BANGLADESH

TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY ACTION PLANS FOR CLIMATE CHANGE ADAPTATION

"DATE OF SUBMISSION" (example, June.2012)

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AIT Asian Institute of Technology

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This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP-RISO Centre (URC) in collaboration with the Regional Centre Asian Institute of Technology, Bangkok for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein is a product of the National TNA team, led by the Ministry of Environment and Forests (MoEF), Government of the People's Republic of Bangladesh.

FOREWORD

Climate change and its multi-dimensional impacts to the potential development sectors have become a reality for Bangladesh. Impacts of climate change are exacerbating many of the current problems the country faces and will relentlessly challenge the country's ability to achieve continuous higher economic growth to eradicate poverty at an expected pace. In this context, Vision 2021 of the Government of Bangladesh noted that climate change poses a serious threat to Bangladesh's goal to accelerate economic growth, substantially eradicate poverty and become a middle-income country by 2021. The Sixth Five-Year-Plan 2011-2015 (FYP 2011-2015) explicitly refers to climate change and the challenges it poses to Bangladesh's development. The Sixth FYP 2011-2015 endeavors to tackle climate change vulnerability through programmes in agriculture, water, environment and disaster management. Environmental sustainability is one of the six core targets of the Sixth FYPs.

In addressing climate change, Bangladesh prepared national policies and strategies to make its major development sectors climate resilient and also to mitigate green-house gas from the potential sectors. Bangladesh was the first developing country to produce National Adaptation Programme of Action (NAPA) in 2005. The NAPA document was further updated in 2009 and identified 45 adaptation measures with 18 immediate and medium-term adaptation measures. Building on lessons learnt from the NAPA, Bangladesh prepared its own country-driven strategy 'Bangladesh Climate Change Strategy and Action Plan- BCCSAP' in 2009 through a participatory approach. BCCSAP identified a number of adaptation measures for short and medium-term implementation to enhance adaptive capacity of vulnerable communities. In fact, the climate resilient development would require 'innovative adaptive measures' through introduction of new and appropriate technologies. Thus, in the country context, a technology needs assessment (TNA) is a pre-requisite for implementing climate-resilient development planning.

Interestingly,I have found the sectors and projects that have been prioritized in the TNA Bangladesh adaptation report resemble the sectors and projects emphasized in the BCCSAP. I strongly believe that the implementation of adaptation projects prioritized at the TNA Adaptation report will help the country in building resilience to the impacts of climate change.

I thank the TNA National Team, my colleagues in the Ministry of Environment and Forests, experts of the relevant sectors for their invaluable contribution in the development of this report. I sincerely acknowledge the contribution of the project personnel and experts of UNEP, GEF, UNEP RISO Center and AIT for their relentless effort in the implementation of the TNA project and for coming up with some specific and prioritized measures for climate change adaptation in Bangladesh.

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PREFACE

Within this overall climate change context, adaptation measures involve the use of technology and its management (development, transfer, adaptation, adoption and diffusion) along with other related aspects such as financing. In the global context, technology development and transfer has increasingly gained a centre-stage in the agenda of negotiations. Whereas in the country context, Technology Needs Assessments (TNA) ,has become an important management tool for a country in formulating development strategies at the national level for adaptation and climate-resilient development planning and program implementation.

Bangladesh, being one of the most vulnerable countries to the impacts of climate change, is already striving to accelerate economic growth and substantially eradicate poverty by 2021 but avoiding the harsh environmental price many countries have paid in the pursuit of growth. In line with the fulfillment of country's sustainable development goal Bangladesh, with the assistance of UNEP, undertook the Technology Needs Assessment (TNA) project to identify the needs for new equipment, techniques, practical knowledge and skills, which are necessary to reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change.

Briefly, this project aims to produce Technology Needs Assessment (TNA) and Technology Action Plans (TAP) for climate change adaptation in Bangladesh. This report provides a list of prioritized the sectors that are likely to be affected by the impacts of climate are require urgent and immediate adaptation actions.

The TNA process in Bangladesh has followed participatory analysis and consultation with the sector specific relevant experts and stakeholders. I thank all of the colleagues, experts and stakeholders who were involved in TNA and contributed to this report.

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ACKNOWLEDGMENTS

Technology Needs Assessment and Technology Action Plan (Part II Report) is an outcome of efforts of a number of people, who shared their experiences and views in identifying barriers for transfer and diffusion of prioritized mitigation technologies, also identified possible measures to overcome the barriers.

Special acknowledgement is to due to the members of National TNA Team namely Dr Rezaul Karim, Environmentalist and Team Leader of National TNA Team, Dr M Asaduzzaman, Research Director, Bangladesh Institute of Development Studies, Dr Ainun Nishat, Vice Chancellor, BRAC University, Dr Ijaz Hussain, Professor, Bangladesh University of Engineering and Technology, Dr Zahirul Haque Khan and Engineer Tarek Bin Hossain of Institute of Water Modeling, Dr AKM Saiful Islam, Associate Professor, Bangladesh University of Engineering and Technology and Md Shamsuddoha of Center for Participatory Research and Development (CPRD).

Acknowledgement is also due to experts and stakeholder of different government and non government organizations who have participated in the national and local level consultations and provided substantive input throughout the development of technology action plan for climate change mitigation.

Special thanks to Dr P Abdul Salam , Assistant Professor, Energy Field of Study, School of Environment, Resources and Development, Asian Institute of technology and Dr Mokbul Morshed Ahmed, Associate Professor, Regional and Rural Development Planning, School of Environment, Resources and Development, Asian Institute of Technology, Bangkok, Thailand and Mr Sudhir Sharma, Senior Climate Change Expert, UNEP RISO Centre for their comments, suggestions and technical inputs while implementing the TNA project in Bangladesh.

Sincere acknowledgement is due to the project personnel of UNEP, GEF, UNEP RISO Center and AIT for their technical support and constructive feedback in all aspect of TNA implementation.

Sincere acknowledgement is also due to Mr Meshba ul Alam, Former Secretary, Ministry of Environment and Forests, Mr Shafiqur Rahman Patwari, Secretary, Ministry of Environment and Forests and to Mr Aparup Chowdhury, Additional Secretary, Ministry of Environment and Forests for their guidance and encouragement in the implementation of TNA project in Bangladesh.

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ABBREVIATIONS

AIS	Agriculture Information Service
ATIs	Agricultural Training Institutions
BARC	Bangladesh Agricultural Research Council
BCCSAP	Bangladesh Climate Change Strategy Action Plan
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
BADC	Bangladesh Agricultural Development Corporation
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BSRI	Bangladesh Institute of Nuclear Agriculture
BWDB	Bangladesh Water Development Board
CPRD	Center for Participatory Research and Development
CEGIS	Centre for Environment and Geographic Information Services
CEP	Coastal Embankment Project
CERDI	Central Extension Resources Development Institute
DAE	Department of Agricultural Extension
DAM	Department of Agricultural Marketing
FFW	Flood Forecasting and Warning
GoB	Government of Bangladesh
HEF	Horticulture and Export Foundation
HRSG	Heat Recovery Steam Generators
ICARDA	International Center for Agriculture in the Dry Land Areas
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
IWM	Institute of Water Modeling
LGED	Local Government Engineering Department
MoEF	Ministry of Environment and Forests
NWMP	National Water Master Plan
NGO	Non-Governmental Organization
SAAOs	Sub-Assistant Agricultural Officers
SCA	Seed Certification Agency
SLR	Sea Level Rise
SRDI	Soil Resources Development Institute
SWS	Storm Warning System
TRM	Tidal River Management
TNA	Technology Needs Assessment
TAP	Technology Action Plans
USAID	United States Agency for International Development
URC	UNEP RISO Centre
WARPO	Water Resource Planning Organisation

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Executive Summary

The Part II Report of the Technology Needs Assessments titled 'Technology Action Plan –TAP' aims to identify barriers that could hinder the transfer and diffusion of adaptation technologies of water and agriculture sector as prioritized in the Part I report. In barrier analysis, the nature of the individual barriers and relationships between the different barriers are discussed. Furthermore, important barriers are determined and ways to remove barriers are elaborated on. This report identifies measures for developing enabling framework conditions e.g. overcoming of economic, legal, institutional barriers and different support services like finance, quality services, standard management etc. This report also includes market mapping and ways of creating favorable framework conditions respectively for the technologies which are classified as consumer goods.

The specific finding of each sector is summarized below:

Water sector

According to the TNA sector prioritization report for water sector six technologies have been selected which include; 1) Rehabilitation of existing Embankments/ dykes and dredging infrastructure development, 2) Comprehensive disaster management incorporating early warning systems and involving community tidal system and infrastructures management, 3) Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion, 4) Tidal river management including computer simulation of tidal flow, 5) Tidal barriers (Sluice gate), 6) Urban Infrastructure development.

The Technology Action Plans (TAPs) for each of the prioritized technology have been developed. There are six specific targets for technology transfer and diffusion of the water sector are;
1) Rehabilitation of 3000 km coastal embankments/ dykes by 2020 and remaining 1500 km by 2025, 2) Up-gradation of Flood Forecasting and Warning (FFW) and Storm Warning System (SWS) by 2018; 3) By 2018, establishment of 3 monitoring station in the South-East, South Middle and South West coastal areas to monitor sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion, 4) Introduce Tidal River Management (TRM) and computer simulation of tidal flow to the 20 sluice gates by 2018, 5) Construct 50 new sluice gates and upscale another 50 sluice gate by 2020, 6) Modernize urban drainage infrastructures of 19 coastal district towns by 2020

Barriers for transfer and diffusion of prioritized technologies and the recommended solution for overcoming the barriers have been identified through stakeholders' consultation and market mapping. The common barriers and recommended solution have been presented in the following table:

Table 1: Common barriers and recommended solution for the transfer and diffusion of water sector technology

Common Barriers	Recommended solution
- Lack of investment, incentive policies - Less financial allocation from the Annual Development Programme (ADP) to the sectoral activities - Less financial allocation to the local authorities - Insufficient technology information and technical assistance - Inadequate institutional capacity in project planning and implementation - Lack of skilled personnel - Limited installation and maintenance capacity - Lack of technical expertise and capacity - Lack of collaboration and networking among the organizations - Less scope of participation of community/ local people in planning and implementation of site specific projects - Limited access to the advanced technology and research tools due to IPR issue - Top-down and centralized planning process	- Increased investment for water infrastructure development - International cooperation and support for plan, design and construct urgently needed new infrastructure (e.g., cyclone shelters, coastal and river embankments and water management systems; urban drainage systems, river erosion control works, flood shelters) to meet the changing conditions expected with climate change - Providing free access to the technologies and devices as well as to the high performing tools and technologies - Waive copyright fees for the technologies and software for computer simulation and modeling - Institutional and human resource capacity building for quality management and maintenance services. - Ensuring participation of local people in the planning and designing of water infrastructures

This report also includes two project ideas i.e. establishment of a special research and development (R & D) center for agriculture sector and undertaking of 'Tidal River Management (TRM), including Computer simulation of tidal flow' for the water sector.

Agriculture sector

For the agriculture sector, seven technologies have been selected which include; 1) Development of salinity tolerant rice varieties, 2) Development of draught tolerant rice varieties, 3) Development of short maturing rice varieties, 4) Establishment of climate-smart Technology Dissemination Center , 5) Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc. 6) Establishment of special agricultural R & D centre and 7) Land use planning

The Technology Action Plans (TAPs) for each of the prioritized technology have been developed. There are seven specific targets for technology transfer and diffusion of the water sector are:

- By 2017, development of 2 types of salinity tolerant rice varieties that can grow respectively in medium (5-10 ppt) and high range (more than 10 ppt) of salinity level.
- By 2017, development of a drought tolerant rice variety that can grow in dry and rainless condition
- By 2017, development of a short-maturing rice variety that can grow and mature within a month
- By 2017, providing training to the farmers of different agro-ecological zones on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.
- Establishment of one climate-smart Agriculture Technology Dissemination Center by 2020
- Establishment of one special agricultural R & D centre by 2020
- By 2017, land use planning using GIS and Remote Sensing technology

Barriers for transfer and diffusion of prioritized technologies and the recommended solution for overcoming the barriers have been identified through stakeholders' consultation and market mapping. The common barriers and recommended solutions have been presented in the following table;

Table 2: Common barriers and recommended solution for the transfer and diffusion of agriculture sector technology

Common Barriers	**Recommended solutions**
- Lack of investment, incentive policies - Less financial allocation from the Annual Development Programme (ADP) to the sectoral activities - Less financial allocation to the local authorities - Insufficient technology information and technical assistance - Inadequate institutional capacity in project planning and implementation - Lack of skilled personnel - Quality of inputs, seeds etc - Limited support service and monitoring - Lack of technical expertise and capacity - Lack of collaboration and networking among the relevant organizations e.g. research organization, extension organization, NGOs etc - Less scope of participation of community/	- Development of climate-resilient rice crop variety through enhancing agricultural research - Scaling-up finance and resources for research and extension and strengthening support services - Sustainable practices: training to farmers on the farming practices of climate-resilient cropping system - Strengthening coordination among research organizations and NGOs - Focusing on coordinated problem-solving and integrated research - Undertaking agro-ecological zone-based research - Ensuring dissemination of quality seed and other inputs to the farmers at subsidized cost - Strengthening linkages among research, extension, educational institutions and

local people in planning and implementation of site specific projects - Limited access to the advanced technology and research tools due to IPR issue - Top-down and centralized planning process	farmers - Ensuring participation of local people in technology experimentation and dissemination to socialize the technology - Waive IPR on the advanced research tools, technologies and agricultural inputs

This report has been prepared through a consultative process with the involvement of stakeholders from government and non-government organizations of the relevant sectors and technologies. In the consultation process, stakeholders from a wider sector and also from the grassroot- level were involved in identifying barriers in transfer and diffusion of technologies, indentifying measures to over cove the barriers, development of market maps for enabling framework for the respective technology.

Institutional arrangement for the TAP and the stakeholders' involvement

Technology Action Plan (TAP) is aimed at analyzing barriers and enabling frameworks for the transfer and diffusion of the prioritized technologies in the light of countries' immediate and long-term adaptation planning. TAP is likely to identify possible barriers for each of the prioritized technology and to identify measures to overcome the barriers and finally to develop short, medium and long-term action plans, including the agencies to be involved for transfer and diffusion of the technology.

On the basis of the methodologies of barriers analysis (Ref: TAP Guide book), the National Team undertook a series of stakeholders' consultation to identify the nature of different barriers, relationships between barriers, determine important barriers and find ways to remove barriers.

