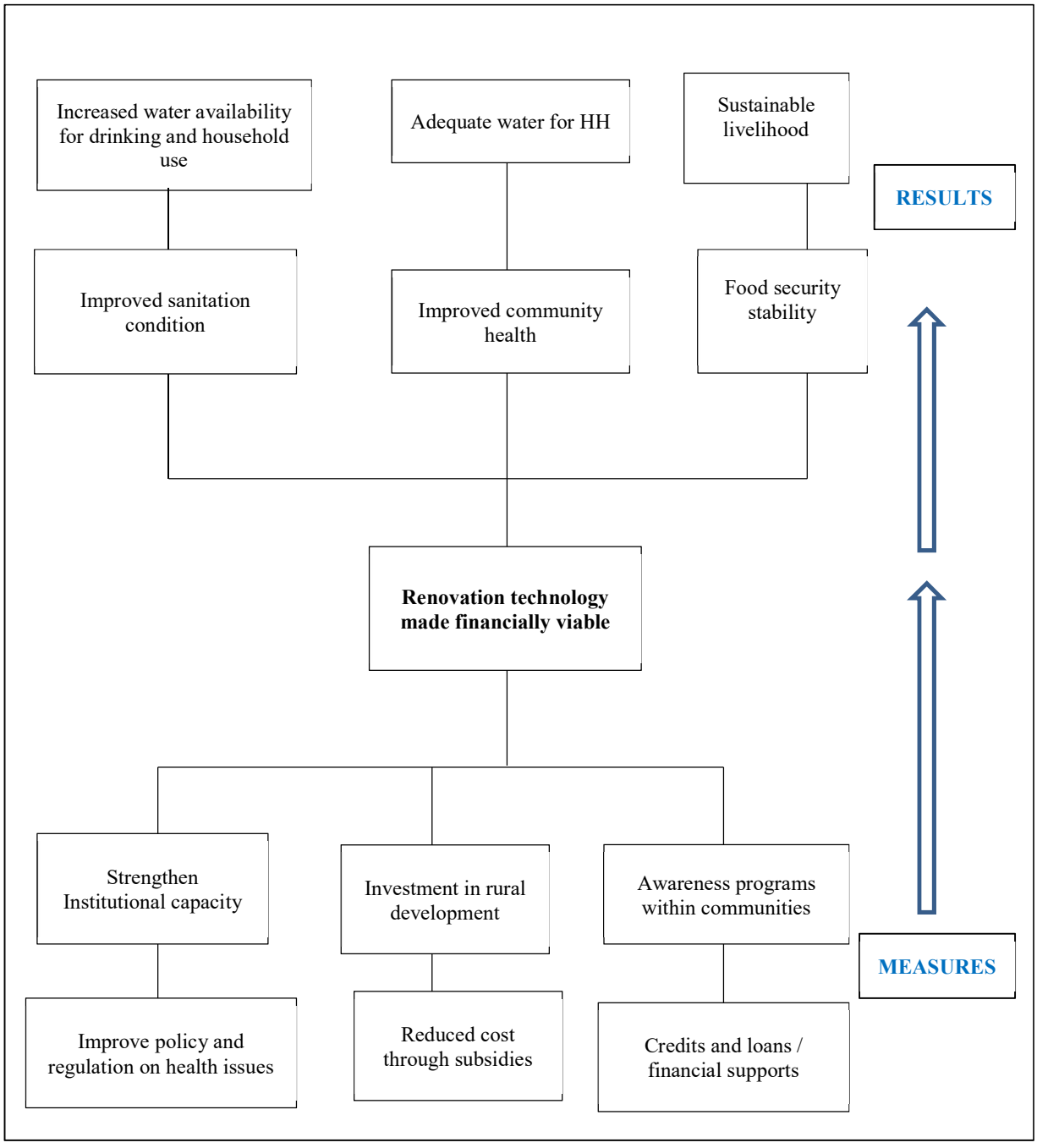
Annex V (B) Solution tree for "Flood disaster risk reduction " technology



Annex VI (A) Problem tree for "Drinking water purifying technology"



Annex VI (B) Solution tree for "Drinking water purifying technology"



Attachment I (A) List of Participants involved in the online meeting on 16 June 2020 (Climate Change Adaptation - Agriculture Sector)

Sr.	Name	Designation	Department	Contact Address
1	Dr. San Oo	Deputy Director General	Environmental Conservation Department (ECD)	sthandaroo@gmail.com
2	U Kyaw San Naing	Director	TNA Coordinator, ECD	kyawsannaing.env@gmail.com
3	Daw Win Min Phyo	Director	Department of Trade	dotregional@gmail.com Mobile: 09421182515
4	Dr. Theingi Myint	Professor	Yezin Agricultural University	theingi.myint@gmail.com Mobile: 09250108681
5	Daw Thin Thuzar Win	Deputy Director	Climate Change Division, ECD	thinthuzar1981@gmail.com
6	Daw Wai Wai Kyaw	Deputy Director	Customs Department	waimoekyaw94@gmail.com Mobile: 095121283
7	Dr. Thida	Assistant Research Officer	Department of Agricultural Research (DAR)	thida.biotech@gmail.com Mobile: 09794255564
8	Dr. Aung Kyaw Thu	Assistant Research Officer	Department of Agricultural Research (DAR)	aungkyawthu.dar@gmail.com Mobile: 09420700614
9	Daw Zin Mar Phyu	Staff Officer	Climate Change Division, ECD	zinmarphyu123@gmail.com
10	Dr. Paung Shin Kam	Research Officer	Department of Agricultural Research	kampau@gmail.com Mobile:09797707146
11	U Myo Than Htun	Lecturer	Yezin Agricultural University	myothantun83@gmail.com Mobile: 09256000717
12	Dr. Khin Zar Kyaw	Staff Officer	Department of Agriculture	zarkyaw@gmail.com Mobile: 09793978793
13	U Sithu Aung	Staff Officer	Forest Department	sithuaungforestry@gmail.com
14	Daw Thimar Win	Agri- Market Consultant	MyanSEED Co.Ltd.	thimarwin1999@gmail.com Mobile: 0943186450
15	Dr. Le Le Win	Programme Officer	Food and Agriculture Organization of the United Nations	lelewin@fao.org Mobile: 0943107706
16	U Kyaw Swan Thu	Deputy Staff Officer	Climate Change Division, ECD	kyawswanthu.9915@gmail.com
17	U Htun Htun Zaw	Program Officer	MERN	tunzayarzaw009@gmail.com Mobile: 09975255705