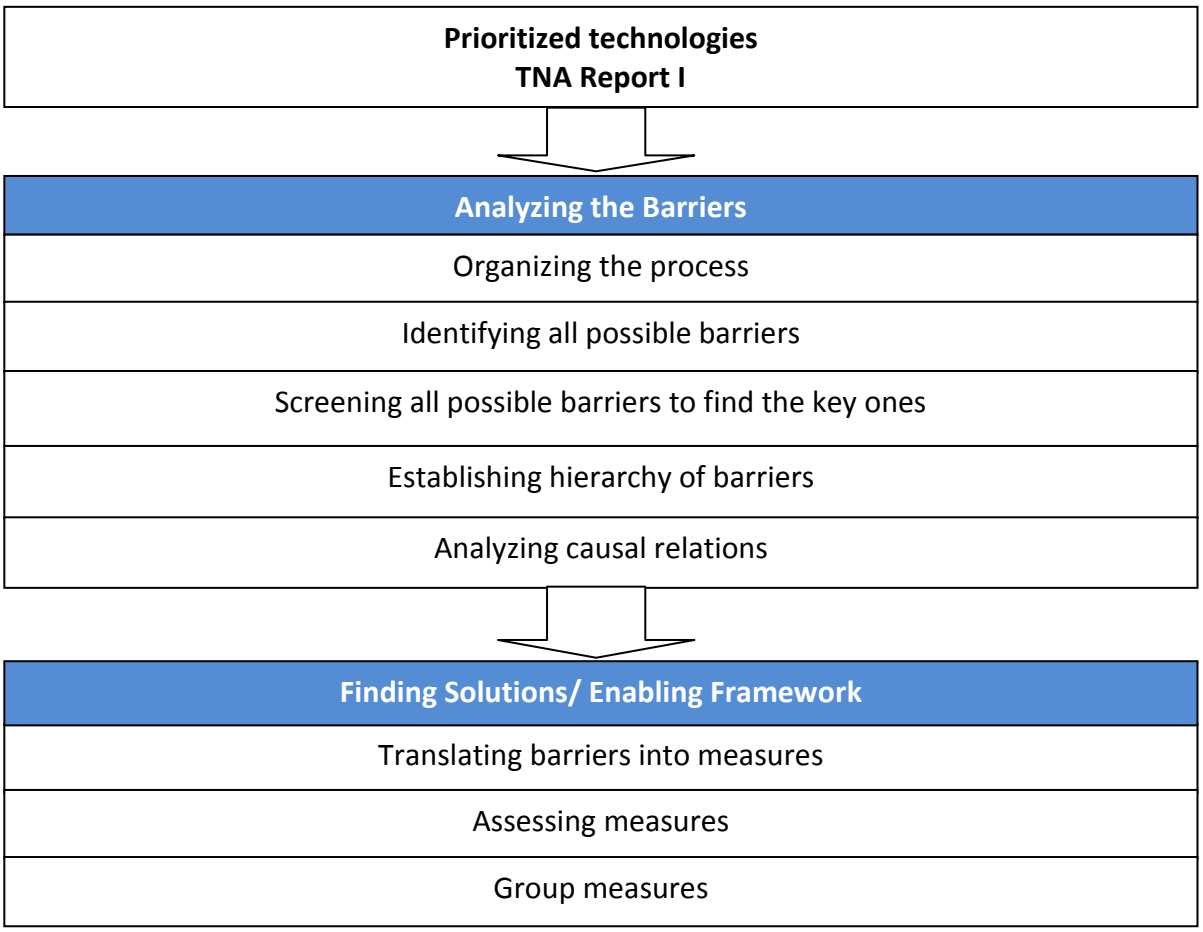

Figure 1: The overall methodologies of barriers analysis and identifying measures for enabling framework

As shown in the above diagram, the main steps followed in identifying and analyzing barriers for transfer and diffusion of adaptation technologies are presented in Box 1.

BOX 1: Main steps followed in identifying and analyzing barriers:

- Organising the process
- Identifying all possible barriers through literature survey, interviews and workshop brainstorms;
- Screening the gross list of barriers to select the most essential ones
- Classifying the selected essential barriers into a hierarchy of categories
- Analyzing the causal relations between barriers
- Finding solutions to overcome barriers by translating barriers into solutions

Stakeholder consultation has been the main feature for TAP preparation. Stakeholders ranged from sectoral experts and professionals from different educational and research institutions government ministries, department and agencies, and NGOs.

Prior to barrier analysis, the types of barriers are categorized to give more on those. The category of different barriers is presented in the following box 2:

BOX 2: Types of different barriers

Economic and financial: lack of access to finance, high cost of capital, financially not viable, inappropriate incentives
Market failures: poor market infrastructure, uneven playing field, inadequate sources of increasing returns, market control by incumbents
Policy, legal and regulatory: insufficient legal framework, highly controlled sector, clash of interests, political instability, bureaucracy, rent-seeking behavior
Network failures: weak connectivity between actors,
Institutional and organizational capacity: lack of professional institutions, limited institutional capacity

Human skills: inadequate training, lack of skilled personnel
Social, cultural and behavioral: consumer preferences and social biases, traditions etc.
Information and awareness: inadequate information, lack of awareness
Technical: uneven technical competition, lack of standards and codes, lack of operation and maintenance (O&M), unreliable product
Other: environmental impacts, lack of physical infrastructure

When all conceivable barriers are identified, the barriers are screened according to their significance. At this stage, barriers are classified into two categories i.e. financial barriers and non financial barriers.

Measures for developing enabling frameworks e.g. overcoming of economic, legal, institutional barriers are discussed and in the stakeholder consultations. Different support services like finance, quality services, standard management etc are also discussed in the consultations.

The market mappings have been done only for a few technologies which are classified as consumer goods. This is to mention that most of the adaptation technologies require large-scale public investment that's why market maps are not done for those technologies. The detail of market map is presented in Annex 2.

Chapter 1. Water Sector

From the sector prioritization exercise, several subsectors of the water sector e.g. infrastructure development, tidal system and infrastructures management, monitoring of sea and coastal changes, comprehensive disaster management and urban resilience improvement etc. have been prioritized in order to enable the water sector to adapt to the adverse effects of climate change. Under these subsectors a number of technological measures have been discussed in the stakeholder consultations, and the shortlisted technologies are presented in Table 1.

Table 3: Prioritized technologies for climate change adaptation for water sector

Subsector	Category	Technology
Infrastructure development	Project Implementation	Rehabilitation of existing Embankments/ dykes and dredging
		Tidal barriers (Sluice gates)
Tidal system and infrastructures management	Project Implementation	Tidal river management including Computer simulation of tidal flow
Monitoring of sea level and coastal changes	Research and knowledge generation	Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion
Comprehensive disaster management	Project Implementation	Comprehensive disaster management incorporating early warning systems and involving community
Urban resilience improvement	Project Implementation	Urban infrastructure improvement

On the basis of overall weighted score, the technology options are prioritized and ranked from high priority to low priority order and presented in table 2

Table 4: Water sector adaptation technologies as per priority order

Technology	Weighted Score	Priority Order
Rehabilitation of existing Embankments/ dykes and dredging	86.1	1
Comprehensive disaster management incorporating early warning systems and involving community	75.91	2
Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion	68.66	3
Tidal river management including computer simulation of tidal flow	65.52	4
Tidal barriers (Sluice gate)	58.88	5
Urban Infrastructure development	56.44	6

1.1 Preliminary and specific targets for technology transfer and diffusion

In view of the country's strive to undertake climate proofing activities, and to realize the targets set for vision 2021 and the Sixth Five Year Plan emphasized adaptation technologies for water sector infrastructure development and management of water resources for enhancing resilience and water security.

Again, the Bangladesh Climate Change Strategy Action Plan (BCCSAP), a 10-year programme to build the capacity and resilience, emphasizes construction of new as well as maintenance of existing infrastructure (e.g., coastal and river embankments, urban drainage) to address short and medium-term impacts of climate change. BCCSAP underscores:

- Repair and rehabilitate existing infrastructure (e.g., coastal embankments, river embankments and drainage systems, urban drainage systems) and ensure effective operation and maintenance systems
- Plan, design and construct urgently needed new infrastructure (e.g., cyclone shelters, coastal and river embankments and water management systems; urban drainage systems, river erosion control works, flood shelters) to meet the changing conditions expected with climate change
- Undertake strategic planning of future infrastructure needs, taking into account the likely (a) future patterns of urbanization and socio-economic development; and (b) the changing hydrology of the country because of climate change

In line with the broader policy goal, the specific targets for technology transfer and diffusion of the water sector are;

- Rehabilitation of 3000 km coastal embankments/ dykes by 2020 and remaining 1500 km by 2025
- Up gradation of Flood Forecasting and Warning (FFW) and Storm Warning System (SWS) by 2018
- By 2018, establishment of 3 monitoring stations in the South-East, South Middle and South West coastal areas to monitor sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion
- Introduction of Tidal River Management (TRM) and computer simulation of tidal flow to 20 sluice gates by 2018
- Construction of 50 new sluice gates and upscaling of another 50 sluice gates by 2020
- Modernization of urban drainage infrastructures of 19 coastal district towns by 2020

1.2 Barrier analysis

Barrier analysis for the transfer and diffusion of the prioritized technologies has been done through stakeholder consultations. In the stakeholder consultations, the group of experts discussed and exchanged information on different barriers that would hinder diffusion of technologies that are categorized as capital goods. Market mapping also has been done in the stakeholder consultations for the technologies categorized as consumer goods. In the

market mapping exercise, the stakeholders discussed the entire existing market elements related to the technologies and the linkages between them. The main elements that have been considered in market mapping are;

a) Enabling environment (e.g. legal, institutional and organizational etc.)
b) Mapping of the market players (e.g. manufacturer, wholesaler, retailer, consumer etc)
c) Support services required for technology transfer and diffusion (e.g. finance, technology standard, performance, product warranty, quality management etc.)

On the basis of information gathered from the stakeholder consultation and market mapping, the Steering Committee and Group of Experts categorized the barriers into two categories, namely financial and non-financial.

1.2.1 Barrier analysis for the transfer and diffusion of rehabilitation of existing Embankments/ dykes and dredging Technology

Bangladesh has experience in construction of embankments, using traditional manual system. So far over 4500 km of embankment was built along river bank and coastal areas. But in the climate change scenario, there will be a need for building more durable embankments with considerable height above the height of projected tidal surge and sea level rise. The rehabilitation of existing embankments/ dykes and dredging would face the following financial and non-financial barriers:

a) Financial barrier

- Construction of more durable embankments with considerable height above the height of projected tidal surge and sea level rise will require increased finance.
- New earth work, regular dredging and the maintenance of embankment along the coast will have high investment costs

b) Non-financial barriers

- Lack of adequate and skilled manpower as well as modern equipment in the soil mechanics laboratories in the country.
- Manual construction practices not feasible as it requires huge labor force.
- Lack of proper river mechanics studies and sediment transport modeling
- Ad-hoc decisions on drainage without study-based information and community consultation.

1.2.2 Barrier analysis for the transfer and diffusion of technology related to Comprehensive disaster management incorporating early warning systems and involving community.

Bangladesh has one of the finest and state-of-the-art Flood Forecasting and Warning (FFW) and Storm Warning System (SWS). This has remarkably reduced loss of human lives. At present, the systems suffice such that the loss of lives can be contained in hundreds and on some occasions few thousands in adverse situations that can help to save more lives. But in the context of more frequent and intense disaster events caused by climate change, real-

time forecasting of impending disasters will be required through modernization of existing warning systems and improvement in warning dissemination system. The financial and non-financial barriers in the transfer and diffusion of said technology includes:

a) Financial barrier

- Modernization of existing warning systems and improvement in warning dissemination system will require more investment

b) Non-financial barriers

- Community orientation to the modernized system and new approach of disaster risk reduction
- No system in place to monitor and forecast slow-onset disaster events like salinity intrusion, drought, ocean acidification etc.

1.2.3 Barrier analysis for the transfer and diffusion of Technology related to monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion

There are only tidal gauges on major ports. Bangladesh Water Development Board collects periodic salinity data in the coastal areas. Therefore, project-based studies are conducted for erosion and sedimentation. Presently, Centre for Environment and Geographic Information Services (CEGIS) maintains database for hydrologic, water quality, and morphological data of the coastal areas but these are not adequate. The financial and non-financial barriers those are indentified in the transfer and diffusion of 'Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion' technology include:

a) Financial barrier

- Increased investment and operational and management fund will be required for the development of robust monitoring system of sea-level rise, tidal fluctuation, salinity intrusion, sedimentation coastal erosion etc.

b) Non-financial barriers

- New institutions and monitoring stations will be required in three different locations in the coastal areas
- Integrated programme for monitoring hydrological, water quality and coastal geomorphology that can assist sea level monitoring is essential
- Lack of institutional capacity for networking with global networking systems for sea-level monitoring.
- Lack of expertise and capacity for climate modeling and satellite based sea-level rise monitoring mechanism

1.2.4 Barrier analysis for the transfer and diffusion of technology related to Tidal river management including computer simulation of tidal flow

TRM is already being used in a number of polders in Bangladesh but it has to be improved to respond to some of the issues such as acceptability of TRM by the local communities. The financial and non-financial barriers for transfer and diffusion of this specific technology are;

a) Financial barrier

- Tidal river management technology requires high investment and O & M cost for new equipments and regular dredging

b) Non-financial barriers

- Lack of community participation in decision making may cause unacceptability of the TRM by the local land owners
- Lack of technological measures for effective sediment deposition in the tidal basin to increase acceptability by the land owners.

1.2.5 Barrier and analysis for the transfer and diffusion of Tidal barriers (Sluice gates) Technology

A large number of sluice gates are in use in the coastal areas for controlling tidal flow and retention of fresh water. Most of the sluice gates in the coastal area were constructed in the early 60's and 70's. Due to prolonged use, and salinity effect, many of the existing sluices, including flap gates have become weak and fragile and lost their draining efficiency. Therefore, it is required to build new sluice gates as well upscale existing ones. The barriers identified in relation to transfer and diffusion of tidal barriers (Sluice gates) technology are:

a) Financial barrier

- High investment for the construction of new sluice gate

b) Non-financial barriers

- Sometimes tidal barrier may result in water logging which can lead to unacceptability of the technology by the local people
- Lack of regular maintenance may cause operational deficiency due to prolonged use

1.2.6 Barrier analysis for the transfer and diffusion of Urban Infrastructure development Technology

Except in Dhaka, most of the urban areas are dependent on natural drainage that is now grossly inadequate due to rapid urbanization and climate change induced erratic rainfall. The financial and non-financial barriers for the transfer and diffusion of Urban Infrastructure Development Technology are;

a) Financial barrier

- High investment and O&M costs for the modernization of existing drainage infrastructure

b) Non-financial barriers

- Inadequate capacity and resources of the local government

1.2. 7 Linkages of the barriers identified

The overall problems and barriers identified in barrier analysis are common in many cases, although just a few are specific for certain technology. Considering common and diverse nature of barriers in technology diffusion and transfers, the barriers have been classified into three major aspects; these are financial, technological and maintenance and support services. To minimize duplication as well as to ensure coherence in identifying barriers, a summary of common barriers of all the water sector technologies are presented in Table 3.

Table 5: Summary of common barriers of water sector technologies

Types of Barrier	Common Barriers
Investment/ Financial Barriers	Lack of investment, incentive policies
	Less financial allocation from the Annual Development Programme (ADP) to the sectoral activities
	Less financial allocation to the local authorities
Capacity	Insufficient technology information and technical assistance
	Inadequate institutional capacity in project planning and implementation
	Lack of skilled personnel
	Limited installation and maintenance capacity
	Lack of technical expertise and capacity
Organizational/ Behavioral	Lack of collaboration and networking among the organizations
	Less scope of participation of community/ local people in planning and implementation of site specific projects
Policy/ Laws	Limited access to the advanced technology and research tools due to IPR issue
	Top-down and centralized planning process

1.3 Enabling framework for overcoming the barriers

Having the list of identified barriers and thorough understanding of the barriers, the TNA National Team examined the ways to overcome the barriers. In doing so, measures for each category of barriers are presented in the box 3.

BOX 3: Measures to address barriers

- Measures to address economic and financial barriers
- Measures to address market failures
- Measures to address policy, legal and regulatory related barriers
- Measures to prevent network failures
- Measures to increase institutional and organizational capacity
- Measures to improve human skills
- Measures to address social, cultural and behavioral barriers
- Measures to increase information and awareness
- Measures to address technical barriers
- Measures to address other barriers

Policies and strategies:	Enabling policies and measures are important to promote technology transfer.
Education and Training:	Education and training are required for capability building of the technical experts, extension workers and others for technology promotion, ensuring support services and proper maintenance of the deployed technologies
Technology Demonstration:	Technology demonstration and awareness-rising are needed to overcome social barriers.
Market support system:	Incentives and tax, tariff and non-tariff barriers etc.
International Cooperation:	The national authority may not be competent enough to develop and diffuse undated technology which is why networking and cooperation with the international organizations are required.
IPR Issues:	In relation to some technologies, international trade and IPR may hamper technology transfer; other regional trade agreements also may act barriers, which should be addressed through international cooperation.

Considering above factors the TNA National Team has organized and facilitated a stakeholder consultation workshop with the group that has been involved in the barrier analysis. During the workshop, barriers for diffusion and transfer of each of the prioritized technology have been presented and then the possible measures of overcoming barriers have been identified through a brain-storming session. Learning from the technology market mapping and root cause analysis also have discussed in identifying possible measures of overcoming barriers.

Measures those have been identified for overcoming barriers of technology diffusion and transfer of water sector are presented below;

1.3.1 Possible solutions to address the barriers for the transfer and diffusion of technology related to rehabilitation of existing Embankments/ dykes and dredging

1.3.1.1 Financial measures

Measure 1: Making detail cost estimation with the targeted timeline for earth work, maintenance and dredging

Measure 2: Reviewing and increasing water sector budgetary allocation for the maintenance of existing embankment

Measure 3: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

1.3.1.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing institutions

Measure 2: Developing of a comprehensive action plan for technical and institutional capacity building

Measure 3: Creating network of experts and generate undated knowledge on river mechanics studies and sediment transport modeling

Measure 4: Training on sediment transport and river mechanics.

Measure 5: Developing a detailed geo-informatics database on sediment transport, erosion and accretion modeling

Measure 6: Creating a network among research and other academic institutions

Measure 7: Developing of a stand-alone and a properly equipped soil mechanics laboratory in the country.

Measure 8: Ensuring participation of local people in the planning and designing of embankment and its maintenance

Measure 9: Scheduling a structure maintenance plan with the participation of local people

1.3.2 Possible solutions to address the barriers for the transfer and diffusion of Technology related to Comprehensive disaster management incorporating early warning systems and involving community.

1.3.2.1 Financial measures

Measure 1: Providing of increased finance to the DRR (Disaster Risk Reduction) sector with a focus of upgrading early warning system

Measure 2: Providing fund for the maintenance of survey satellite to ensure accurate data

Measure 3: Reviewing and increasing DRR sector budgetary allocation for more research and understanding the impacts of slow onset events.

Measure 4: Providing free access to the technologies and devices used in weather forecasts and early warning systems e.g. Remote Sensing and Satellite Image Data, updated software for climate modeling etc. as well as high performing tools and technologies

Measure 5: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

1.3.2.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing DRR institutions

Measure 2: Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc.

Measure 3: Building capacity on the application of global climate models through increasing international collaboration with the atmospheric, oceanographic, mathematical research institutes in country and abroad

Measure 4: Developing of a stand-alone and a properly equipped research institute to monitor impacts of the slow onset event and developing a monitoring protocol and early warning system for this.

Measure 5: Ensuring participation of local people and local institution in the dissemination of early warning system

Measure 6: Developing of an effective communication system for quick dissemination of disaster warning following the existing Standing order for Disasters.

Measure 7: Continuous improvement of the forecasting to provide longer lead time

1.3.3 Possible solutions to address the barriers for the transfer and diffusion of technology related to Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion

1.3.3.1 Financial measures

Measure 1: Increasing sector specific budgetary allocation for the procurement and maintenance of monitoring devices

Measure 2: Providing fund for capacity building of the research organizations for advanced research of the impacts of climate change in water and related sectors.

Measure 3: Providing free access to the technologies and devices used in weather forecasts and monitoring of changes e.g. Remote Sensing and Satellite Image Data, updated software for climate modeling etc. as well as high performing tools and technologies

Measure 4: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

1.3.3.2. Non-financial measures

Measure 1: Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc.

Measure 2: Building capacity of the public research institution on the application of global climate models through increasing international collaboration with

the atmospheric, oceanographic, mathematical research institutes in country and abroad

Measure 3: Developing of a comprehensive monitoring tools on the basis of the research outcome

Measure 4: Making synergies among the institutions while determining a common data standards and developing an appropriate data collection procedure

Measure 5: Training to the monitoring personnel on data collection and data administration for consistent and accurate data collection

Measure 6: Developing of a data verification/ screening system

Measure 7: Ensuring participation of local people and local institution and local knowledge in monitoring the impacts of climate change in the local context

1.3.4 Possible solutions to address the barriers for the transfer and diffusion of technology related to related to tidal river management including Computer simulation of tidal flow

1.3.4.1 Financial measures

Measure 1: Increasing sector specific budgetary allocation for TRM

Measure 2: Increasing budgetary allocation to the local administration for the development of maintenance of local level water infrastructures

Measure 3: Waiving copyright fees for the technologies and software for computer simulation of the tidal flows

Measure 4: Providing free access to the tools and devices e.g. Remote Sensing and Satellite Image Data, for climate modeling, simulation etc.

Measure 5: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

1.3.4.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing institutions e.g. Bangladesh Water Development Broad and the Institute of Water Modeling

Measure 2: Developing of a comprehensive action plan with time scale from introducing tidal river management technology to the existing water regulating structures

Measure 3: Increasing collaboration between national and local level authority in planning, designing and implementation of TRM in local level

Measure 4: Increasing institutional capacity on the modeling of sediment transportation

Measure 5: Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling

Measure 6: Ensuring participation of local people in the planning and designing of TRM and its management

Measure 7: Scheduling a structure maintenance plan with the participation of local people

Measure 8: Learning from local wisdom on the regulation of water flows while not creating water-logging and not hampering the agriculture production

1.3.5 Possible solutions to address the barriers for the transfer and diffusion of Tidal barriers (Sluice gates) Technology

1.3.5.1 Financial measures

Measure 1: Making a detail sectoral plan with cost estimation and timeline for construction of new sluice gates and up-scaling the existing

Measure 2: Reviewing and increasing budgetary allocation for the construction and maintenance of the sluice gates

Measure 3: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

1.3.5.2. Non-financial measures

Measure 1: Developing of a comprehensive action plan with time scale for construction of new sluice gates and up-scaling of the existing ones

Measure 2: Creating network of experts and generate updated knowledge on river mechanics studies and sediment transport modeling

Measure 3: Launching a project together with the TRM for technological innovation suitability for the coastal areas of Bangladesh.
for

Measure 4: Establishing collaboration among research and other academic institutions involved in the operation and management of water infrastructures

Measure 5: Ensuring participation of local people in the planning and designing of sluice gates and their maintenance

Measure 6: Working with the communities to listen to their opinion and problems in the construction and management of the sluice gates

Measure 7: Scheduling a structure maintenance plan with the participation of local people

Measure 8: Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling

1.3.6 Possible solutions to address the barriers for the transfer and diffusion of Urban Drainage Development Technology

1.3.6.1 Financial measures

Measure 1: Making a detail sectoral plan with cost estimation and timeline for construction of urban drainage infrastructure

Measure 2: Increasing budgetary allocation to the local government authority for the development of maintenance of urban drainage infrastructures

Measure 3: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

1.3.6.2. Non-financial measures

Measure 1: Developing of a comprehensive action plan for the coastal districts with time scale from developing urban drainage system

Measure 2: Increasing collaboration between national and local level authority in designing urban drainage plan.

Measure 3: Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling

1.3.7 Recommended solutions for the water Sector

The water related vulnerability has attracted researchers in various disciplines for a long time. The Government addressed the water sector issues from time to time by developing a master plan, perspective plans, strategies, and action plans mainly to deal with the water related disasters and to enhance food production. The latest such documents are the National Water Master Plan (NWMP) and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). There are also other outcomes of assessment related to climate change such as the Economics of Adaptation to Climate Change conducted by the World Bank, and a research report - Economic Modeling of Climate Change Adaptation Needs for Physical Infrastructures in Bangladesh prepared by the Climate Change Cell of the Ministry of Environment and Forests. Besides, the Annual Development Programmes of the Government define the activities that are undertaken in each year.

The NWMP that was adopted in 2004 contained a total of 84 programmes listed under eight clusters. The main focus of those programmes are water sector management, multi-purpose water schemes, construction of barrages, dredging of waterways, improvement of flood control and drainage infrastructures that would include raising embankments, flood protection including urban areas, urban drainage improvement, river erosion control, land reclamation, addressing water logging in the south-western region, strengthening protection of coastal area, development of irrigation systems, surface water development, drought management, water supply and sanitation provision in the urban and rural areas, water tanks and construction of arsenic-free water sources and water conservation.

These polders, of which forty-nine are sea-facing, provide a first line of defense for millions of people in the coastal belt. All these polders are not functioning the way these were

intended due to siltation in the river bed causing water logging with loss of agricultural production. These problems are being addressed by introducing an age old approach that is practiced in the Netherlands, the Tidal River Management (TRM) to take advantage of the natural tide movement in rivers to address the drainage problems in the polders. During flood tide, the tide is allowed to enter into an embanked low-lying area (tidal basin) where the sediment carried in by flood tide is deposited. During ebb tide, water flows out of the tidal basin with greatly reduced sediment load and eventually erodes the downstream river bed. The natural movement of flood and ebb tide along the tidal basin and along the downstream river maintains a proper drainage capacity in that river. People have to allow their land to be used for tidal basin operation that has to be addressed by compensation to the land owners, hoping that the land will rise after three or four years. Acceptability of the TRM by the local land owners poses to be a major obstacle.

The TRM adaptation is a success story in Bangladesh as a social and hydrological solution to a complex problem that continues to be a serious challenge for the South-west region of the country, particularly in the coastal areas. This seems to be an answer to protect the sea facing polders in the face of rising seas, and the hydro-geomorphologic changes of the coastal areas. There are technological and sociological challenges that have to overcome. One major challenge is that the villagers have to be lured back to their land that was leased for shrimp aquaculture.

Under these sub-sectors, a number of technological measures have been discussed in the stakeholder consultations. The prioritization exercise in the water sector included for example, infrastructure development, tidal system and infrastructure management, monitoring of sea and coastal changes, comprehensive disaster management and urban resilience to enable the water sector to adapt to the adverse effects of climate change.

In consideration of the context above, the recommended solutions for water sector are:

a) Increased investment for water infrastructure development
b) International cooperation and support for plan, design and construct urgently needed new infrastructure (e.g., cyclone shelters, coastal and river embankments and water management systems; urban drainage systems, river erosion control works, flood shelters) to meet the changing conditions expected with climate change
c) Free access to the technologies and devices as well as to the high-performing tools and technologies
d) Waiver of copyright fees for the technologies and software for computer simulation and modeling
e) Institutional and human resource capacity building for quality management and maintenance services.
f) Participation of local people in the planning and designing of water infrastructures

1.4 Technology action plan, project ideas, and other issues in Water Sector

1.4.1 Technology action plan (one for each technology)

1.4.1.1.Technology action plan for the rehabilitation of existing embankments/ dykes and dredging

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 6: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Rehabilitation of existing embankments/ dykes and dredging	Investment	Making detail cost estimation with the targeted timeline for earth work, maintenance and dredging	√	
		Reviewing and increasing water sector budgetary allocation for the maintenance of existing embankment	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Reviewing technical and institutional capacities of the existing institutions	√	
		Training on sediment transport and river mechanics.	√	
		Developing of a comprehensive action plan for technical and institutional capacity building	√	
	Organizational/ behavioral change	Creating network of experts and among research and other academic institutions to generate updated knowledge on river mechanics studies and sediment transport modeling	√	
		Developing a detailed geo-informatics database on sediment transport, erosion and accretion modeling		√
		Developing of a stand-alone and a properly equipped soil mechanics laboratory in the country.		√

		Ensuring participation of local people in the planning and designing of embankment and its maintenance	√	
	Laws/ Policy	Scheduling a structure maintenance plan with the participation of local people	√	

b) Technology Action Plan

Table 7: Technology action plan for rehabilitation of existing Embankments/ dykes and dredging

Sector: Water					
Specific technology: rehabilitation of existing Embankments/ dykes and dredging					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Making detail cost estimation with the targeted timeline for earth work, maintenance and dredging	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Water Resources, (MoWR), Bangladesh Water Development Board (BWDB)	2013-2017	50	Readily available detail const estimation for the policy makers and investors
Reviewing and increasing water sector budgetary allocation for the maintenance of existing embankment	To ensure regular maintenance of existing embankment with increased finance from Annual Development Programme (ADP).	MoWR, Ministry of Planning	2013-2017	35	Increased water sector budgetary allocation from the ADP
Making a sector and technology specific proposal and generating funds from the development	To ensure immediate and long-term funds from international sources.	MoWR, BWDB	2013-2017	25	Communicated technology specific proposal

partners and other international adaptation funding sources					to the development partners
Capacity development					
Reviewing technical and institutional capacities of the existing institutions	To identify technical and institutional capacity gaps.	MoWR	2013-2017	20	Identified capacity gap of the respective institutions
Training on sediment transport and river mechanics.	To increase technical capacity of the water sector experts, this in turn, will help designing embankment structure while considering sediment transportation and river dynamics.	MoWR SPARSO, IWM	2013-2017	35	Institutions are staffed with skilled and expert human resource
Developing of a comprehensive action plan for technical and institutional capacity building	To help policy makers and other stakeholders to prioritize actions and make investment decision on the priority action.	MoWR, BWDB	2013-2017	50	Readily available comprehensive action plan for the policy makers and investors
Organizational/ behavioral change					
Creating network among experts research and other academic institutions to generate updated knowledge on river mechanics studies and sediment transport modeling	To facilitate cooperation and information sharing between institutions and experts	MoWR, MoEF, IWM, BWDB, CEGIS,	2013-2017	25	Increased sharing of information among experts and institutions.
Developing a detailed geo-informatics database on sediment transport, erosion and accretion modeling	To help water sector experts and decision makers in designing and implementing infrastructure projects in an efficient manner.	IWM, BWDB, CEGIS,	2013-2023	40	Availability of open and accessible database for

					research use and project designing
Developing of a stand-alone and a properly equipped soil mechanics laboratory in the country.	To facilitate required scientific analysis and one-stop support on the technicalities of infrastructure development.	MoWR	2013-2023	100	Availability of research data, reports etc for planning and designing water infrastructure projects
Ensuring participation of local people in the planning and designing of embankment and its maintenance	To increase local ownership on the project and will increase peoples' acceptance.	MoWR, BWDB	2013-2017	30	Increased local ownership and social acceptance of the technology
Policy and law					
Scheduling a structure maintenance plan with the participation of local people	To ensure proper maintenance of the embankment.	MoWR, BWDB	2013-2017	20	Increased involvement of the local people in the maintenance of the water infrastructures.

1.4.1.2. Technology action plan for Comprehensive disaster management incorporating early warning systems and involving community.

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

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Table 8 : Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Comprehensive disaster management incorporating early warning systems and involving community	Investment	Providing of increased finance to the DRR (Disaster Risk Reduction) sector with a focus of upgrading early warning system	√	
		Providing fund for the maintenance of survey satellite to ensure accurate data	√	
		Increasing DRR sector budgetary allocation for more research and understanding the impacts of slow onset events.	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Reviewing technical and institutional capacities of the existing DRR institutions	√	
		Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc.	√	
		Building capacity on the application of global climate models through increasing international collaboration with the atmospheric, oceanographic, mathematical research institutes in country and abroad		√
		Continuous improvement of the forecasting to provide longer lead time		√
	Organizational/ behavioral change	Developing of a stand-alone and a properly equipped research institute to monitor impacts of the slow onset event and developing a monitoring protocol and early warning system for this.		√
		Ensuring participation of local people and local institution in the dissemination of early warning system	√	
		Developing of an effective communication system for quick dissemination of disaster warning following the existing Standing	√	

		order for Disasters.		
	Policy and law	Providing free access to the technologies and devices used in weather forecasts and early warning systems e.g. Remote Sensing and Satellite Image Data, updated software for climate modeling etc. as well as high performing tools and technologies		√

b) Technology Action Plan

Table 9: Technology action plan for Comprehensive disaster management incorporating early warning systems and involving community

Sector: Water					
Specific technology: Comprehensive disaster management incorporating early warning systems and involving community					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Providing of increased finance to the DRR (Disaster Risk Reduction) sector with a focus of upgrading early warning system	To ensure increased finance from Annual Development Programme (ADP).	Ministry of Disaster Management and Relief (MoDMR) , Department of Disaster Management (DDM), Ministry of Water Resources,	2013-2017	30	Increased level of budgetary allocation for DRR related activities
Providing fund for the maintenance of survey satellite to ensure accurate data	To ensure availability of survey satellite data quality	Ministry of Finance, MoDMR	2013-2017	25	Availability of survey satellite in the weather forecasting

					stations
Increasing DRR sector budgetary allocation for more research and understanding the impacts of slow onset events.	To facilitate actions and measures for addressing slow onset events	Ministry of Planning, Ministry of Finance, MoDMR	2013-2017	20	Available funds for research on the impacts of slow onset events
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To ensure immediate and long-term funds from international sources.	MoDMR, DDM,	2013-2017	35	Readily available detail const estimation for the policy makers and investors
Capacity development					
Reviewing technical and institutional capacities of the existing DRR institutions	To identify technical and institutional capacity gaps in dealing DRR.	MoDMR, DDM,	2013-2017	20	Identified capacity gap of the DRR sector institutions
Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc.	To get updated information, data and satellite image.	MoDMR, DDM, SPARSO, Bangladesh Meteorological Department (BMD). Red cross and Red Crescent Society,	2013-2017	25	Increased sharing of information, data and satellite image among experts and institutions.
Building capacity on the application of global climate models through increasing international collaboration with the atmospheric, oceanographic, mathematical research institutes in country and abroad	To build capacity of local experts. It also will reduce cost for hiring international experts.	MoDMR, DDM, SPARSO, Bangladesh Meteorological Department (BMD), Red cross and Red	2013-2023	30	DRR sector and meteorological institutions and staffed with skilled and expert human resource