Attachment I (B) List of Participants involved in the online meeting on 17 June 2020 (Climate Change Adaptation – Water Resource Management Sector)

Sr.	Name	Designation	Department	Email & Ph no.
1	U Kyaw San Naing	Director	TNA Coordinator, ECD	kyawsannaing.env@ gmail.com
2	Daw Win Min Phyo	Director	Department of Trade	dotregional@gmail.com Mobile: 09421182515
3	Daw Thin Thuzar Win	Deputy Director	Climate Change Division, ECD	thinthuzar1981@gmail. com
4	Dr. San Win	Deputy Director	Climate Change Division, ECD	Sanwin.ecd@gmail.com Mobile:09788259959
5	Daw Wai Wai Kyaw	Deputy Director	Myanmar Custom	waimoekyaw94@ gmail.com Mobile: 095121283
6	Dr. Win Min Oo	Deputy Director	Department of Rural Development	winminoomyanmar@ gmail.com Mobile: 092045995
7	U Kyaw Naing Oo	Deputy Director	Directorate of Water Resources and Improvement of River System	knaingoo1977@gmail.com Mobile: 09776038332
8	Daw Thi Thi Soe Min	Assistant Director	Climate Change Division, ECD	thithi.malun@gmail.com Mobile:09401560983
9	Daw Thandar Wint Wint Khaing	Assistant Director	Planning and GIS Division, ECD	tdwindwrm@gmail.com Mobile:09-450028742
10	Dr. Aung Than Oo	Assistant Director	Irrigation and Water Utilization Management Department	aungthoo@gmail.com Mobile: 095155224
11	U Aung Kyaw Soe	Assistant Director	Dry Zone Greening Department	aungkyawsoeone@gmail. com
12	Dr. Kyu Kyu Sein	Assistant Director	Department of Meteorology and Hydrology	sein.dmhmdy@gmail.com Mobile: 09 250 954 661
13	U Aung Aung	Staff Officer	Environmental Impact Assessment Division, ECD	aungaung1361986@ gmail.com
14	Dr. Win Htein	Staff Officer	Natural Resources Division, ECD	dr.winhtein.ecd@gmail. com

Sr.	Name	Designation	Department	Email & Ph no.
15	U Thein Htaik Aung	Staff Officer	Human Resource Division, ECD	theinhtaikaung.ecd@gmail.com
16	U Ye Phyo Aung	Staff officer	Irrigation and Water Utilization Management Department	yephyoeaung.hydro@gmail.com Mobile: 09776580468
17	U Salai Thura Zaw	Fresh Water resources Program Officer	World Wide Fund for Nature (WWF)	salai.thurazaw@wwf.org Mobile: 0951229331
18	Daw Thin Thin Aye	Program Officer	World Food Programme (WFP)	thinthin.aye@wfp.org Mobile: 0943016310
19	Daw Khin Thein Htwe	Environmental and Social Management Framework Specialist of Universal Service Reform Project	Post and Telecommunication Departmentı World Bank	theinkhinhtwe@gmail.com Mobile: 0943088398
20	Daw Aye Kyawt Swe	Agri- Market Consultant	Mercycorps Myanmar	aswe@mercycorps.org Mobile: 09 973933672
21	Daw Theint Theint Aung	Environmental and Social Management Framework Specialist of Universal Service Reform Project	Ecosystem Conservation and Community Development Initiative	theintaung09@gmail.com Mobile: 095181293

Attachment I List of participants involved in feedback and comments via Emails for the 1st Draft BA & EF Report (Climate Change Adaptation – Water Resource Management Sector)

Sr.	Name	Designation	Department	Contact Address
1	Daw Win Min Phyo	Director	Department of Trade	dotregional@gmail.com Mobile: 09421182515
2	Dr. Theingi Myint	Professor	Yezin Agricultural University	theingi.myint@gmail.com Mobile: 09250108681
3	Daw Wai Wai Kyaw	Deputy Director	Myanmar Custom, Ministry of Trade	waimoekyaw94@gmail.com Mobile: 095121283
4	Dr. Paung Shin Kam	Research Officer	Department of Agricultural Research, MOALI	kampau@gmail.com Mobile:09797707146
5	Dr. Thida	Assistant Research Officer	DAR	thida.biotech@gmail.com Mobile: 09794255564
6	Dr.Yazar Hein	Associate Professor	YAU	yarzarhein@yau.edu.mm Mobile: 0943188246
7	Dr. Khin Zar Kyaw	Staff Officer	Department of Agriculture, MOALI	zarkyaw@gmail.com Mobile: 09793978793
8	U Htun Htun Zaw	Program Officer	MERN	Tunzayarzaw009@gmail.com Mobile: 09975255705
9	Daw Thimar Win	Agri- Market Consultant	MyanSEED Co.Ltd.	thimarwin1999@gmail.com Mobile: 0943186450

Sr.	Name	Designation	Department	Email & Ph no.
1	Daw Win Min Phyo	Director	Department of Trade	dotregional@gmail.com Mobile: 09421182515
2	Daw Wai Wai Kyaw	Deputy Director	Myanmar Custom	waimoekyaw94@gmail.com Mobile: 095121283
3	Dr. Win Min Oo	Deputy Director	Department of Rural Development	winminoomyanmar@gmail.com Mobile: 092045995
4	Daw Thandar Wint Wint Khaing	Assistant Director	Planning and GIS Division, ECD	tdwindwrm@gmail.com 09-450028742

5	Dr. Aung Than Oo	Assistant Director	Irrigation and Water Utilization Management Department	aungthoo@gmail.com Mobile: 095155224
6	U Aung Kyaw Soe	Assistant Director	Dry Zone Greening Department	aungkyawsoeone@gmail.com
7	Dr. Kyu Kyu Sein	Assistant Director	Department of Meteorology and Hydrology	sein.dmhmdy@gmail.com Mobile: 09 250 954 661
8	U Ye Phyo Aung	Staff officer	Irrigation and Water Utilization Management Department	yephyoeaung.hydro@gmail.com Mobile: 09776580468
9	U Salai Thura Zaw	Fresh Water resources Program Officer	World Wide Fund for Nature (WWF)	salai.thurazaw@wwf.org Mobile: 0951229331
10	Daw Thin Thin Aye	Program Officer	World Food Programme (WFP)	thinthin.aye@wfp.org Mobile: 0943016310
11	Daw Khin Thein Htwe	Environmental and Social Management Framework Specialist of Universal Service Reform Project	Post and Telecommunication Department, World Bank	theinkhinhtwe@gmail.com Mobile: 0943088398
12	Daw Aye Kyawt Swe	Agri- Market Consultant	Mercycorps Myanmar	aswe@mercycorps.org Mobile: 09 973933672
13	Daw Theint Theint Aung	Environmental and Social Management Framework Specialist of Universal Service Reform Project	Ecosystem Conservation and Community Development Initiative	theintaung09@gmail.com Mobile: 095181293