		Crescent Society,			
Continuous improvement of the forecasting to provide longer lead time	To ensure dissemination of disaster warning well before on striking any disaster.	DDM, SPARSO, Bangladesh Meteorological Department (BMD),	2013-2023	30	Increased level of preparedness in facing disaster events
Organizational/ behavioral change					
Developing of a stand-alone and a properly equipped research institute to monitor impacts of the slow onset event and developing a monitoring protocol and early warning system for this.	To make available research based information on the impacts of slow onset events, which will help policy makers and investors to take necessary measures and action.	Ministry of Planning, Ministry of Finance, MoDMR	2013-2023	60	Availability of research data, reports etc for planning and designing water infrastructure projects
Ensuring participation of local people and local institution in the dissemination of early warning system	To facilitate quick understanding and dissemination of disaster early warnings	MoDMR, DDM, Red cross and Red Crescent Society, NGOs	2013-2017	30	Increased local ownership and social acceptance of the technology
Developing of an effective communication system for quick dissemination of disaster warning following the existing Standing Order for Disasters (SOD).	To encourage spontaneous response of all stakeholders in pre-disaster period	MoDMR, DDM, Red cross and Red Crescent Society, NGOs	2013-2017	20	Established an quick information dissemination system as per SOD
Policy and law					
Providing free access to the technologies and devices used in weather forecasts and early warning systems e.g. Remote Sensing and Satellite Image Data,	To reduce investment costs and will increase data quality	MoDMR, DDM,	2013-2023	40	Removed IPR barriers in accessing research tools and technology and reduced technology cost.

updated software for climate modeling etc. as well as high performing tools and technologies					

1.4.1.3. Technology action plan for Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures are presented in the table below:

Table 10: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion	Investment	Increasing sector specific budgetary allocation for the procurement and maintenance of monitoring devices	√	
		Providing fund for capacity building of the research organizations for advanced research of the impacts of climate change in water and related sectors.	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Building capacity of the public research institution on the application of global climate models through increasing international collaboration with the atmospheric, oceanographic, mathematical research institutes in country and abroad		√
		Training to the monitoring personnel on data collection and data administration for consistent and accurate data collection	√	
		Developing of a comprehensive monitoring tools on the basis of the	√	

		research outcome		
		Developing of a data verification/ screening system	√	
	Organizational/ behavioral change	Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc.	√	
		Making synergies among the institutions while determining a common data standards and developing an appropriate data collection procedure		√
		Ensuring participation of local people and local institution and local knowledge in monitoring the impacts of climate change in the local context	√	
	Policy and law	Providing free access to the technologies and devices used in weather forecasts and monitoring of changes e.g. Remote Sensing and Satellite Image Data, updated software for climate modeling etc. as well as high performing tools and technologies		√

b) Technology Action Plan

Table 11: Technology action plan for Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion

Sector: Water					
Specific technology: Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					

Increasing sector specific budgetary allocation for the procurement and maintenance of monitoring devices	To ensure availability of necessary monitoring devices	Ministry of Finance, MoDMR, MoWR, MoEF	2013-2017	40	Available funds for procurement and maintenance of the monitoring devices
Providing fund for capacity building of the research organizations for advanced research of the impacts of climate change in water and related sectors.	To generate necessary information, data on the impacts of climate change in water sector.	Ministry of Finance, MoDMR, MoWR, MoEF	2013-2017	60	Implementation of more research projects on the impacts of climate change in water sector
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To have access to immediate and long-term funds from international sources.	Ministry of Finance, MoDMR, MoWR, MoEF	2013-2017	30	Readily available technology specific cost estimation for the policy makers and investors
Capacity development					
Building capacity of the public research institution on the application of global climate models through increasing international collaboration with the atmospheric, oceanographic, mathematical research institutes in country and abroad	To increase expertise and efficiency of local experts. It also will reduce cost for hiring international experts.	SPARSO, BMD, IWM, CEGIS	2013-2023	60	Water sector and meteorological institutions and staffed with skilled and expert human resource
Training to the monitoring personnel on data collection and data administration for consistent and accurate data collection	To have site specific database on the impact of climate change	SPARSO, BMD, IWM, CEGIS	2013-2017	30	
Developing a comprehensive monitoring tools on the basis of research outcome	To understand impacts of climate change and climate variability in the local context.	SPARSO, BMD, IWM, CEGIS	2013-2017	30	Increased level of understanding on the site specific impacts

					of climate change
Developing of a data verification/ screening system	To ensure availability of quality data	SPARSO, BMD, IWM, CEGIS	2013-2017	25	Ensured availability of quality data
Organizational/ behavioral change					
Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc.	To learn and enhance understanding and knowledge on the advanced tools and technologies	SPARSO, BMD, IWM, CEGIS	2013-2017	20	Increased sharing of information, data and satellite image among experts and institutions.
Making synergies among the institutions while determining a common data standards and developing an appropriate data collection procedure	To generate standardized data while reducing cost for data collection	SPARSO, BMD, IWM, CEGIS, BUET, Department of Environment (DoE)	2013-2023	20	Ensured availability of standardized data and developed a common data bank.
Ensuring participation of local people and local institution and local knowledge in monitoring the impacts of climate change in the local context	To ensure involvement of community people to the local level adaptation planning and undertake site specific adaptation measures	MoDMR, MoWR, MoEF, DoE	2013-2017	20	Increased local ownership and social acceptance of the technology
Policy and law					
Providing free access to the technologies and devices used in weather forecasts and monitoring of changes e.g. Remote Sensing and Satellite Image Data, updated software for climate modeling etc. as well as high performing tools and technologies	To reduce investment costs and will increase data quality	MoDMR, MoWR, MoEF,	2013-2023	40	Removed IPR barriers in accessing research tools and technology and reduced technology cost.

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1.4.1.4. Technology action plan for Tidal River Management (TRM) including Computer simulation of tidal flow

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 12: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short and Medium Term (1-5 years)	Long Term 1-10 years
Tidal River Management (TRM) including Computer simulation of tidal flow	Investment	Increasing sector specific budgetary allocation for TRM	√	
		Increasing budgetary allocation to the local administration for the development and maintenance of local level water infrastructures	√	
		Providing free access to the tools and devices e.g. Remote Sensing and Satellite Image Data, for climate modeling, simulation etc.		√
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Reviewing technical and institutional capacities of the existing institutions e.g. Bangladesh Water Development Broad and the Institute of Water Modeling	√	
		Increasing institutional capacity on the modeling of sediment transportation	√	
		Developing of a comprehensive action plan with time scale from introducing tidal river management technology to the existing water regulating structures	√	
		Developing site specific geo-informatics database on sediment		√

		transport, erosion and accretion modeling		
	Organizational/ behavioral change	Increasing collaboration between national and local level authority in planning, designing and implementation of TRM in local level	√	
		Ensuring participation of local people in the planning and designing of TRM and its management	√	
		Learning from local wisdom on the regulation of water flows while not creating water logging and not hampering the agriculture production	√	
	Policy and law	Waive copyright fees for the technologies and software for computer simulation of the tidal flows		√
		Scheduling a structure maintenance plan with the participation of local people		√

b) Technology Action Plan

Table 13: Technology action plan for tidal river management including Computer simulation of tidal flow

Sector: Water					
Specific technology: Tidal River Management (TRM) including Computer simulation of tidal flow					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/TRM ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Increasing sector specific budgetary allocation for TRM	To have available fund for tidal river management	Ministry of Finance, MoDMR, MoWR	2013-2017	40	Available funds for the introduction of TRM to the sluice gates

Increasing budgetary allocation to the local administration for the development of maintenance of local level water infrastructures	To ensure involvement and participation of local government authority in the project planning, implementation and maintenance activities	Ministry of Finance, MoWR	2013-2017	30	Ensured maintenance local level water infrastructures by the local government authority.
Providing free access to the tools and devices e.g. Remote Sensing and Satellite Image Data, for climate modeling, simulation etc.	To reduce investment costs and will increase data quality	SPARSO, BMD, IWM, CEGIS, BUET, DoE,	2013-2023	40	Availability tools and devices in the water sector and engineering institutions
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To have access to immediate and long-term funds from international sources.	Ministry of Finance, MoDMR, MoWR	2013-2017	20	Readily available technology specific cost estimation for the policy makers and investors
Capacity development					
Reviewing technical and institutional capacities of the existing institutions e.g. Bangladesh Water Development Broad and the Institute of Water Modeling	To identify technical and institutional capacity gaps of the existing institutions	SPARSO, BMD, IWM, CEGIS, BUET, DoE	2013-2017	25	Identified capacity gap of the respective institutions
Increasing institutional capacity for the modeling of sediment transportation	To have well equipped institutions with technical experts.	SPARSO, BMD, IWM, CEGIS, BUET, DoE	2013-2017	45	Institutions are staffed with skilled and expert human resource
Developing of a comprehensive action plan with time scale from introducing tidal river management technology to the	To help policy makers and other stakeholders to prioritize actions and make investment decision on the	MoWR, BMD, MoDMR,	2013-2017	60	Readily available comprehensive action plan for the policy makers and

existing water regulating structures	priority action. This also will maximize potentials of the respective organizations.				investors
Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling	To help water sector experts and decision makers in designing and implementing infrastructure projects in an efficient manner.	SPARSO, BMD, IWM, CEGIS, BUET	2013-2023	150	Availability of open and accessible database for research use and project designing
Organizational/ behavioral change					
Increasing collaboration between national and local level authority in planning, designing and implementation of TRM in local level	To learn and enhance understanding and knowledge on TRM	BMD, IWM, CEGIS, BUET	2013-2017	50	Increased involvement of local government authority in project design and implementation.
Ensuring participation of local people in the planning and designing of TRM and its management	To ensure proper planning and implementation of TRM	MoDMR, MoWR, BMD, LGED	2013-2017	50	Increased local ownership and social acceptance of TRM technology
Learning from local wisdom on the regulation of water flows while not creating water logging and not hampering the agriculture production	To reduce the risk of any environmental impacts and risk of water logging	MoDMR, MoWR, BMD, LGED, IWM, CEGIS, BUET, DoE, NGOs	2013-2017	30	Reduced environmental impacts of TRM
Policy and law					
Waiving copyright fees for the technologies and software for computer simulation of the tidal flows	To reduce investment costs and will increase data quality	MoDMR, MoWR, BMD, LGED, IWM, CEGIS, BUET,	2013-2023	30	Removed IPR barriers in accessing research tools and technology and reduced technology cost.

Scheduling a structure maintenance plan with the participation of local people	To ensure proper maintenance of TRM infrastructure	MoWR, BMD, LGED, IWM,	2013-2023	20	Increased involvement of local people in the maintenance of TRM technology.

1.4.1.5. Technology action plan for Tidal barriers (Sluice gates) Technology

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 14: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Tidal barriers (Sluice gates) Technology	Investment	Making a detail sectoral plan with cost estimation and timeline for construction of new sluice gates and up-scaling the existing ones	√	
		Reviewing and increasing budgetary allocation for the construction and maintenance of the sluice gates	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Developing of a comprehensive action plan with time scale for construction of new sluice gates and up-scaling of the existing ones	√	
		Launch a project together with the TRM for technological innovation for suitability for the coastal areas of Bangladesh.		√
		Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling		√
	Organizational/ behavioral	Creating network of experts and generate updated knowledge on river mechanics studies and sediment transport modeling	√	

	change	Establishing collaboration among research and other academic institutions involved in the operation and management of water infrastructures	√	
		Ensuring participation of local people in the planning and designing of sluice gates and their maintenance	√	
		Working with the communities to listen to their opinion and problems in the construction and management of the sluice gates	v	
	Policy/ Law	Scheduling a structure maintenance plan with the participation of local people		√

b) Technology Action Plan

Table 15: Technology action plan for Tidal barriers (Sluice gates) Technology

Sector: Water					
Specific technology: Tidal barriers (Sluice gates) Technology					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Making a detail sectoral plan with cost estimation and timeline for construction of new sluice gates and up-scaling the existing	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Planning, MoWR	2013-2017	100	Readily available detail const estimation for the policy makers and investors
Reviewing and increasing budgetary allocation for the construction and maintenance of the sluice gates	To ensure regular maintenance of sluice gates embankment with increased finance from Annual Development Programme	Ministry of Finance, Ministry of Planning, MoWR	2013-2017	30	Increased water sector budgetary allocation from the ADP for construction and maintenance of

	(ADP).				tidal barriers
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Planning, MoWR	2013-2017	20	Communicated technology specific proposal to the development partners
Capacity development					
Developing of a comprehensive action plan with time scale for construction of new sluice gates and up-scaling of the existing ones	To help policy makers and other stakeholders to prioritize actions and make investment decision on the priority action.	MoWR, BMD, LGED, , IWM, CEGIS	2013-2017	50	Readily available comprehensive action plan for the policy makers and investors
Launching a project together with the TRM for technological innovation for suitability for the coastal areas of Bangladesh.	To upscale the technology appropriate for coastal areas	MoWR, BMD, LGED, IWM,	2013-2023	50	Implementation of experimentation project for technology innovation and suitability study
Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling	To help water sector experts and decision makers in designing and implementing infrastructure projects in an efficient manner.	IWM, CEGIS, BUET, SPARSO	2013-2023	60	Availability of open and accessible database for research use and project designing
Organizational/ behavioral change					
Creating network of experts and generating updated knowledge on river mechanics studies and sediment transport modeling	To get updated information, data, tools and technology	MoWR, BMD, LGED, MoDMR, IWM, CEGIS, BUET,	2013-2017	20	Increased sharing of information among experts and institutions.
Establishing collaboration among	To learn and enhance	MoWR, BMD,	2013-2017	30	Increased level of

research and other academic institutions involved in the operation and management of water infrastructures	understanding and knowledge on the technology	LGED, MoDMR, IWM, CEGIS, BUET,			efficiency in operation and management of tidal barriers through collaborated effort of the related institutions
Ensuring participation of local people in the planning and designing of sluice gates and their maintenance	To ensure ownership on the local people to planning and implementation of TRM	MoWR, BMD, LGED,	2013-2017	20	Increased local ownership and social acceptance of sluice gate technology
Working with the communities to listen to their opinion and problems in the construction and management of the sluice gates	To reduce the risk of any environmental impacts and risk of water logging	MoWR, BMD, LGED,	2013-2017	25	Reduced environmental impacts for the construction of sluice gates
Policy and law					
Scheduling a structure maintenance plan with the participation of local people	To ensure proper maintenance of tidal barriers	MoWR, BMD, LGED,	2013-2023	20	Increased involvement of local people in the maintenance of tidal barrier technology.

1.4.1.6. Technology action plan for Urban Drainage Development Technology

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures are presented in the table below:

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Table 16: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Urban Drainage Development Technology	Investment	Making a detail sectoral plan with cost estimation and timeline for construction of urban drainage infrastructure	√	
		Increasing budgetary allocation to the local administration for the development of maintenance of urban drainage infrastructure	√	
		Making a sector- and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources		√
	Capacity development	Developing of a comprehensive action plan for the coastal districts with time-scale from developing urban drainage system		√
		Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling		√
	Organizational/ behavioral change	Increasing collaboration between national and local level authority in designing urban drainage plan.	√	
		Establishing collaboration among research and other academic institutions involved in the operation and management of urban infrastructure planning	√	

b) Technology Action Plan

Table 17: Technology action plan for Urban Drainage Development Technology

Sector: Water					
Specific technology: **Urban Drainage Development Technology**					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/	Monitoring, Reporting and

				Unit ('000 USD)	verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Making a detail sectoral plan with cost estimation and timeline for construction of new sluice gates and up-scaling the existing	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Planning, Ministry of Local Government and Cooperatives, City Corporations	2013-2017	80	Readily available detail const estimation for the policy makers and investors
Reviewing and increasing budgetary allocation for the construction and maintenance of the sluice gates	To ensure regular maintenance of sluice gates embankment with increased finance from Annual Development Programme (ADP).	Ministry of Planning, Ministry of Finance, Ministry of Local Government &Cooperatives, City Corporations	2013-2017	60	Increased water sector budgetary allocation from the ADP for construction and maintenance of tidal barriers
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Local Government and Cooperatives, City Corporations	2013-2023	35	Communicated technology specific proposal to the development partners
Capacity development					

Developing of a comprehensive action plan for the coastal districts with time scale from developing urban drainage system	To help policy makers and other stakeholders to prioritize actions and make investment decision on the priority action.	Ministry of Local Government and Cooperatives, City Corporations	2013-2023	25	Readily available comprehensive action plan for the policy makers and investors
Developing site specific geo-informatics database on sediment transport, erosion and accretion modeling	To help water sector experts and decision makers in designing and implementing infrastructure projects in an efficient manner.	LGED, SPARSO, IWM, CEGIS	2013-2023	50	Availability of open and accessible database for research use and project designing
Organizational/ behavioral change					
Increasing collaboration between national and local level authority in designing urban drainage plan.	To ensure participation of local government authority (e.g. City Corporation) in project planning and implementation.	LGED, SPARSO, IWM, CEGIS	2013-2017	20	Increased involvement of local government authority in designing and implementation of urban drainage infrastructure.
Establishing collaboration among research and other academic institutions involved in the operation and management of urban infrastructure planning	To learn and enhance understanding and knowledge on the technology	Ministry of Local Government and Cooperatives, City Corporations, LGED, SPARSO, IWM, CEGIS	2013-2017	20	Increased level of efficiency in planning, designing operation and management of urban drainage infrastructure through collaborated effort of the related institutions

1.4. 2 Brief summary of project ideas for international support (Details in Annex 3)

The project idea for water sector adaptation technology is to 'Operationalize Tidal river Management (TRM) including Computer simulation of tidal flow'.