Attachment III Draft Barrier Lists for Screening (Agriculture Sector)

Attachment III (A) Technology 1 Solar powered drip irrigation

Economic and Financial barriers

1. High cost of initial installation and maintenance
2. High-interest rate of loans for technology developers
3. Lack of formal credit and loan facilities for farmers
4. Lack of economic feasible data of the technology
5. Limited funding available from government and development actors

Non- Financial barriers

1. Lack of policy, rules and guidelines which encourage the adoption of the technology,
2. Inadequate extension services,
3. Limited numbers of extension staff in Township level DOA

4. Low national budget allotted to the extension services,
5. Weakness in agriculture research activities,
6. Low budget allotted to research institutions
7. Limited capacity and limited numbers of technicians

Community/ farmers level

1. Farmers' low knowledge on better water use efficiency, and future water scarcity,
2. Highly skilled labor needed for installation, operation, and maintenance,
3. Drips pipes / sets easily damaged and difficult in handling
4. Insufficient information and awareness program of the technology to the farmers
5. Low capacity to sustainable use of technology
6. Farmers preference furrow irrigation (less complicated) to the drip irrigation
7. Inadequate farmers' skill for the technology
8. Inadequate Information and networking
9. Limited awareness raising programs and activities
10. Limited market and market information of the technology

Attachment III (B) Technology 2 Conservation Agriculture

Financial barriers

1. High initial cost of establishment for small holder farmers
2. Farm machineries imported, and expensive,
3. High hiring cost of machines for land preparation for initial years
4. Inadequate credit and loan facilities for farmers
5. High interest rates of loans for the developers/ entrepreneurs
6. Few public and private investment on research and development
7. Limited funding available from government and development actors

Non-financial barriers

1. Very few policies and guidelines to encourage the CA technology
2. Limited CA policy which improve the sustainable crop production,
3. No integration of CA/ sustainable agriculture in the development plans
4. Weak implementation of project plans by the related government organizations
5. Insecure land tenure system
6. Customary rights for the land ownerships neglected,
7. Farmers have less sense of ownership, no motivation of sustainable production
8. Lack of economic and financial feasibility study
9. Few research findings and costs and benefits of the adoption of CA
10. Mechanization is needed for the technology
11. Mechanized planters and seeders required
12. Limited technical knowhow of extension workers of DOA and Land Use Division
13. Inadequate extension service and number of service personal,
14. Low national budget for extension services
15. Few research activities on this particular technology,
16. Low national budget allotted in agriculture research,
17. Lack of coordination among stakeholder organizations, public and public sector organization,
18. Very few trained technicians for the technology

Community/ farmers

1. Inadequate knowledge of farmers on conservation practices
2. Low awareness training and workshops to the community
3. Limited income for long development period (3-4 years) for realizing return on investments,
4. Preference to conventional crop production methods which produces more yields in an immediate cash return,

Attachment III (C)Technology 3 Salinity Tolerance Rice varieties

Economic and Financial barriers

1. Inadequate financial resources for research and extension
2. Limited agricultural credit and loans
3. No specific credit system with low interest rates
4. Limited funding available from government and development actors
5. Limited development actors such as government agencies, donor agencies and NGOs

Non-financial barriers

1. Limited policies encouraging for the use of stress tolerance rice seeds
2. Low effectiveness for the operation of existing rules and regulations
3. Very few integrations of climate change considerations in rural development plans
4. Neglected issues of more salinity intrusion and rice yield loss of farmers
5. Weak in institutional and organizational capacity
6. Limited communication and extension approach
7. Poor networking with farmers and producers of rice value added product
8. Delay process for seed registration,
9. Inefficiency in seed production, and distribution system,
10. Delayed release of new/ improved rice varieties
11. Inadequate technicians and staff for the extension services
12. Insufficient seed production, distribution and delivery systems
13. Inadequate of physical infrastructures for seed production
14. Limited research programs for saline tolerance rice varieties
15. Low institutional capacity on agricultural research,
16. Insufficient funds for the long-term research to produce improved rice varieties
17. Market failure due to the uncertainty and low seed demand
18. Low market for the rice value added product

Community/ farmers level

1. Low information about the new improvement rice varieties released from DAR
2. Inadequate training on seed multiplication method for farmers
3. Limited farmers' skills for the technology
4. Low preference of improved new varieties comparing with their local resistant varieties

Attachment IV Brief meeting notes of Zoom meeting held on 16 June 2020 (Agriculture Sector)

For the barrier screening, online zoom meetings were organized by the ECD, Nay Pyi Taw for the agriculture sector and water sector on 16 June and 17 June, 2020, respectively.

Deputy General Director (ECD) gave the introductory speech, warming up the stakeholders about the TNA Project and BA-EF Report. National Consultant (CC Adaptation) explained each selected technology first and then the participants discussed and gave comments on the barriers and measures, and most were agreed by all participants and TWG. These comments were added accordingly under barriers and measures of the respective sections of the technologies. The national consultant, with the

collaboration of the national TNA team, revised the BA-EF report by adding the relevant comments.

The following are the comments and inputs of the stakeholders.

(1) Solar powered drip irrigation

YAU: For the Economic & Financial barriers, the technology and value of the product should be matching each other. Incentive for the farmers as well as market incentive should be added as measures. Uses of solar powered drip and salinity tolerance rice have no incentives unless their products can fetch better prices.

Agri- Market Consultant, MyanSEED Co. Ltd.: Market incentive and private sector involvement should put as measures, Onions in dry zone and sugarcane chili and tomato in Shan State were grown under contract farming, no difficulties for investment, therefore put contract farming as a measure; As barriers, to put the weak participation of private sectors in all technologies in the report; to add the few importers and suppliers as a barrier in market mapping, as one of the causes of high price of facilities .

DAR: For enabling environment – the maintenance of solar is required, put it as a barrier; put fertigation to make the technology stronger; for the repair of the solar and drip sets, it can be consulted with dealers for "after sale services".