Major objectives of this project are:

- To undertake Tidal River Management (TRM) using indigenous method with medium and long term program, and

- To undertake medium and long term indigenous and modern technology though improved planning, design, construction and gate improvement

TRM has the benefits of:

a) Reducing siltation in the river, increasing drainage capacity and tidal prism,
b) Reducing drainage congestion / water logging within the polder and peripheral rivers,
c) Increasing ground level of the TRM basin,
d) Providing quick drainage and
e) Increasing operating efficiency.

1.5 Summary

The transfer and diffusion of the selected technologies of water sector adaptation will, therefore, depend largely on the development of enabling environment while overcoming the barriers. Some of the measures are presented below:

Short Term

- Making detail cost estimation with the targeted timeline for earth work, maintenance
- Reviewing and increasing budgetary allocation
- Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources
- Reviewing technical and institutional capacities of the existing institutions
- Training on sediment transport and river mechanics
- Developing of a comprehensive action plan for technical and institutional capacity building
- Gaining Knowledge on river mechanics studies and sediment transport modeling
- Ensuring participation of local people in the planning and designing of embankment and its maintenance
- Scheduling a structure maintenance plan with the participation of local people
- Providing of increased finance to the DRR (Disaster Risk Reduction) sector with a focus of upgrading early warning system

- Providing fund for the maintenance of survey satellite to ensure accurate data

- Increasing DRR sector budgetary allocation for more research and understanding the impacts of slow onset events

- Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc

- Ensuring participation of local people and local institution in the dissemination of early warning system

- Developing of an effective communication system for quick dissemination of disaster warning following the existing Standing order for Disasters

- Increasing sector specific budgetary allocation

- Providing fund for capacity building of the research organizations for advanced research of the impacts of climate change in water and related sectors

- Training to the monitoring personnel on data collection and data administration for consistent and accurate data collection

- Developing of a data verification/ screening system

- Creating collaboration with national and international level institutions for exchanging knowledge, data and satellite image etc

- Ensuring participation of local people and local institution and local knowledge in monitoring the impacts of climate change in the local context

- Increasing institutional capacity on the modeling of sediment transportation

- Developing of a comprehensive action plan with time scale from introducing tidal river management technology to the existing water regulating structures

- Increasing collaboration between national and local level authority in planning, designing and implementation of TRM in local level

- Learning from local wisdom on the regulation of water flows while not creating water logging and not hampering the agriculture production

- Creating network of experts and generate updated knowledge on river mechanics studies and sediment transport modeling

- Establishing collaboration among research and other academic institutions involved in the operation and management of water infrastructures

- Working with the communities to listen to their opinion and problems in the construction and management of the sluice gates

- Increasing collaboration between national and local level authority in designing urban drainage plan

Long Term:

- Developing a detailed geo-informatics database on sediment transport, erosion and accretion modeling
- Developing of a stand-alone and a properly equipped soil mechanics laboratory in the country
- Building capacity on the application of global climate models through increasing international collaboration with the atmospheric, oceanographic, mathematical research institutes in country and abroad

- Continuous improvement of the forecasting to provide longer lead time

- Developing of a stand-alone and a properly equipped research institute to monitor impacts of the slow onset event and developing a monitoring protocol and early warning system for this

- Providing free access to the technologies and devices used in weather forecasts and early warning systems e.g. Remote Sensing and Satellite Image Data, updated software for climate modeling etc. as well as high performing tools and technologies

- Making synergies among the institutions while determining a common data standards and developing an appropriate data collection procedure

- Scheduling a structure maintenance plan with the participation of local people
- Launch a project together with the TRM for technological innovation for suitability for the coastal areas of Bangladesh

- Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

- Developing a comprehensive action plan for the coastal districts with time-scale from developing urban drainage system

CHAPTER 2. Agriculture Sector

From the sector prioritization exercise several subsectors of agriculture sector e.g. technology development and knowledge management, research development and extension services and management of support sectors etc., have been prioritized in order to enable the agriculture sector to adapt to the adverse effects of climate change. Under these subsectors, a number of technological measures have been discussed in the stakeholder consultations, and shortlisted, which is presented in Table 11.

Table 18: Prioritized technologies for climate change adaptation for agriculture sector

Subsector	Category	Technology
Technology development and knowledge management	Varietal development	Development of salinity tolerant rice varieties
		Development of draught tolerant rice varieties
		Development of short maturing rice varieties
Research, Development and Extension services	Project Implementation	Establishment of special agricultural R & D centre
		Establishment of climate smart Technology Dissemination Center
		Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.
Management of support sectors	Research and knowledge generation	Land-use planning

On the basis of overall weighted score the technology options are prioritized and ranked from high priority to low priority order and presented in table 12.

Table 19: Agriculture sector adaptation technologies as per priority order

Technology	Weighted Score	Priority Order
Development of salinity tolerant rice varieties	81.92	1
Development of drought tolerant rice varieties	77.17	2
Development of short maturing rice varieties	70.39	3
Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.	64.81	4
Establishment of climate smart Agriculture Technology Dissemination Center	62.19	5
Establishment of special agricultural R & D centre	56.08	6
Land use planning	43.86	7

2.1 Preliminary targets for technology transfer and diffusion

Poverty eradication is the top most development priority of the Government of Bangladesh. Bangladesh is striving to accelerate economic growth and substantially eradicate poverty by 2021 but avoiding the harsh environmental price many countries have paid in the pursuit of growth [Ministry of Environment and Forest (MoEF, 2009)].

To complement the country's development priority e.g. poverty reduction and attaining food security it is critical to make certain required technological support for climate smart agriculture technology development and dissemination.

Again, the Bangladesh Climate Change Strategy Action Plan (BCCSAP), a 10-year programme to build the capacity and resilience, emphasizes development of climate resilient cropping system to address short and medium-term impacts of climate change. BCCSAP underscores:

'Development of climate-change resilient cropping systems (e.g., agricultural research to develop crop varieties, which are tolerant of flooding, drought and salinity, and based on indigenous and other varieties suited to the needs of resource poor farmers), fisheries and livestock systems to ensure local and national food security'

In line with the broader policy goal, the specific targets for technology transfer and diffusion of agriculture sector are;

- By 2017, development of 2 types of salinity tolerant rice varieties that can grow respectively in medium (5-10 ppt) and high range (more than 10 ppt) of salinity level.
- By 2017, development of a drought tolerant rice variety that can grow in dry and rainless conditions
- By 2017, development of a short-maturing rice variety that can grow and mature within a month
- By 2017, providing training to the farmers of different agro-ecological zones on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.
- Establishment of one climate-smart Agriculture Technology Dissemination Center by 2020
- Establishment of one special agricultural R & D centre by 2020
- By 2017, gets ready land use planning using GIS and Remote Sensing technology

2.2 Barrier analysis

Similar to the Sector 1 barrier analysis for the transfer and diffusion of the prioritized technologies, this too has been done through stakeholder consultations. The barriers, identified in stakeholder consultation also through the market mapping, have been presented below:

2.2.1 Market mapping and analysis for the transfer and diffusion of salinity tolerant rice variety

a) Financial Barrier

- Long term research investment for the development of salinity tolerant rice variety
- High investment for demonstration and extension of this technology to spread this technology to the farmers level
- Reduced level of public sector investment for demonstration and extension of agricultural technology

b) Non- financial barrier

- Lack of skilled human resource for research and development in the public sector institutions
- Lack of policy decision for introducing new farming system with new rice verities in the salinity prone areas.
- Lack of research capacities of the public research organizations for the development of resilient rice varieties e.g. Saline tolerant rice varieties
- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Intellectual properties issues, especially patenting on the high yielding variety (HYV) and genetically modified (GM) variety
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Lack of suitability of the imported technology and variety in the local context
- Limited scope of field testing for environmental risk assessment and disease prevalence of the varieties imported by private sector
- Social acceptance of the new technology
- Lack of efficiency of the seed certification authority
- Insufficient measures to monitor the quality of private sector seed and other agricultural inputs
- Cost of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.

2.2.2 Market mapping and analysis for the transfer and diffusion of drought tolerant rice varieties

a) Financial Barrier

- Long term research investment is required for the development of drought tolerant rice variety
- High investment is required for demonstration and extension of this technology to the reaching this technology to the farmers level

- Reduced level of public sector investment for demonstration and extension of agricultural technology

b) Non- financial barrier

- Lack of skilled human resource for research and development in the public sector institutions
- Lack of policy decision for introducing new farming system with new rice verities in the drought prone areas.
- Lack of research capacities of the public research organizations for the development of resilient rice varieties e.g. drought tolerant rice varieties
- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Intellectual properties issues, especially patenting on the high yielding variety (HYV) and genetically modified (GM) variety
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Lack of suitability of the imported technology and variety in the local context
- Limited scope of field testing for environmental risk assessment and disease prevalence of the varieties imported by private sector
- Lack of social acceptance of the new technology
- Lack of efficiency of the seed certification authority
- Insufficient measures to monitor the quality of private sector seed and other agricultural inputs
- Cost of the input services e.g. seed, irrigation etc. for transfer and diffusion of the drought tolerant rice variety.

2.2.3 Market mapping and analysis for the transfer and diffusion of short maturing rice varieties

a) Financial Barrier

- Long term research investment for the development of short maturing rice variety
- High investment for demonstration and extension of this technology to the reaching this technology to the farmers level
- Reduced level of public sector investment for demonstration and extension of agricultural technology

b) Non- financial barrier

- Lack of skilled human resource for research and development in the public sector institutions
- Lack of policy decision for introducing new farming system with new rice verities in the flood and drought prone areas.

- Lack of research capacities of the public research organizations for the development of resilient rice varieties e.g. short maturing rice variety
- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Intellectual properties issues, especially patenting on the high yielding variety (HYV) and genetically modified (GM) variety
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Lack of suitability of the imported technology and variety in the local context
- Limited scope of field testing for environmental risk assessment and disease prevalence of the varieties imported by private sector
- Lack of social acceptance of the new technology
- Lack of efficiency of the seed certification authority
- Insufficient measures to monitor the quality of private sector seed and other agricultural inputs
- Cost of the input services e.g. seed, irrigation etc. for transfer and diffusion of the short-maturing rice variety.

2.2.4 Market mapping and analysis for training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.

a) Financial barrier

- High operational and management cost for training materials development and providing training
- Reduced level of public investment for the technology dissemination to the farmers level

b) Non- financial barrier

- Lack of skilled extension workers with technical knowhow on the improved farming practices
- Lack of collaboration and networking among the organizations responsible for agricultural extension services, irrigation and water management and soil fertility management
- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Farmers refusal of the advanced farming practices

2.2.5 Market mapping and analysis for the establishment of climate-smart Agriculture Technology Dissemination Center

a) Financial barrier

- High investment and operational cost for establishment of center

b) Non- financial barrier

- Lack of collaboration and networking among the organizations responsible for agricultural extension services
- Lack of technologies that can predict pest and disease and pest outbreak
- Inadequate technical knowhow of the extension workers on the advanced farming practices
- Lack of Social acceptance of the new technology and changing cropping pattern/ duration

2.2.6 Market mapping and analysis for the transfer and diffusion of technology related to establishment of special agricultural R & D centre

a) Financial Barrier

- Lack of long-term and predicted funds for research for climate change resilient agricultural technology development, transfer and diffusion
- High investment for demonstration and extension of this technology to reaching this technology to the farmers
- Reduced level of public sector investment for research and development of agricultural technology

a) Non -financial Barrier

- Lack of collaboration and networking among the organizations responsible for agricultural research and development
- Limited and fragmented research networks
- Lack of skilled human resource for research and development in the public sector institutions
- Lack of high quality tools for agronomic research
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Inadequate technical knowhow of the extension workers on the advanced farming practices
- Lack of pest and disease database
- Lack of Social acceptance of the new technology and changing cropping pattern/ duration

2.2.7 Market mapping and **analysis for the transfer and diffusion of Land use planning technology**

a) Financial barrier

- High investment and operational cost

b) Non-financial barrier

- Lack of skilled personnel in GIS based planning
- Limited application of GIS and remote sensing technologies

- Lack of policies in land zoning and utilization

2.2. 4 Linkages of the barriers identified

Similar to Sector 1, the common barriers for the transfer and diffusion of agriculture sector technologies are identified under three broad categories. A list of common barriers under each category is presented in Table 18 below.

Table 20: Summary of common barriers of agriculture sector technologies

Types of Barrier	Common Barriers
Investment/ Financial Barriers	Lack of investment, incentive policies
	Less financial allocation from the Annual Development Programme (ADP) to the sectoral activities
	Less financial allocation to the local authorities
Capacity	Insufficient technology information and technical assistance
	Inadequate institutional capacity in project planning and implementation
	Lack of skilled personnel
	Quality of inputs, seeds etc
	Limited support service and monitoring
	Lack of technical expertise and capacity
Organizational/ Behavioral	Lack of collaboration and networking among the relevant organizations e.g. research organization, extension organization, NGOs etc
	Less scope of participation of community/ local people in planning and implementation of site specific projects
Policy/ Laws	Limited access to the advanced technology and research tools due to IPR issue
	Top-down and centralized planning process

2.3 Enabling framework for overcoming the barriers

Having the list of identified barriers and thorough understanding of the barriers, the TNA National Team examined the ways to overcome the barriers. In doing so, measures of each category of barriers are presented in the following box 6;

BOX 6: Measures to address barriers

- Measures to address economic and financial barriers
- Measures to address market failures
- Measures to address policy, legal and regulatory related barriers
- Measures to prevent network failures
- Measures to increase institutional and organizational capacity
- Measures to improve human skills
- Measures to address social, cultural and behavioural barriers
- Measures to increase information and awareness
- Measures to address technical barriers
- Measures to address other barriers

2.3.1 Possible solutions to address the barriers for the transfer and diffusion of salinity tolerant rice variety

2.3.1.1 Financial measures

Measure 1: Making detail cost estimation for development, transfer and diffusion of salinity tolerant rice crop variety

Measure 2: Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety

Measure 3: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

Measure 4: Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.

2.3.1.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing public sector rice research institutions

Measure 2: Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions

Measure 3: Creating network of experts and generate updated knowledge on the development of high yielding variety

Measure 4: Training and capacity building of the experts of the research organizations for the development of resilient rice varieties e.g. Saline tolerant rice varieties

Measure 5: Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector

Measure 6: Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety

Measure 7: Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.

Measure 8: Ensuring suitability testing of the imported or the newly developed varieties

Measure 9: Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to farmers

Measure 10: Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices

Measure 10: Introducing laws and strategy to monitor private sector business in seed and other inputs services

2.3.2 Possible solutions to address the barriers for the transfer and diffusion of drought tolerant rice variety

2.3.2.1 Financial measures

Measure 1: Making detail cost estimation for development, transfer and diffusion of salinity tolerant rice crop variety

Measure 2: Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety

Measure 3: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

Measure 4: Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.

2.3.2.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing public sector rice research institutions

Measure 2: Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions

Measure 3: Creating network of experts and generate updated knowledge on the development of high yielding variety

Measure 4: Training and capacity building of the experts of the research organizations for the development of resilient rice varieties e.g. Saline tolerant rice varieties

Measure 5: Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector

Measure 6: Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety

Measure 7: Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.

Measure 8: Ensuring suitability testing of the imported or the newly developed varieties

Measure 9: Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach the farmers

Measure 10: Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices

Measure 11: Introducing laws and strategy to monitor private sector business in seed and other inputs services

2.3.3 Possible solutions to address the barriers for the transfer and diffusion of short maturing rice variety

2.3.3.1 Financial measures

Measure 1: Making detail cost estimation for development, transfer and diffusion of short maturing rice crop variety

Measure 2: Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety

Measure 3: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

Measure 4: Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.

2.3.3.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing public sector rice research institutions

Measure 2: Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions

Measure 3: Creating network of experts and generate updated knowledge on the development of high yielding variety

Measure 4: Training and capacity building of the experts of the research organizations for the development of climate change resilient rice varieties e.g. short maturing rice varieties

Measure 5: Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector

Measure 6: Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety

Measure 7: Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.

Measure 8: Ensuring suitability testing of the imported or the newly developed varieties

Measure 9: Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach the farmers

Measure 9: Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices

Measure 10: Laws and strategy to monitor private sector business in seed and other inputs services

2.3.4 Possible solutions to address the barriers for the transfer and diffusion of Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc

2.3.4.1 Financial measures

Measure 1: Reviewing and increasing budgetary allocation for agricultural training and extension services

Measure 2: Public and private sector funding for training and agricultural extension services

Measure 3: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

2.3.4.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing training and extension agencies

Measure 2: Developing of a comprehensive action plan for technical and institutional capacity building of the public and private sector training providing organizations

Measure 3: Training and capacity building of the experts of the research organizations for the dissemination of climate change resilient rice varieties

Measure 4: Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety

Measure 5: Demonstrating the new technology to increase social acceptance

Measure 6: Strengthening system support and other services through quality assurance, information on new practices, financial services etc

Measure 7: Assigning focal point for sharing and coordination of activities of different agencies

Measure 8: Introducing laws and strategy to encourage private sector involvement in the agricultural extension and dissemination services

2.3.5 Possible solutions to address the barriers for the transfer and diffusion of technology related to establishment of climate smart Agriculture Technology Dissemination Center

2.3.5.1 Financial measures

Measure 1: Reviewing and increasing budgetary allocation for the establishment of a climate smart technology dissemination center.

Measure 2: Public and private sector funding for training and agricultural extension services

Measure 3: Sector and technology-specific proposal and generating funds from the

development partners and other international adaptation fnding sources

2.3.5.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing training and extension agencies

Measure 2: Developing of a comprehensive action plan for technical and institutional capacity building of the public and private sector training providing organizations

Measure 3: Training and capacity building of the experts of the research organizations for the dissemination of climate change resilient rice varieties

Measure 4: Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety

Measure 5: Demonstrating the new technology to increase social acceptance

Measure 6: Strengthening system support and other services through quality assurance, information on new practices, financial services etc

Measure 7: Assigning focal point for sharing and coordination of activities of different agencies

Measure 8: Introduing laws and strategy to encourage private sector investment in the agricultural extension and dissemination services

2.3.6 Possible solutions to address the barriers for the transfer and diffusion of technology related to establishment of special agricultural R & D centre

2.3.6.1 Financial measures

Measure 1: Reviewing and increasing budgetary allocation for agricultural research and development

Measure 2: Providing long-term and predicted funds for research for climate change resilient agricultural technology development, transfer and diffusion

Measure 2: Making a sector- and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources

2.3.6.2. Non-financial measures

Measure 1: Reviewing technical and institutional capacities of the existing agricultural research organizations

Measure 2: Developing of a comprehensive action plan for technical and institutional capacity building of the public and private sector agricultural research organizations

Measure 3: Training and capacity building of the experts of the research organizations for development, diffusion and transfer of the climate change resilient agricultural technology

Measure: Promoting research collaboration between organizations, especially at the regional and international level

Measure 5: Demonstrating the new technology to increase social acceptance

Measure 6: Ensuring high quality tools for agronomic research

Measure 7: Establishing biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties

Measure 8: Developing a database on pest and disease

Measure 9: Raising public awareness and encourage technology transfer on pest/ disease outbreak

Measure 10: Introducing laws and strategy to encourage private sector investment in the agricultural research and development

2.3.7 Possible solutions to address the barriers for the transfer and diffusion of Land use planning technology

2.3.7.1 Financial measures

Measure 1: Providing finance for land use planning

Measure 2: Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources

2.3.7.2. Non-financial measures

Measure 1: Launching a major programme on land use planning

Measure 2: Training and capacity building of the experts on the application of GIS and Remote Sensing technology

Measure 3: Policies to enforce land utilization on the basis of land use planning

2.3.4 Recommended solutions for Agriculture Sector

Considering above context the recommended solutions for water sector are;

g) Increased investment for water infrastructure development

h) International cooperation and support for plan, design and construct urgently needed new infrastructure (e.g., cyclone shelters, coastal and river embankments and water management systems; urban drainage systems, river erosion control works, flood shelters) to meet the changing conditions expected with climate change

i) Institutional and human resource capacity building for quality management and maintenance services.

2.4 Technology action plan, project ideas, and other issues in Agriculture Sector

2.4.1 Technology action plan (one for each technology)

1.4.1.1. Technology action plan for salinity tolerant rice variety

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 21: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Salinity tolerant rice variety	Investment	Making detail cost estimation for development, transfer and diffusion of salinity tolerant rice crop variety	√	
		Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
		Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.	√	
	Capacity development	Reviewing technical and institutional capacities of the existing public sector rice research institutions	√	
		Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions	√	
		Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the		√

		farmers		
		Training and capacity building of the experts of the research organizations for the development of climate change resilient rice varieties e.g. Saline tolerant rice varieties	√	
		Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices		√
		Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.		√
	Organizational/ behavioral change	Creating network of experts and generate updated knowledge on the development of climate change resilient high yielding variety	√	
		Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	√	
		Ensuring suitability testing of the imported or the newly developed varieties	√	
	Policy/ Law	Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector		√
		Introducing laws and strategy to monitor private sector business in seed and other inputs services	√	

b) Technology Action Plan

Table 22: Technology action plan for Salinity tolerant rice variety

Sector: Agriculture					
Specific technology: **Salinity tolerant rice variety**					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure

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	1	2	3	4	5
Investment					
Making detail cost estimation for development, transfer and diffusion of salinity tolerant rice crop variety	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Agriculture, Department of Agriculture Extension (DAE), Bangladesh Agriculture Research Council (BARC)	2013-2017	300	Readily available detail cost estimation for the policy makers and investors for development, transfer and diffusion of salinity tolerant rice variety
Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety	To ensure immediate and need based finance for agricultural research from the Annual Development Programme (ADP).	Ministry of Agriculture, Ministry of Finance	2013-2017	50	Increased agriculture sector budgetary allocation from ADP
Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.	To overcome financial barriers and to encourage farmers to apply this technology	Ministry of Agriculture, Ministry of Finance	2013-2017	100	Increased farmer's accessibility and affordability to the agricultural input services
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Agriculture, DAE, BARC	2013-2017	40	Communicated technology specific proposal to the development partners
Capacity development					
Reviewing technical and	To identify technical and	Ministry of	2013-2017	30	Identified technical

institutional capacities of the existing public sector rice research institutions urban drainage system	institutional capacity gaps of the existing institutions	Agriculture,			and institutional capacity gaps of the rice research institutions
Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions	To help policy makers and other stakeholders to prioritize actions and make investment decision on the priority action. This also will maximize potentials of the respective organizations.	Ministry of Agriculture, Bangladesh Rice Research Institute (BRRI) DAE, BARC	2013-2017	50	Readily available comprehensive action plan for capacity building of the rice research institutions
Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers	To ensure supply of quality seed and technology specific appropriate farming technology to the farmers	Ministry of Agriculture, DAE	2013-2023	40	Ensured supply of quality seeds and other inputs and dissemination of appropriate technologies to the farmers level
Training and capacity building of the experts of the research organizations for the development of resilient rice varieties e.g. Saline tolerant rice varieties	To ensure availability of local experts. It also will reduce cost for hiring international experts.	DAE, BARC, Soil Research and Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)	2013-2017	60	Research organizations are staffed with skilled and expert human resource
Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor	To upscale the technology on the basis of field based result	DAE, BARC, Soil Research and	2013-2017	250	Developed and institutional capacity mechanism for

the effectiveness of the new technology and farming practices		Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)			effectiveness of the new technology
Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.	To make use of high-quality properties of the indigenous varieties in the development of new ones.	DAE, BARC, Soil Research and Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)	2013-2023	150	Developed new variety through hybridization with the indigenous one.
Organizational/ behavioral change					
Creating network of experts and generate updated knowledge on the development of climate resilient high yielding rice variety	To learn and enhance understanding and knowledge on the technology	DAE, BARC, SRDI, BINA, BRRI	2013-2017	30	Increased sharing of information, knowledge and tools for the development of climate resilient high yielding rice variety
Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	To increase acceptability of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other stakeholders	DAE, BARC, BRRI, NGOs, Private Sector	2013-2017	35	Increased acceptance of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other

					stakeholders
Ensuring suitability testing of the imported or the newly developed varieties	To ensure supply of only quality seeds and appropriate farming technology to the farmer.	Ministry of Agriculture, DAE, BARC,	2013-2017	20	Institutions in place to ensure supply and dissemination of quality seeds and appropriate farming technology to the farmer.
Policy/ Law					
Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector	To have free access to the advanced farming technologies and inputs	Ministry of Agriculture, Ministry of Environment	2013-2023	40	Removed IPR barriers in accessing high quality inputs research tools and technology
Introducing Laws and strategy to regulate private sector business in seed and other inputs services	To ensure supply farmer's friendly , environmentally feasible and affordable technology by the private sector	Ministry of Agriculture, DAE	2013-2017	30	Developed policy to regulate private sector involvement in agriculture sector

1.4.1.2. Technology action plan for drought tolerant rice variety

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

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Table 23: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Salinity tolerant rice variety	Investment	Making detail cost estimation for development, transfer and diffusion of drought tolerant rice crop variety	√	
		Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
		Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the drought tolerant rice variety.	√	
	Capacity development	Reviewing technical and institutional capacities of the existing public sector rice research institutions	√	
		Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions	√	
		Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers		√
		Training and capacity building of the experts of the research organizations for the development of resilient rice varieties e.g. drought tolerant rice varieties	√	
		Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices		√
		Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.		√

	Organizational/ behavioral change	Creating network of experts and generate updated knowledge on the development of high yielding variety	√	
		Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	√	
		Ensuring suitability testing of the imported or the newly developed varieties	√	
	Policy/ Law	Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector		√
		Laws and strategy to monitor private sector business in seed and other inputs services	√	

b) Technology Action Plan

Table 24 : Technology action plan for Salinity tolerant rice variety

Sector: Agriculture					
Specific technology: **Salinity tolerant rice variety**					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Making detail cost estimation for development, transfer and diffusion of drought tolerant rice crop variety	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Agriculture, Department of Agriculture Extension (DAE), Bangladesh	2013-2017	300	Readily available detail cost estimation for the policy makers and investors for development, transfer and diffusion of salinity tolerant

		Agriculture Research Council (BARC)			rice variety
Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety	To ensure immediate and need based finance for agricultural research from the Annual Development Programme (ADP).	Ministry of Agriculture, Ministry of Finance	2013-2017	50	Increased agriculture sector budgetary allocation from ADP
Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the drought tolerant rice variety.	To overcome financial barriers and to encourage farmers to apply this technology	Ministry of Agriculture, Ministry of Finance	2013-2017	100	Increased farmer's accessibility and affordability to the agricultural input services
Making a sector- and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Agriculture, DAE, BARC	2013-2017	40	Communicated technology specific proposal to the development partners
Capacity development					
Reviewing technical and institutional capacities of the existing public sector rice research institutions urban drainage system	To identify technical and institutional capacity gaps of the existing institutions	Ministry of Agriculture,	2013-2017	30	Identified technical and institutional capacity gaps of the rice research institutions
Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions	To help policy makers and other stakeholders to prioritize actions and make investment decision on the priority action. This also will maximize potentials of the	Ministry of Agriculture, Bangladesh Rice Research Institute (BRRI) DAE, BARC	2013-2017	50	Readily available comprehensive action plan for capacity building of the rice research institutions

	respective organizations.				
Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers	To ensure supply of quality seed and technology specific appropriate farming technology to the farmers	Ministry of Agriculture, DAE	2013-2023	40	Ensured supply of quality seeds and other inputs and dissemination of appropriate technologies to the farmers level
Training and capacity building of the experts of the research organizations for the development of resilient rice varieties e.g. drought tolerant rice varieties	To ensure availability of local experts. It also will reduce cost for hiring international experts.	DAE, BARC, Soil Research and Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)	2013-2017	60	Research organizations are staffed with skilled and expert human resource
Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices	To upscale the technology on the basis of field based result	DAE, BARC, Soil Research and Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)	2013-2017	250	Developed and institutional capacity mechanism for effectiveness of the new technology
Developing of biological database e.g. genetic bank of local indigenous economic crops that	To make use of high-quality properties of the indigenous varieties in the development	DAE, BARC, Soil Research and	2013-2023	150	Developed new variety through hybridization with the

can be used for developing new varieties.	of new ones.	Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)			indigenous one.
Organizational/ behavioral change					
Creating network of experts and generate updated knowledge on the development of high yielding variety	To learn and enhance understanding and knowledge on the technology	DAE, BARC, SRDI, BINA, BRRI	2013-2017	30	Increased sharing of information, knowledge and tools for the development of climate resilient high yielding rice variety
Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	To increase acceptability of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other stakeholders	DAE, BARC, BRRI, NGOs, Private Sector	2013-2017	35	Increased acceptance of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other stakeholders
Ensuring suitability testing of the imported or the newly developed varieties	To ensure supply of only quality seeds and appropriate farming technology to the farmer.	Ministry of Agriculture, DAE, BARC,	2013-2017	20	Institutions in place to ensure supply and dissemination of quality seeds and appropriate farming technology to the farmer.
Policy/ Law					
Waiving IPR fees for transfer and	To have free access to the	Ministry of	2013-2023	40	Removed IPR barriers

diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector	advanced farming technologies and inputs	Agriculture, Ministry of Environment			in accessing high quality inputs research tools and technology
Laws and strategy to monitor private sector business in seed and other inputs services	To ensure supply of farmer's friendly , environmentally feasible and affordable technology by the private sector	Ministry of Agriculture, DAE	2013-2017	30	Developed policy to regulate private sector involvement in agriculture sector