Customs Department: The department has already issued zero import tax for agriculture produce; if it is submitted with the official recommendation letter from the ministries, solar panel, solar controller; solar inverter will have tax exemption: zero percent for custom tax and trade tax. Therefore, import taxes are not the barriers for the technologies, and not for the high price of the agriculture inputs in the market.

DOA: For the institutional and organizational capacity, the barrier is the poor technology of installation due to poor extension services.

Local staff of FAO: The formation of new/ updated policy and legal will take a long time while the project periods are generally short. Most projects have funding assistance, it is better to collaborate with government agencies for the funding requirement.

ECD: From drip irrigation, the solar batteries and plastics, consider the waste management and educate the farmers; in barriers, better use the word "limited", instead of "poor".

Myanmar Environmental Habitation Network (MERN): As measures for technology dissemination – job training and contract farming as measures.

(2) Salinity tolerance rice varieties in coastal and inland salinity area

DAR: There are two salinity processes such as inland salinity and coastal salinity; technical needs / limited technical information, weak in research and development for both technologies as barriers.

DAR: More saline areas expansion in Ayeyarwady Region is evident. Sea water intrusion maps were available for some areas, such as in Latbutta Townships, recently.

MyanSEED Co.Ltd.: For the Institutional/organization capacity, encourage seed associations as measures; for example, in the Market Chain map - early generation seeds were cultivated by MRS (Myanmar Rice Society); Seed campaign and extend seed trade fairs by the ministry, NGOs and MRS; financing support is necessary for post harvesting infrastructure.

YAU: A financing mechanism is required for the rice value chain for small holder.

(3) Conservation Agriculture (CA)

DAR: To introduce CA technology, it firstly needs to consider to balance the input and output for the farmers; farmers cannot withstand the yield reduction in the initial years of CA; Support the pioneer farmers as an enabling measure.

DOA: Erosion happens also in Dry Zone, but it is difficult for CA with less water condition, the land with irrigation water will be suitable for this technology; put ground water recharge technology as a measure.

MyanSEED Co.Ltd.: Farmers participation in the production level is important to produce value addition, GAP (Good Agricultural Practice) rice, and Nature rice, Eco –rice, SRP (Sustainable Rice Platform) certified rice; to get the premium price is a measure, better to think of for the saline tolerance to add its value.

ECD Director: Conclusion remark at 12:30pm

Attachment V Feedbacks and comments on the draft BA-EF Report via E-mails to ECD

(1) Solar power drip irrigation technologies

Customs Department: The Department has set "Zero customs" for the imports of the following materials related with agriculture - Agricultural insecticide sprayers and similar appliances, items for horticultural Drip Irrigation system, chemicals and natural fertilizers, insecticides, etc. There is no tax payment for the solar panel, solar controller, solar inverter, etc. The zero customs for – land preparation for cultivation for agriculture and horticulture, and ploughs, harrows, seeders, planters, trans planters, fertilizer distributors, and agricultural machinery, etc.; The barrier should not be placed on "Import policies", because the department has already done to mitigate the difficulties for the import of the agriculture inputs; National Economic Strategy (NES) has already set up the policies and guidelines for the GAP, safe foods for import and exports.

DOA: Introduce Contract Farming System for more reliable markets for farmers; Contract farming for township-wise and village-tract –wise management systems; Encourage more widely use of GAP and organic farming as enabling measures; Introduce more crop species for commercial farms and management systems, Improve Post-harvest technology and its related infrastructure;

DAR: Encourage reliable markets for agriculture produce; Capacity development trainings for growing with net- house.

MercyCorps: Collaborate with private sectors who are selling net house to provide private extension service; To create financial service (Special loan/ long term loan scheme with low interest rate); Provide technical awareness, hands-on training, extension service on the management of green-house system; Promote awareness of water utilization training and network and management system for water saving technologies.

ECCDI,: Create incentives for community ownership and participation, Cost-sharing system to subsidize the technology; Awareness training to farmers on climate change; Introduce other important crops for export production; Improve coordination among public departments and private sectors relevant to the technology.

A national consultant (WB project): Subsidy program should start to support farmers to use the technology widely.

(2) Conservation Agriculture (CA) technology

DOA: Draw land use planning in particular areas, starting from Township level.

DAR: Encourage building factory/ plant for producing natural fertilizers and organic fertilizers; Produce farm tools and machineries equipment for CA;

MercyCorps: AMD should do cost sharing with farmers – reduce the hiring cost for land preparation for CA; Create financial service (Special loan/ long term loan) for farmers; collaborate among departments. Inter/ intra departments & Ministry and other organizations like NGOs, INGOs and Research Institutes.

ECCDI: Update the agriculture policies to promote CA; Policies and legal instruments should encourage adoption and implementation of CA; promote financial support for research, extension and crop insurance that encourage CA; Capacity building Trainings and TOT to the organizations and local community; Provides adequate incentives that encourage the adoption and implementation of CA; provide capacities, skills and incentives to build a larger number of extension agents (public and private sector) to improve the Farmer to Extension Worker Ratio.

(3) Improvement of STR varieties in coastal and inland salinity areas

YAU: Improve policies encouraging creating measures to support the long-term research and development of technologies; Support skill training and technology development and transfer; for the technology dissemination, develop the network.

DAR: Encourage networking among all stakeholders related with the technology.

MercyCorps: Improve the status for skill training technology development and transfer; Government institutions should collaborate with NGOs, INGOs, private sector; Build a networking system for technology transfer among all stakeholders; Hand-on trainings and demonstration plots.

MERN**:** Cost sharing or subsidies for farmers' initial investment

Attachment VI KII with technology experts for STR varieties

Key Informant Interview (KII) with technology experts in Kyaukse Township, Mandalay Region

Meeting Date: 23-3-2020

Meeting Place: Agri-biotechnology Research Unit, Department of Research and Innovation, Ministry of Education, Kyaukse, Mandalay Region

1. Dr. Mya Min, Director, Agri-biotechnology Research Unit, (Mobile: 09760744773; Email: minnmya@gmail.com)
2. Dr. Kaing Zar Lin, Deputy Director, Agri-biotechnology Research Unit,
3. Dr. Nandar Aye Win, Director, Aquaculture Lab.
4. U Tint Lwin, Staff officer, Agricultural Research Farm Manager, Kyaukse Farm (Mobile: 09963751199)
5. Daw Ni Ni Aung, Staff officer, Agricultural Research Farm Manager, Kyaukse Farm

Attachment VII NPV analysis for the improvement of "Solar powered drip irrigation" technology

(A) NPV analysis

The project will invest 11,937 Million Kyats (around 9 Million USD) to promote solar pumping and drip irrigation system. The whole system will include solar pmp, drip Irrigation set, and fertigation system. The project plan is to promote this system in chili cultivation in dry zone. Taking careful consideration of less and less water availability, drip irrigation with solar pumping system will be applied as a climate change adaptation technology. It will replace the farmers' conventional practice of furrow irrigation with diesel engine pumping, which takes large water consumption and waste of water. Moreover, under the limited water resource areas, this technology gives effective water usage so that farmers can use water in longer period than the furrow irrigation practice. The cost of production and return on acre of chili production with furrow irrigation is mentioned below Table.