1.4.1.3. Technology action plan for short maturing rice variety

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 25: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Short maturing rice variety	Investment	Making detail cost estimation for development, transfer and diffusion of short maturing rice crop variety	√	
		Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety	√	
		Making a sector- and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
		Providing subsidy to the price of the input services e.g. seed, irrigation	√	

		etc. for transfer and diffusion of the short maturing rice variety.		
	Capacity development	Reviewing technical and institutional capacities of the existing public sector rice research institutions	√	
		Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions	√	
		Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers		√
		Training and capacity building of the experts of the research organizations for the development of resilient rice varieties e.g. short maturing rice varieties	√	
		Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices		√
		Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.		√
	Organizational/ behavioral change	Creating network of experts and generate updated knowledge on the development of high yielding variety	√	
		Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	√	
		Ensuring suitability testing of the imported or the newly developed varieties	√	
	Policy/ Law	Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector		√
		Laws and strategy to monitor private sector business in seed and other inputs services	√	

b) Technology Action Plan

Table 26 : Technology action plan for short maturing rice variety

Sector: Agriculture					
Specific technology: Short maturing rice variety					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Making detail cost estimation for development, transfer and diffusion of short maturing rice variety	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Agriculture, Department of Agriculture Extension (DAE), Bangladesh Agriculture Research Council (BARC)	2013-2017	300	Readily available detail cost estimation for the policy makers and investors for development, transfer and diffusion of salinity tolerant rice variety
Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety	To ensure immediate and need based finance for agricultural research from the Annual Development Programme (ADP).	Ministry of Agriculture, Ministry of Finance	2013-2017	50	Increased agriculture sector budgetary allocation from ADP
Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and	To overcome financial barriers and to encourage farmers to apply this technology	Ministry of Agriculture, Ministry of	2013-2017	100	Increased farmer's accessibility and affordability to the

diffusion of the short maturing rice variety.		Finance			agricultural input services
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Agriculture, DAE, BARC	2013-2017	40	Communicated technology specific proposal to the development partners
Capacity development					
Reviewing technical and institutional capacities of the existing public sector rice research institutions urban drainage system	To identify technical and institutional capacity gaps of the existing institutions	Ministry of Agriculture,	2013-2017	30	Identified technical and institutional capacity gaps of the rice research institutions
Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions	To help policy makers and other stakeholders to prioritize actions and make investment decision on the priority action. This also will maximize potentials of the respective organizations.	Ministry of Agriculture, Bangladesh Rice Research Institute (BRRI) DAE, BARC	2013-2017	50	Readily available comprehensive action plan for capacity building of the rice research institutions
Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers	To ensure supply of quality seed and technology specific appropriate farming technology to the farmers	Ministry of Agriculture, DAE	2013-2023	40	Ensured supply of quality seeds and other inputs and dissemination of appropriate technologies to the farmers level
Training and capacity building of the experts of the research organizations for the development of resilient rice varieties e.g.	To ensure capacity of local experts. It also will reduce cost for hiring international experts.	DAE, BARC, Soil Research and Development	2013-2017	60	Research organizations are staffed with skilled and expert human

drought tolerant rice varieties		Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)			resource
Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices	To upscale the technology on the basis of field based result	DAE, BARC, Soil Research and Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)	2013-2017	250	Developed and institutional capacity mechanism for effectiveness of the new technology
Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties.	To make use of high-quality properties of the indigenous varieties in the development of new ones.	DAE, BARC, Soil Research and Development Institute(SRDI), Bangladesh Institute of Nuclear Agriculture (BINA)	2013-2023	150	Developed new variety through hybridization with the indigenous one.
Organizational/ behavioral change					
Creating network of experts and generate updated knowledge on the development of high yielding variety	To learn and enhance understanding and knowledge on the technology	DAE, BARC, SRDI, BINA, BRRI	2013-2017	30	Increased sharing of information, knowledge and tools for the development

					of climate resilient high yielding rice variety
Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	To increase acceptability of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other stakeholders	DAE, BARC, BRRI, NGOs, Private Sector	2013-2017	35	Increased acceptance of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other stakeholders
Ensuring suitability testing of the imported or the newly developed varieties	To ensure supply of only quality seeds and appropriate farming technology to the farmer.	Ministry of Agriculture, DAE, BARC,	2013-2017	20	Institutions in place to ensure supply and dissemination of quality seeds and appropriate farming technology to the farmer.
Policy/ Law					
Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector	To have free access to the advanced farming technologies and inputs	Ministry of Agriculture, Ministry of Environment	2013-2023	40	Removed IPR barriers in accessing high quality inputs research tools and technology
Introducing Laws and strategy to monitor private sector business in seed and other inputs services	To ensure supply of farmer's friendly , environmentally feasible and affordable technology by the private sector	Ministry of Agriculture,	2013-2017	30	Developed policy to regulate private sector involvement in agriculture sector

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1.4.1.4. Technology action plan for Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 27: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc	Investment	Reviewing and increasing budgetary allocation for agricultural training and extension services	√	
		Public and private sector funding for training and agricultural extension services	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Reviewing technical and institutional capacities of the existing training and extension agencies	√	
		Training and capacity building of the experts of the research organizations for the dissemination of climate change resilient rice varieties		
		Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers		√
		Developing comprehensive action plan for technical and institutional capacity building of the public and private sector training providing organizations	√	
	Organizational/ behavioral	Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high	√	

	change	yielding variety (HYV) and genetically modified (GM) variety		
		Demonstrating the new technology to increase social acceptance	√	
		Strengthening system support and other services through quality assurance, information on new practices, financial services etc	√	
		Assigning focal point for sharing and coordination of activities of different agencies	√	
	Policy/ Law	Laws and strategy to encourage private sector involvement in the agricultural extension and dissemination services		√

b) Technology Action Plan

Table 28: Technology action plan for Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc

Sector: Agriculture					
Specific technology: **Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc**					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Reviewing and increasing budgetary allocation for agricultural training and extension services	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Agriculture, DAE, BARC	2013-2017	100	Increased agriculture sector budgetary allocation from ADP
Public and private sector funding for training and agricultural extension services	To ensure immediate and need based finance for agricultural training and technology extension from the	Ministry of Agriculture, Ministry of Finance	2013-2017	40	Increased funding from public and private sectors

	Annual Development Programme (ADP).				
Making a sector and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Agriculture, Ministry of Finance	2013-2017	20	Communicated technology specific proposal to the development partners
Capacity development					
Reviewing technical and institutional capacities of the existing training and extension agencies	To identify technical and institutional capacity gaps of the existing institutions	Ministry of Agriculture,	2013-2017	20	Identified technical and institutional capacity gaps of the rice research institutions
Training and capacity building of the experts of the research organizations for the dissemination of climate change resilient rice varieties	To learn and enhance understanding and knowledge on the extension of agricultural technology	Ministry of Agriculture, Bangladesh Rice Research Institute (BRRI) DAE, BARC	2013-2017	50	Research organizations are staffed with skilled and expert human resource
Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers	To ensure supply of quality seed and technology specific appropriate farming technology to the farmers.	Ministry of Agriculture, DAE	2013-2023	30	Ensured supply of quality seeds and other inputs and dissemination of appropriate technologies to the farmers level
Developing comprehensive action plan for technical and institutional capacity building of the public and private sector training providing	To help policy makers and other stakeholders to prioritize actions and make investment decision on	Ministry of Agriculture, DAE, BARC,	2013-2017	40	Readily available comprehensive action plan for capacity building of the rice

organizations	priority action				research institutions
Organizational/ behavioral change					
Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	To increase acceptability of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other stakeholders	DAE, BARC, SRDI, BINA, BRRI, NGOs , Private Sector	2013-2017	20	Increased acceptance of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other stakeholders
Demonstrating the new technology to increase social acceptance	To promote and socialize the application of the technology	DAE, BARC, BRRI, NGOs	2013-2017	30	Increased social acceptance of the technology
Strengthening system support and other services through quality assurance, information on new practices, financial services etc	To ensure effective and quick transfer and diffusion of the technology	Ministry of Agriculture, DAE, BARC,	2013-2017	30	Increased delivery of support services
Assigning focal point for sharing and coordination of activities of different agencies	To enhance coordination among different agencies and to facilitate uniform strategies and actions among the agencies	Ministry of Agriculture, Ministry of Water Resources, DAE, BARC, BRRI,	2013-2017	20	Related ministries departments appointed a focal person for increased sharing and coordination
Policy/ Law					
Introducing laws and strategy to encourage private sector involvement in the agricultural extension and dissemination services	To facilitate private sector involvement in agricultural extension and dissemination services.	Ministry of Agriculture,	2013-2023	20	Developed private sector supportive laws and policies for agricultural extension and dissemination.

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1.4.1.5. Technology action plan for climate smart Agriculture Technology Dissemination Center

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 29: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Climate smart Agriculture Technology Dissemination Center	Investment	Reviewing and increasing budgetary allocation for the establishment of a climate smart technology dissemination center.	√	
		Public and private sector funding for training and agricultural extension services	√	
		Making a sector- and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Reviewing technical and institutional capacities of the existing training and extension agencies	√	
		Developing of a comprehensive action plan for technical and institutional capacity building of the public and private sector training organizations	√	
		Training and capacity building of the experts of the research organizations for the dissemination of climate change resilient rice varieties	√	
		Developing comprehensive action plan for technical and institutional capacity building of the public and private sector training providing organizations	√	
	Organizational/	Creating a network among research organization, academic institutions	√	

	behavioral change	and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety		
		Demonstrating the new technology to increase social acceptance	√	
		Strengthening system support and other services through quality assurance, information on new practices, financial services etc	√	
		Assigning focal point for sharing and coordination of activities of different agencies		
	Policy/ Law	Introduing laws and strategy to encourage private sector involvement in the agricultural extension and dissemination services		√

b) Technology Action Plan

Table 30: Technology action plan for of climate smart Agriculture Technology Dissemination Center

Sector: Agriculture					
Specific technology: **Climate smart Agriculture Technology Dissemination Center**					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Reviewing and increasing budgetary allocation for the establishment of a climate smart technology dissemination center.	To help policy makers and investors to have a clear idea on investment requirement for the implementation of the technology.	Ministry of Agriculture, Ministry of Finance	2013-2017	250	Increased agriculture sector budgetary allocation for the establishment of a climate smart dissemination center.
Public and private sector funding for training and agricultural extension services	To ensure immediate and need based finance for agricultural training and technology extension both	Ministry of Agriculture, Ministry of Finance	2013-2017	60	Increased funding from public and private sectors

	from public and private sectors.				
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Agriculture, Ministry of Planning, Ministry of Finance	2013-2017	20	Communicated technology specific proposal to the development partners
Capacity development					
Reviewing technical and institutional capacities of the existing training and extension agencies	To identify technical and institutional capacity gaps of the existing institutions	Ministry of Agriculture,	2013-2017	20	Identified technical and institutional capacity gaps of the rice research institutions
Developing comprehensive action plan for technical and institutional capacity building of the public and private sector training organizations	To help policy makers and other stakeholders to prioritize actions and make investment decision on priority action	Ministry of Agriculture, Ministry of Planning	2013-2017	30	Readily available comprehensive action plan for capacity building of the rice research institutions
Training and capacity building of the experts of the research organizations for the dissemination of climate change resilient rice varieties	To learn and enhance understanding and knowledge on the extension of agricultural technology	Ministry of Agriculture, DAE	2013-2017	50	Research organizations are staffed with skilled and expert human resource
Organizational/ behavioral change					
Creating a network among research organization, academic institutions and NGOs to remove misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety	To increase acceptability of the high yielding variety (HYV) and genetically modified (GM) variety to the farmers and other stakeholders	DAE, BARC, SRDI, BINA, BRRI, NGOs , Private Sector	2013-2017	20	Increased acceptance of the high yielding variety (HYV) and genetically modified (GM) variety by the farmers and other

					stakeholders
Demonstrating the new technology to increase social acceptance	To promote and socialize the application of the technology	DAE, BARC, BRRI, NGOs	2013-2017	30	Increased social acceptance of the technology
Strengthening system support and other services through quality assurance, information on new practices, financial services etc	To ensure effective and quick transfer and diffusion of the technology	Ministry of Agriculture, DAE, BARC,	2013-2017	40	Increased delivery of support services
Assigning focal point for sharing and coordination of activities of different agencies	To enhance coordination among different agencies and to facilitate uniform strategies and actions among the agencies	Ministry of Agriculture, Ministry of Water Resources, DAE, BARC, BRRI,	2013-2017	20	Related ministries departments appointed a focal person for increased sharing and coordination
Policy/ Law					
Introducing Laws and strategy to encourage private sector involvement in the agricultural extension and dissemination services	Laws and strategy to encourage private sector involvement in the agricultural extension and dissemination services	Ministry of Agriculture,	2013-2023	20	Developed private sector supportive laws and policies for agricultural extension and dissemination.

1.4.1.6. Technology action plan for the establishment of special agricultural R & D centre

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

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Table 31: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Establishment of special agricultural R & D centre	Investment	Reviewing and increasing budgetary allocation for agricultural research and development	√	
		Providing long term and predicted funds for research for climate change resilient agricultural technology development, transfer and diffusion	√	
		Making a sector- and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Reviewing technical and institutional capacities of the existing agricultural research organizations	√	
		Developing of a comprehensive action plan for technical and institutional capacity building of the public and private sector agricultural research organizations	√	
		Capacity building of the experts of the research organizations for development, diffusion and transfer of the climate change resilient agricultural technology	√	
		Promoting research collaboration between organizations, especially at the regional and international level	√	
		Ensuring high quality tools for agronomic research		√
	Organizational/ behavioral change	Raising public awareness and encourage technology transfer on pest/ disease outbreak	√	
		Demonstrating the new technology to increase social acceptance	√	
		Establishing biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties		√

		Developing a database on pest and disease		√
	Policy/ Law	Introducing laws and strategy to encourage private sector investment in the agricultural research and development		√

b) Technology Action Plan

Table 32 : Technology action plan for the Establishment of special agricultural R & D centre

Sector: Agriculture					
Specific technology: **Establishment of special agricultural R & D centre**					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure
	1	**2**	**3**	**4**	**5**
Investment					
Reviewing and increasing budgetary allocation for agricultural research and development	To ensure immediate and need based finance for agricultural research from the Annual Development Programme (ADP).	Ministry of Agriculture, Ministry of Finance	2013-2017	300	Increased agriculture sector budgetary allocation from ADP
Providing long-term and predicted funds for research for climate change resilient agricultural technology development, transfer and diffusion	To ensure long-term and need based finance for agricultural research.	Ministry of Agriculture, Ministry of Finance	2013-2017	60	Ensured long-term project funding for agricultural research
Making a sector- and technology-specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Agriculture, Ministry of Planning, Ministry of	2013-2017	30	Communicated technology specific proposal to the development partners

		Finance			
Capacity development					
Reviewing technical and institutional capacities of the existing agricultural research organizations	To identify technical and institutional capacity gaps of the existing institutions	Ministry of Agriculture	2013-2017	20	Identified technical and institutional capacity gaps of the rice research institutions
Developing of a comprehensive action plan for technical and institutional capacity building of the public and private sector agricultural research organizations	To help policy makers and other stakeholders to prioritize actions and make investment decision	Ministry of Agriculture, Ministry of Planning	2013-2017	40	Readily available comprehensive action plan for capacity building of the rice research institutions
Capacity building of the experts of the research organizations for development, diffusion and transfer of the climate change resilient agricultural technology	To increase expertise and efficiency of local experts. It also will reduce cost for hiring international experts.	Ministry of Agriculture, DAE, BARC	2013-2017	40	Research organizations are staffed with skilled and expert human resource for transfer and diffusion and climate resilient agricultural technology
Promoting research collaboration between organizations, especially at the regional and international level	To enhance research capacity	Ministry of Agriculture, DAE, BARC, BRRI, SRDI	2013-2017	30	Increased sharing of information, knowledge and tools for the development of climate resilient high yielding rice variety
Ensuring high quality tools for agronomic research	To strengthen capacity on agronomic research	DAE, BARC	2013-2023	50	Research organizations are staffed with skilled

					and expert human resource for agronomic research
Organizational/ behavioral change					
Raising public awareness and encourage technology transfer on pest/ disease outbreak	To ensure dissemination of environment friendly pest/ disease control technology	Ministry of Agriculture, DAE, BARC	2013-2017	30	Increased measures for agricultural disease and pest control
Demonstrating the new technology to increase social acceptance	To promote and socialize the application of the technology	Ministry of Agriculture, DAE, BARC	2013-2017	40	Increased social acceptance of the technology
Establishing biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties	To make use of high-quality properties of the indigenous varieties in the development of new ones.	Ministry of Agriculture, DAE, BARC	2013-2023	25	Developed new variety through hybridization with the indigenous one.
Developing a database on pest and disease	To undertake appropriate measures for pest and disease control	Ministry of Agriculture, DAE, BARC	2013-2023	20	Established appropriate measures for pest and disease control
Policy/ Law					
Introducing laws and strategy to encourage private sector investment in the agricultural research and development	To encourage private sector involvement in agricultural research	Ministry of Agriculture,	2013-2023	20	Developed private sector supportive laws and policies for agricultural research

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1.4.1.7. Technology action plan for Land Use Planning

a) Aggregation and grouping of identified measures

Following identification of measures in the stakeholders' consultation workshop, the identified measures have been grouped under broader strategic measures presented in the table below;

Table 33: Grouping of measures under broader criteria

Technology	Strategic measures	Specific measure	Timeline	
			Short Term (1-5 years)	Long Term 1-10 years
Land use Planning	Investment	Providing finance for land use planning	√	
		Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	√	
	Capacity development	Launching a major programme on land use planning		√
		Training and capacity building of the experts on the application of GIS and Remote Sensing technology	√	
	Policy/ Law	Policies to enforce land utilization on the basis of land-use planning		√

b) Technology Action Plan

Table 34 : Technology action plan for Land Use Planning

Sector: Agriculture					
Specific technology: **Establishment of special agricultural R & D centre**					
Measures (Grouped under broader category)	Importance of the measure	Implementing agency	Timescale	Cost for the measures/ Unit ('000 USD)	Monitoring, Reporting and verification for measure

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	1	2	3	4	5
Investment					
Providing finance for land-use planning	To ensure finance for technology implementation	Ministry of Land, Ministry of Finance	2013-2017	350	
Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources	To get immediate and long-term funds from international sources.	Ministry of Land, Ministry of Planning, SPARSO	2013-2017	100	Communicated technology specific proposal to the development partners
Capacity development					
Launching a major programme on land use planning	To undertake appropriate measures for launching land use planning	Ministry of Land, Ministry of Planning, SPARSO	2013-2023	50	Initiated major programme of land use planning
Training and capacity building of the experts on the application of GIS and Remote Sensing technology	To learn and enhance understanding and knowledge on the application of GIS and Remote Sensing tools and technology	Ministry of Land, SPARSO	2013-2017	40	Research organizations are staffed with skilled and expert human resource for GIS and RS application
Policy/ Law					
Introducing policies to enforce land utilization on the basis of land-use planning	To ensue land utilization of the basis of land use planning	Ministry of Land	2013-2023	20	New policy in place to ensure land utilization as per land use planning

2.4. 2 Brief summary of project ideas for international support (Details in Annex 3)

The project idea for the agriculture sector adaptation technology is to 'establish a special research and development (R & D) center'

Main objectives of the project are: a) to research on the development of context specific or climate resilient crop production technologies, b) to identify the technological needs for sustainable agricultural production in different stress conditions caused by climate change, c) to establish a smooth institutional and coordination mechanisms of all the existing agricultural research institutions in country and abroad to consolidate all agricultural success stories on adaptation technologies in government, non-government and private initiatives.