Based on the farmers' experience, it is assumed that by utilizing this technology, fertigation system and solar pumping system reduce the cost of production, especially operation cost such as inter-cultivation, weeding cost, fuel, and some percentage of pest and disease management cost and fertilizer application.

The project will provide the technology to 6,900 farmers in five years project phase. The breakdown of the number is also described in the excels sheet. As the number of farmers will be disseminated in five years, the return of the production is also calculated according to the number of farmers provided in each year.

In the calculation, the opportunity cost, discounted rate (6 percent) refers the current bank interest rate in Myanmar. As the IRR rate of 18 % has greater percentage than the interest rate (Opportunity Cost), the project is profitable. And Net Present Value (NPV) shows positive, meaning the project is profitable for implementation (Excel file attached).

The maximum rate of IRR that produces Zero NPV is 18.225102372% with the following equation:

$CF1\ (1+irr)^{-0} + CF\ 2(1+irr)^{-1} + CF2\ (1+irr)^{-2} + CF\ 3(1+irr)^{-3} + CF\ 4\ (1+irr)^{-4} + CF\ 5(1+irr)^{-5} = 0$

Since the Benefit Cost Ratio shows 1.8 percent, it is assumed that the project is profitable and acceptable to implement.

In this project investment calculation, total amount was calculated with the cost of drip irrigation system. However, in reality, it might not possible to provide 100 % provision to the farmers, 6900. It can be 50 percent of provision and 50 percent of the total will go for project operation cost. Therefore, 50 percent of total project cost will benefit to targeted farmers.

Cost of cultivation and Return of one acre of chili in Yamethin Township, 2020-2021 (Source: DOA Yamethin Township, Mandalay Region): with conventional practice of furrow irrigation with diesel pumping

Sr.	Particu-lar	Unit	Unit cost	Labor Cost					Material cost		Grand total
				Family		Outside family		Total	Qty	Cost	
				Qty	Cost	Qty	Cost				
	Nursery				16600			16600			16600
1	Land preparation	Pair	7000	1	7000			7000			7000
	Bed forma-tion	MD	4800	2	9600			9600			9600
	Field prepara-tion				21400		69600	91000			91000
	FYM applica-tion	MD	4800	2	9600	2	9600	19200			19200
	Tractor plowing	round	30000			1	30000	30000			30000
2	Tractor harrowing	round	30000			1	30000	30000			30000
	Planting row/line drawing	Pair	7000	1	7000			7000			7000
	Weeds cleaning	MD	4800	1	4800			4800			4800
3	Care and Management				114400		28800	143200			143200

Sr.	Particu-lar	Unit	Unit cost	Labor Cost					Material cost		Grand total
				Family		Outside family		Total	Qty	Cost	
				Qty	Cost	Qty	Cost				
	watering nursery	MD	4800	4	19200			19200			19200
	Trans-planting	MD	4800	2	9600	4	19200	28800			28800
	Fertili-zer application	MD	4800	3	14400			14400			14400
	Weeding	MD	4800	2	9600	2	9600	19200			19200
	Inter cultiva-tion	Pair	7000	4	28000			28000			28000
	Irrigation	MD	4800	3	14400			14400			14400
	Pesticide spraying	MD	4800	4	19200			19200			19200
4	Harvesting				48000		144000	192000			192000
	Picking/ sun drying	MD	4800	10	48000	30	144000	192000			192000
5	Inputs									322500	
	Seed	pack	5000						10	50000	50000
	Manure	bag	16500						2	33000	33000
	Fertilizer	bag	43000						1	43000	43000
	Fungicide	pack	7000						3	21000	21000
	Pesticide	pack	6500						5	32500	32500
	FYM	cart	25000						5	125000	125000
	Fuel	gallon	3000						6	18000	18000
	TOTAL				**200400**		**242400**	**442800**		**322500**	**765300**

Average yield: 350 Viss / acre (1 Viss = 1.67 kg; 1 acre= 0.405 ha)

Cost/Viss: 4000 MMK

Income/acre: 1,400,000 MMK (Myanmar Kyats)

Cost of cultivation/ac: 765,300 MMK

Benefit/Return 634,700 MMK

Unit cost: 2187 MMK

Ratio of cost and return: 1:1.83

Attachment VII (B1) Detailed calculation of NPV analysis for the improvement of "Solar powered drip irrigation" technology was described in separate excel file attached.

		Discounted Rate/ Opportunity Cost	6%	(It refers to the Myanmar Central Bank Interest Rate)	IRR 18.225102372%	The maximum rate that produces Zero NPV	
	Year	Cash Flow / Future value	Present Value (Discounted Cash Flow)				
	0	(11,937,000,000)	(11,937,000,000)				
	1	1,257,240,000	1,186,075,471.70				
	2	2,828,790,000	2,517,613,029.55		IRR 18 %, NPV=	78,387,108.00	
	3	4,400,340,000	3,694,610,315.90				
	4	5,971,890,000	4,730,296,226.55		-		
	5	7,229,130,000	5,402,026,475.21				
			5,593,621,518.9	Net present Value			
Net Present Value			5,593,621,519		As NPV at IRR is still Positive, project should be Invested.		
Internal Rate of Return			18%		As the IRR rate has greater percentage than the interest rate (Opportunity		
		PV	FV/ (1+ 6%) ^n				
			B/C >1	As the Benefit Cost Ratio is greater than 1, the project is acceptable and profitable.			
		BCR=B/C					
		1.82					

Attachment VII (B2) Detailed calculation of NPV analysis for the improvement of "Solar powered drip irrigation" technology

Cost and Return in Traditional Practice		
Return		
Yield per acre	350	viss
Price	4000	
Return	1,400,000	
Production cost traditional practice	765,300	per acre

Intercultivation	28000
Weeding	57600
Irrigation	14400
Fuel Cost	18000
	118000
Decrease cost due to the technolgy	59000

59000

Net Profit	634,700

Return in Drip Irritation		
50 % increase	Increased yield (Total)	
175	525	
Return	2,100,000	
Production cost drip irrigation system	706,300	
Irrigation system (depreciation)	346,000	
Total cost	1,052,300	

Net Profit	1,047,700
	413,000

	Drip Irrigation set including solar pump	MMK		
1	Drip irrigation system for 1 acre (Drip Pipe)	1400000	This depends on the acrage	If the plot size is less than 1 acre, the cost will be less
2	Pump system for primary water delivery soruce (Solar System)	200000	Fixed system	
3	Pump system for water delivery from mini reservoir to drip irrigation area	130000	Fixed system	It can be used till 4-5 acres
	The whole System of Irrigation system one acre	1,730,000		
	5 years	346,000		
	The drip irrigation system will last 5 years which can be assumed the economic life of the project. Therefore, the cost of drip irrigation will be taken into account as 346,000 MMK in each year of production cost.			

Attachment VII (B3) Detailed calculation of NPV analysis for the improvement of "Solar powered drip irrigation" technology

Year	Number of key farmers	Rate provision(MMK)		USD				
1	1200	1,730,000	2076000000	1596923.08			50%	50%
2	1500	1,730,000	2595000000	1996153.85				
3	1500	1,730,000	2595000000	1996153.85				
4	1500	1,730,000	2595000000	1996153.85				
5	1200	1,730,000	2076000000	1596923.08				
Total Investment	6900		11,937,000,000.00	9,182,307.69	4,591,153.85	3,287,000,000		
						11,937,000,000		

Year	Target	Number of farmers who receive return	Net Profit	Total profit increase		BCR	
0	1200	0	1,047,700.00	0		1.82	
1	1500	1200	1,047,700.00	1257240000			
2	1500	2700	1,047,700.00	2828790000			
3	1500	4200	1,047,700.00	4400340000			
4	1500	5700	1,047,700.00	5971890000			
5	1200	6900	1,047,700.00	7229130000			
				21687390000	16,682,607.69		

Attachment VIII NPV analysis for the improvement of "Saline tolerance rice varieties" technology NPV analysis (described in separate excels attached file)

Attachment VI NPV analysis for the development of "Salinity Tolerant Rice Varieties" technology dissemination

Target area (ac) 10,000 (Ayeyarwaddy 6000 ac + Dryzone 4000 ac)
Project Implemtation Pe 6 years

Year	Farmer Participatory Seed Multiplication (FPSM) Phase (4 years)							STR Production (4 years)				Net Income	Net Present Value			
	Seed Area (ac)	Seed Production Cost (USD/year)	Project Administrative/ extension cost	Cost of FPSM	Produced Seed	Project Share (bsk)	Participant Farmers' Share (bsk)	STR Production Area (ac/year)	Cost	Rice Production (bsk)	Return (USD)		NPV at 8% d.f	NPV at 12% d.f	NPV at 16% d.f	NPV at 44% d.f
1	25	15,000	4,000	19,000	1,000	500	500	0	0	0	0	-19000	-17592.59259	-16964.28571	-16379.31034	-13194.44444
2	500	300,000	4,000	304,000	20,000	10000	10000	0	0	0	0	-304000	-260631.0014	-242346.9388	-225921.522	-146604.9383
3	500	300,000	12,000	312,000	20,000	10000	10000	10,000	2,000,000	600,000	2,400,000	88000	69857.23721	62636.66181	56377.87527	29471.02195
4	500	300,000	12,000	312,000	20,000	10000	10000	10,000	2,000,000	600,000	2,400,000	88000	64682.62705	55925.5909	48601.61661	20465.98746
5			6000					10,000	2,000,000	600,000	2,400,000	400000	272233.2788	226970.7423	190445.2062	64602.23316
6			6000					10,000	2,000,000	600,000	2,400,000	400000	252067.8508	202652.4485	164176.9019	44862.66191
7																
8																
				947,000					8,000,000		9,600,000	653,000	380,617	288,874	217,301	-397

Initial investment	**947,000.00**
BC	**1.07**
NPV at 8% discount fact	**380,617.40**
NPV at 12% discount fac	**288,874.22**
NPV at 16% discount fac	**217,300.77**
IRR	**0.44**

Attachment VIII (B) NPV analysis for the improvement of "Saline tolerance rice varieties" technology

Attachmnet VI NPV analysis for the development of "Salinity Tolerant Rice Varieties" technology dissemination

Year	Farmer Participatory Seed Multiplication (FPSM) Phase (4years)					STR Production (6 years)				Net Income	Net Present Value			
	Seed Area (ac)	Seed Production Cost (USD/year)	Project Administrative/ extension cost	Cost of FPSM	Produced Seed	STR Production Area (ac/year)	Cost	Rice Production (bsk)	Return (USD)		NPV at 8% d.f	NPV at 12% d.f	NPV at 16% d.f	NPV at 56.5% d.f
1	25	15,000	4,000	19,000	1,000	0	0	0	0	-19000	-17592.6	-16964.3	-16379.3	-12140.6
2	500	300,000	4,000	304,000	20,000	0	0	0	0	-304000	-260631	-242347	-225922	-124121
3	500	300,000	12,000	312,000	20,000	10,000	2,000,000	600,000	2,400,000	88000	69857.24	62636.66	56377.88	22958.3
4	500	300,000	12,000	312,000	20,000	10,000	2,000,000	600,000	2,400,000	88000	64682.63	55925.59	48601.62	14669.84
5						10,000	2,000,000	600,000	2,400,000	400000	272233.3	226970.7	190445.2	42607.72
6						10,000	2,000,000	600,000	2,400,000	400000	252067.9	202652.4	164176.9	27225.38
7						10,000	2,000,000	600,000	2,400,000	400000	233396.2	180939.7	141531.8	17396.41
8						10,000	2,000,000	600,000	2,400,000	400,000	216107.6	161553.3	122010.2	11115.92
				947,000			12,000,000		14,400,000	1,453,000	830,121	631,367	480,843	-288

Attachment IX (A) KII with officials from DZGD

Key Informant Interview (KII) with officials from Dry Zone Greening Department (DZGD), Mandalay Region
Meeting Date: 13-5-2020
Meeting Place: DZGD office, Patheingyi Headquarter office, Mandalay Region
Participants

1. U Myat Kaung Kyaw, Director
2. U Moe Zaw, Deputy Director (Mobile: 09266177694; Email: moezaw11@gmail.com)
3. U Aung Kyaw Soe, Deputy Director
4. U Aung Win Kyaw, Staff Officer (09421752897)
5. U Aung Than Myint, Staff Officer

Attachment IX (B) KII with officials from IWUMD

Key Informant Interview (KII) with officials from Irrigation and Water Utilization Management Department (IWUMD), Mandalay Region
Meeting Date: 5-6-2020
Meeting Place: IWUMD office, Mandalay Region

1. U Aung Moe Win, Director, IWUMD, Mandalay
2. U Zaw Wun, Deputy Director,
3. U San Min Tun, Assistant Director
4. U Tin Myint Aung, Staff Officer (Mobile: 095067859)

Attachment X Draft Barrier Lists for screening (Water Resource Management Sector)

(A)Technology 1 Renovation of village ponds and tube wells

Financial barriers

1. High cost of renovation,
2. High cost of maintenance,
3. High rate of loans and credits for technology developers,

Non-financial barriers

1. Limited legal and regulatory framework for water management,
2. Underground water law does not exist yet,
3. Low Technology knowledge and skills,
4. Limited technical knowhow for installation, maintenance requirements
5. Inadequate Data on Underground water resources
6. Poor standards, codes for certification
7. Limited institutional and organizational capacity
8. Low expertise and staff number for this technology
9. Weakness in research
10. Inadequate feasibility study for the hydrology and ground water access
11. Inadequate assessments on ground water quality and availability

Community/ farmers level

1. Inadequate Information and knowledge,
2. Limited knowledge of the safe and clean water

3. Water scarcity in future climate change scenario
4. Lack of maintenance of the facility
5. Often failure of the facility: tube wells often broken and village earthen pond easily eroded and siltation
6. Lack of sense of ownership,
7. Some villagers do not value the benefit of safe water supply
8. Weak participation in repair and maintenance
9. Lack of cash incentives of the technology
10. Lack of trainings and workshops for safe and clean water for health issues

(B)Technology 2 Flood disaster risk reduction in Ayeyarwady delta of Myanmar

Financial barriers

1. Huge investment and maintenance costs,
2. High cost of installation and renovation,
3. High cost of construction materials- High price of materials,
4. High price of labor cost,
5. Incremental costs to adapt to climate change
6. Limited access of national and international funding,
7. Limited international cooperation for the flood DRM in Myanmar,

Non-financial barriers

1. Limited implementation of existing law and action plans
2. Limited national disaster management activities
3. Inefficient enforcement of national DRM policy
4. Lack of integration of DRM in development plans and project
5. Limited laws and regulations for the river basins management,
6. Low level of technology
7. Poor accessibility for information on rainfall and weather data
8. Weakness in institutional capacity,
9. Insufficient data and information for risk of flooding,
10. Poor flood risk management and disaster preparedness,
11. Limited “Hazard and risk assessment,
12. Insufficient database on water resources and water basin environment,
13. Limited environmental impact assessments (EIA) in the past
14. Weak collaboration among the lead ministries,
15. Insufficient observation data or long-term research of the technology
16. Carry out better improvement on early warning system of natural disaster
17. Low research activities on flood disaster management, flood disaster impact assessment, etc.

Community/ farmers level

1. Very low Information and awareness on DRM processes,
2. Lack of understanding of water related hazards under the climate change,
3. Low public awareness of knowledge of the flood disasters
4. Poor information on flood risk preparation water related hazards

5. Communities weak participation in DRM processes
6. Very few activities of trainings and awareness raising activities to the community
7. Networking among government organizations and private sectors, LNGOs and INGOs and the local community

(C) Technology 3 Water purifying technology in remote villages

Financial barriers

1. High cost of installation and maintenance
2. High cost of construction materials, High price of imported materials, High transaction costs
3. Inadequate credit and loan for community to construct the infrastructure by the village community
4. Lack of subsidy program for the village community
5. High operation cost of diesel where the national electricity is unavailable; and community needs to share the cost,
6. Lack of economic feasible data of the technology
7. Limited funding available from government and development actors
8. Limited development actors such as government agencies, donor agencies and NGOs

Non-financial barriers

1. Limited policy and guidelines to support the health, water and sanitation
2. limited laws/ guidelines to encourage the consuming of safe and clean water in rural areas
3. Lack of policy and regulation for prohibition of use of unsafe water for the community
4. Few technicians for the technology
5. Limited technology for installation and maintenance of rural communities
6. Lack of standards, codes for certification for water purifiers
7. Weak in institutional and organizational capacity
8. Insufficiency in capacity of related ministries for the technology dissemination
9. Many villages generally consume the unsafe water when the scarcity of potable water
10. Low institutional capacity on research and development
11. Low researches on Arsenic / salt contamination in ground water
12. Low research in water borne diseases of surface water
13. Few numbers of research institutions and laboratories

Community/ farmers level

1. Insufficient awareness of the how to use the technology
2. Inadequate information and knowledge of the advantages of safe and clean water
3. Low awareness in environmental issues of more and more drinking water scarcity and impurity in future climate change scenario
4. Low preference of good /purified water
5. Low knowledge on health issues, rural communities do not value the safe drinking water
6. Poor management traditions for long-term sustainability

Attachment XI Brief Meeting notes of the Zoom meeting held on 17 June 2020 (Water Resource Management Sector)

ECD - Deputy Director: Brief introduction to the project;

The national consultant firstly explained the selected technology and then the meeting participants discussed on it. Most comments and suggestions were agreed by all participants and TWG. These were added accordingly under barriers and measures of the respective sections of respective technology in the report.

The following are the inputs of the participants for barrier screening processes:

(1) Renovation and improvement of village ponds and tube wells in Myanmar (Dry Zone)

DZGD: while construction/ renovation time, the local labors were used as many as possible. Therefore "no interest by community during the rehabilitation" was not a barrier. In the report; no return/ benefit during renovation and construction time (dry seasons) should be revised. (Note: The report was already edited and revised accordingly.)

ECD: It was not clear that for the Renovation and Improvement for tube well and Village Pond, which technology is to be emphasized. For the Technology Needs Assessment, the technologies should be more thoroughly discussed.

ECD: Not to emphasize much on the financial requirement and not to confuse with financial need assessment.

DZGD: Please focus the discussion on the preferred the technology diffusion, not the technology itself; focus also on replenishment of underground water.

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

World Wide Fund for Nature (WWF): Good flow of water in rivers is also important factor for food prevention, as a measure.

IWUMD: Detention dam, Diversion channel, embankment to control floods by measures;

DWRI: Collaboration with early warning of DMH was required for the collaboration. The barriers were - limited the information on River Basin environment, water resources database, selection and prioritization of cascade systems/ minor tank for restoration; Measures: Develop a policy/ strategy to identify needs and urgency based on climate change modeling; Strict enforcement of relevant environment laws/ regulations.

ECD: River basins management committee should be strong enough; in the Dry Zone, it needs to consider the ground water storage capacity; reduce the number of tube wells; at the time of floods in delta, to maintain the drinking water – use filter tank for drinking water.

IWUMD: Watershed management in upstream is an important measure, Research and Development in surface water level and aquifer level is necessary for the technical issues.

DWRI: The department is carrying out the River Basin Management for the river bank erosion control; to reduce the floods, dredging of the sands, which was one of the measures for control floods.

DMH: Flood hazard maps were issued for the priority areas, in total for ten (10) Towns; there is no hazard maps for sea level rise and hazard map for risk reduction, technical needs are barriers for Sea Level Rise, Storm Surge and others.

DZGD: The occurrence of "River floods" were experienced in Myanmar, therefore it should be given priority, rather than the other disasters.

A national consultant - (WWF) Forest plantation in head area is a measure.

(3) Water purifying technology in remote villages of Myanmar

ECD: The technology is related with three major ministries such as Ministry of Education, Ministry of Health and Sports and Ministry of Agriculture, Livestock and Irrigation, take care not to overlap the projects. Since the major department for this technology is DRD, MOALI; others are supporting and collaborating departments. Work in collaboration.

DRD: Although the Ayeyarwady delta, Yangon, Bago and Rakhine had sufficient rains and many streams and small rivers, but water quality was not good enough to drink. DRD has done pilot projects and had experience that in a series of about 10 purifiers could accommodate almost the whole village (in Pathein Township, Chaung Wa village) as a success story. Give awareness training for sustainability as measures; National Drinking Water Quality Standard was published in 2019, which has 16 Priority Parameters; during the implementing process it should be consistence with these parameters.

A national consultant (Universal Service Reform Project): traditional filter for drinking water (earthen pot) will reduce the cost, as a measure. DRD replied that these pots are only for the household level, it does not cover the village level.

Customs Department: It was described that "Purifiers with capacity above 500 liters are 3% of import duty; the capacity below 500 liters are 7.5%; If it is for the donation purpose, application for exemption can be submitted; According to the Free Trade Area Agreement, if the materials are imported from ASEAN, the import tax are reduced.

National consultant (Universal Service Reform Project): The community does not have knowledge and information how to use the filters, awareness raising is necessary as a measure.

ECD: Use the low or Non-cost material such as sand filters; for the awareness trainings, the collaboration of related ministries is required.

Deputy Director of ECD (National TNA Team) gave a closing remark at 1:00pm.

Attachment XII Feedbacks and comments on the draft BA-EF Report through E-mails to ECD (Water Sector)

(A) Renovation and improvement of village ponds and tube wells

IWUMD: Create a loan or credit system for the technology developers; Conduct preliminary survey to prioritize the neediest areas for water; Develop standards for rainwater harvesting ponds and should follow these standards; Develop underground water standards and establish laboratories for water test; Conduct research to ensure the underground water quality for drinking water; Conduct Pre-feasibility studies before the technology starts; Organize consultative meetings for the participation of local communities and form WUG and WUA.

DRD: Explore funds from the donor agencies and support partially to the community for labor charges; for the time being, lack of policy to control the excessive use of ground water; Underground water policy was submitted to the approval of parliament; reduce the construction cost by using possible methods; create a feasible loan and credit system for producers and importers of the technology.

DZGD: Work together among the related government organizations and NGOs and private sectors;

Customs Department: Develop policies for loan and credit system with reduced interest rates; there are tax relaxation for some goods, such as water pipes and tubing facilities, import license are not necessary for several a

agri-items,

Trade Department: Fluctuation of import prices depends on the world prices of fuel, exchange rates of foreign currencies, etc; the high price of agri-inputs does not depend on the trade policies; agriculture inputs such as seeds, fertilizers, pesticides and farm machineries, had already reduced import license fees or tax exemption; the department also allowed the international investments since 2015.

YAU: Awareness and capacity building training to the staffs of related institutions; Upgrade institutional structures; Encourage establishment of R & D Institution for hydrology; Acquire funds from donor agencies; Use of low-cost technologies, encourage participation of locals in decision making in renovation works; In line with the underground Water Law which will be released soon, draw rules and follow the instructions.

MercyCorps: Get funds from Donor Agencies and support the local labor charges; Use low cost technologies, community should contribute workforce or cost sharing for ownership sense and maintain the facility for the long term.

ECCDI: Barrier: Lack of monitoring of ground water and hydrology information; Absence of communication between technology producer and user,

A national consultant (WB): Existing village ponds and tube wells are not sustainable due to lack of maintenance and ownership of local community,

(4) Flood disaster risk reduction in Ayeyarwady delta

IWUMD: Formulate standard regulation / procedure of the management committee of the river basins and deltas; organize the consultative meetings to understand and continued activities to apply the DRM Policy**;** prepare the future disasters plans; create potential maps for flood disasters and evaluation studies.

YAU: Acquire funds from donor agencies, put more national budget for these activities; Increase the capacity for R & D related with hydrology; Improve the data access for rainfall data and etc. Improve R & D institutions for the data colllection of flood disasterr impact,

DMH: No barriers for the limited access in meteorological data; Daily rainfall data and others are issued and published in Official Facebook and distribution by the DMH in a timely manner; there will be cost for some data sharing to contribute to the national budget; DMH also supports the data without charges for the request of the governmental organizations

(5) Water purifying technology in remote villages

YAU: Develop low cost technologies, Increase R & D Institutions; Increase knowledge of community on the quality water technology; Conduct education program

DRD: Barrier - Weak in observing the National Drinking Water Policy; Limited standards and regulation; prioritize the neediest areas for installation of water purifiers; Limited knowledge on water, health and hygiene; Remoteness of the areas - difficult for the purified water access,