This special research and development (R & D) center will develop adaptation technologies that are environmentally sustainable, culturally compatible, socially acceptable, economically feasible and technically viable.

2.5 Summary

The transfer and diffusion of the selected technologies of agriculture sector will, therefore, depend largely on the development of enabling environment while overcoming the barriers. Some of the measures are presented below:

Short Term:

- Making detail cost estimation for development, transfer and diffusion of salinity tolerant rice crop variety
- Reviewing and increasing budgetary allocation for agricultural research for the development of climate change resilient rice crop variety
- Making a sector and technology specific proposal and generating funds from the development partners and other international adaptation funding sources
- Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.
- Reviewing technical and institutional capacities of the existing public sector rice research institutions
- Developing of a comprehensive action plan for technical and institutional capacity building of the rice research institutions
- Training and capacity building of the experts of the research organizations for the development of resilient rice varieties
- Introducing laws and strategy to monitor private sector business in seed and other inputs services
- Creating network of experts and generate updated knowledge on the development of high yielding variety
- Creating a network among research organization, academic institutions and NGOs to remove to misunderstanding about high yielding variety (HYV) and genetically modified (GM) variety

- Ensuring suitability testing of the imported or the newly developed varieties
- Making detail cost estimation for development, transfer and diffusion of drought tolerant rice crop variety
- Introducing laws and strategy to monitor private sector business in seed and other inputs services
- Making detail cost estimation for development, transfer and diffusion of short maturing rice crop variety
- Providing subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the short maturing rice variety
- Reviewing and increasing budgetary allocation for agricultural training and extension services
- Exploring public and private sector funding for training and agricultural extension services
- Reviewing technical and institutional capacities of the existing training and extension agencies
- Demonstrating the new technology to increase social acceptance
- Strengthening system support and other services through quality assurance, information on new practices, financial services etc
- Assigning focal point for sharing and coordination of activities of different agencies
- Reviewing and increasing budgetary allocation for the establishment of a climate smart technology dissemination center.
- Public and private sector funding for training and agricultural extension services
- Developing of a comprehensive action plan for technical and institutional capacity building of the public and private sector training providing organizations
- Strengthening system support and other services through quality assurance, information on new practices, financial services etc
- Providing long term and predicted funds for research for climate change resilient agricultural technology development, transfer and diffusion
- Capacity building of the experts of the research organizations for development, diffusion and transfer of the climate change resilient agricultural technology
- Promoting research collaboration between organizations, especially at the regional and international level
- Raising public awareness and encourage technology transfer on pest/ disease outbreak
- Providing finance for land use planning

- Training and capacity building of the experts on the application of GIS and Remote Sensing **t**echnology

Long Term:

- Strengthening capacity of the seed certification authority so that only the quality seeds and easily adaptable farming technologies reach to the farmers
- Strengthening capacity of the monitoring and evaluation wing of the agriculture sector to monitor the effectiveness of the new technology and farming practices
- Developing of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Waiving IPR fees for transfer and diffusion of high yielding variety (HYV) and genetically modified (GM) variety developed by private sector
- Training and capacity building of the experts of the research organizations for the dissemination of climate change resilient rice varieties
- Introducing laws and strategy to encourage private sector involvement in the agricultural extension and dissemination services
- Assigning focal point for sharing and coordination of activities of different agencies
- Developing a database on pest and disease
- Launching a major programme on land use planning
- Policies to enforce land utilization on the basis of land use planning

Part III

Cross-cutting issues for the National TNA and TAPs

Cross –cutting issues for Water Sector Adaptation

Part II of TNA report is the action plan for the prioritized technologies to make water sector and water sector infrastructure climate-resilient. It identifies barriers that could obstruct transfer and diffusion of technologies and also measures to overcome the barriers. In addition to these, the TNA National Committee has identified the following issues as cross-cutting issues which are to be considered for technology transfer and diffusion; these are-

a) **Implementation of National Water Management Plan:** The NWMP that was adopted in 2004 listed a total of 84 programmes under eight clusters. The main focus of those programmes are water sector management, multi-purpose water schemes, construction of barrages, dredging of waterways, improvement of flood control and drainage infrastructures that would include raising embankments, flood protection including urban areas, urban drainage improvement, river erosion control, land reclamation, addressing water logging in the south-western region, strengthening protection of coastal area, development of irrigation systems, surface water development, drought management, water supply and sanitation provision in the urban and rural areas etc. Implementation of water sector has prioritized technologies as proposed in the TNA which also complements implementation of National Water Management Plan and vice versa.

b) **Polder management:** The sea-facing polders provides a first line of defense for millions of people living in the coastal belt. The existing forty-nine sea facing polders are not functioning well due to siltation in the river bed causing water logging with loss of agricultural production. These problems are being addressed by introducing an age old approach that is practiced in the Netherlands namely, the Tidal River Management (TRM) to take advantage of the natural tide movement in rivers to address the drainage problems in the polders. During flood tide, the tide is allowed to enter into an embanked low-lying area (tidal basin) where the sediment carried in by flood tide, is deposited. During ebb tide, water flows out of the tidal basin with greatly reduced sediment load and eventually erodes the downstream river bed. The natural movement of flood and ebb tide along the tidal basin and along the downstream river maintains a proper drainage capacity in that river.

c) **Coordinated problem solving mechanism along with the community:** Though the TRM adaptation is a success story in Bangladesh but acceptability of the TRM by the local land owners poses to be a major obstacle. People, who allow their land to be used for tidal basin operation, should be compensated in a proper manner.

Cross –cutting issues for Agriculture Sector Adaptation

The development and adoption of climate change resilient crop varieties has been a key undertaking of the technological change in agriculture. These varieties should have the potential to grow in salinity and extreme environmental conditions such as drought and flooding. Also relevant in ensuring food security are the efforts to produce varieties with shorter term maturity which enable cropping intensification (Hossain et al., 2007).

In this context, Part II of TNA report which is the action plan for the prioritized technologies elaborates on how to develop climate resilient rice crop technologies, identified barriers in transfer and diffusion of technologies and identified measures to overcome the barriers. In addition to these, the TNA National Committee has identified the following issues as cross-cutting issues which are to be considered for technology transfer and diffusion. These are

a) **Sustainable practices through training of farmers:** While a number of GoB agencies (BARI, BRRI, LGED) and NGOs are involved in training farmers to adopt sustainable practices in the use of soil, water and chemical inputs, DAE remains the main provider of training across the country. The effectiveness of DAE, which counts on a force of about 12,600 Sub-Assistant Agricultural Officers (SAAOs) operating all over the country, is constrained by the availability of resources to finance costs other than salaries, such as transportation, communications, physical infrastructure and other running costs, which are often financed through project. All SAAOs have diplomas from one of the 11 Agricultural Training Institutions (ATIs), but resources are needed to update their knowledge of new technologies and emerging farming systems (USAID, 2011).

b) **Enhancing agricultural research:** The Draft National Agriculture Policy (2010) fully acknowledges the importance of research, highlighting in particular post-production technologies, high value crops, value addition, agribusiness management and trade, biotechnology, hybrid seeds, climate change, disaster and stress tolerant varieties (to flood, drought, cyclone and salinity), deep water crop management, and organic farming. Consistently with the priority assigned to agricultural research, the Government increased funding for the research institutes under NARS from Tk 3.32 billion in 2010/11 to Tk 3.67 billion in 2011/12, but its share in total National Budget decreased from 0.25% to 0.22% during the same period. Despite this increase, the level of financing is still considered suboptimal. USAID (2011) points to the need to enhance not only size but also allocation of funds so as to make research more demand driven and maximize its impact at field level (USAID, 2011).

c) **Strengthening coordination among research organizations and NGOs:** In the institutional front, the increased involvements of NGOs and universities have already been mentioned. Another important development is the approval of the Bangladesh Agricultural Research Council Act in 2011, which is expected to enhance coordination of the research activities conducted by 12 institutions operating under the supervision of different ministries.

This should help improve the efficiency of the research system by minimizing duplication of efforts; improve efficiency of fund allocation and quality of research.

d) **Agricultural extension:** The Draft National Agriculture Policy (2010) foresees a shift from the top-down, hierarchical approach to extension to a bottom-up, decentralized and participatory model in which farmers, researchers and extension workers will serve as peers. Moreover, it foresees enhanced coordination and collaboration between public, private and voluntary extension initiatives in such a way to pursue more efficiently diverse agricultural goals and the needs of diverse categories of farmers with a special emphasis on the needs of women and young farmers.

e) **Focusing on coordinated problem-solving and integrated research:** In line with the Sixth Five–year-Plan (2011-2015), the research system needs greater coordination and integration to avoid fragmentation and duplication. The research approach needs to be oriented toward farming systems or integrated production systems, instead of being commodity-based. Its planning, program monitoring and coordination must be strengthened.

f) **Undertaking agro-ecological zone-based research:** Climate change will impact cropping differently in different agro-ecological zones. This calls for efforts to develop technologies suited to the specific characteristics of the different agro-ecological zones. For instance, in

case of rice, particular emphasis needs to be placed on varieties that are less dependent on irrigation and fertilizers of shorter duration, to allow further intensification, diversification and employment generation during current lean season.

g) **Scaling-up agricultural research funding**: The budget allocated for agricultural research is very low in Bangladesh compared to the average for developing countries: about 0.24% of agricultural GDP over the period 2007/08-2010/11, compared to about 0.62% for developing countries as a group, and 2.80% for developed countries. Research funding needs to be up-scaled in order to allow the 'technological breakthrough' needed to secure the required intensification, diversification, sustainability and resilience of national agriculture.

h) **Strengthening linkages among research, extension, education and farmers:** As pointed out by USAID (2011), extension services draw their strength from research as well as from farmers' innovations by transferring up-to-date findings from research to farmers, while providing researchers feedback on farmers' concerns and innovations. Yet, agricultural research, education and extension in Bangladesh are not demand-driven. A top-down approach is characteristic of researchers, educationists and extensionists. Even when new technologies and products have been developed at the institutes and universities, the impact at the field level can be minimal. Strengthening linkages among research, extension, education and farmers is vital for sustaining agriculture development.

Annexes

Annex I. Technology Factsheets

Factsheets for Water Sector Technologies

A Name of Technology: Rehabilitation of existing Embankments/ dykes and dredging

A.1 Introduction

Bangladesh has experience in construction of embankments using traditional manual system. So far over 4500 km of embankment was built along river bank and coastal areas. But in the climate change scenario, there will be a need for building more durable embankments with considerable height above the height of projected tidal surge and sea level rise

A.2 Technology characteristics

Water/ Infrastructure development

A.3 Country specific / applicability

Redesign of crest level of embankments/dykes incorporating Sea Level Rise (SLR), subsidence and storm surge and providing adequate berm at the C/S.
Construction of a narrow embankment (ring Bund) at existing height of embankment apart from the main embankment and filling the gap in between by dredged earth to provide berm.

A.4 Status of technology in country

All the coastal embankments and sea dykes were constructed under Coastal Embankment Project (CEP) in the early 60's and 70's. Due to prolonged use and weather effects, the cross sections of the existing embankments including the crest level have been reduced significantly. In addition sea level rise due to global warming effect these embankments and dykes are under serious threats to breach.

A.5 Barriers

a)Financial barrier

- Construction of more durable embankments with considerable height above the height of projected tidal surge and sea level rise will require increased finance.
- New earth work, regular dredging and the maintenance of embankment along the coast will have high investment cost.

b) Non-financial barriers

- Lack of adequate and skilled manpower as well as modern equipments in the soil mechanics laboratories in the country.
- Manual construction practices are not feasible as it requires huge labor force.
- Lack of proper river mechanics studies and sediment transport modeling
- Ad-hoc decisions on drainage without study based information and community consultation.

A.6 Benefits to economic / social and environmental development

The proposed embankment rehabilitation will allow no or less seepage during flood and high tide and will provide protection against cyclonic and tidal surge. Further, the rehabilitated embankment will require no or less annual maintenance. Adaptation benefits like increased safety of people's life and crops including provision of emergency shelter on the berm at C/S can be achieved against cyclone and tidal surge.

A.7 Costs

Capital Costs: Approximate cost of TK 100.00 lakhs per vent; (USD 125000)

Operational and Maintenance costs: Rehabilitation / repair of sluice gate = Tk 25 lakh /per vent (Approx); (USD 31250)

B. Name of Technology: Comprehensive disaster management involving community-based programs and early warning systems for storm surge and cyclones

B.1 Introduction

Bangladesh has one of the finest and state of the art Flood Forecasting and Warning (FFW) and Storm Warning System (SWS). This has remarkably reduced loss of human lives. Although the present losses are in hundreds and on occasions few thousands due to adverse situations that can be remedied to save more lives. But in the context of more frequent and intense disaster events caused by climate change will require real-time forecasting of impending disasters through modernization of existing warning systems and improvement in warning dissemination system

B.2 Technology characteristics

Water/ Comprehensive disaster management

B.3 Country specific / applicability

- Research for development of system management to minimize casualty and loss of properties and livestock against cyclonic surge.
- Development of appropriate and meaningful range and duration of warning system
- Dissemination of forecasting up to the Community level
- Construction/ rehabilitation of Cyclone shelters
- Capacity building

B.4 Status of technology in country

In the last decade, the frequency of cyclone and storm surge in the coastal area has increased significantly due to global climate change. The traditional preparedness, warning system and rescue measures against pre- and post- cyclonic surge was proven as to be not adequate and needs improvement and modernization. Coordination and monitoring of Pre- and post-disaster activities should be strengthened. This will require medium and long-term program using modern technology.

B.5 Barriers

Financial barrier

- More investment required for the modernization of existing warning systems and improvement in warning dissemination system

Non-financial barriers

- Community orientation to the modernized system and new approach of disaster risk reduction
- No system in place to monitor and forecast slow-onset disaster events like salinity intrusion, drought, ocean acidification etc.

B.6 Benefits to economic / social and environmental development

- The technology will increase sense of security, reduce magnitude of disaster; reduce casualties and loss of properties and livestock.

B.7 Costs

Capital costs:

The program will cost approximately

Tk 50/- lakh for research,
Tk 25/- lakh for development of up-graded warning system,
Tk 500/- lakh/ no. for construction of new cyclone shelter,
Tk 50 lakh/ no. for rehabilitation of cyclone shelter,
Tk 1/- lakh/ km for planning and implementation of Eco-friendly landscape & aforestation,
Tk 25/- lakh/ community for provision of renewable energy (solar system) and
Tk 0.5/- lakh/ household for provision of rainwater harvesting & sanitation.

Operational and Maintenance costs

For capacity building, approximate cost of training, workshop for providing life jacket/ buoy, etc. would be Tk 05/- lakh/ community. (USD 6250)

C. Name of Technology: Monitoring sea level, tide, salinity, sedimentation and coastal erosion

C.1 Introduction

There are only tidal gauges on major ports. Bangladesh Water Development Board collects periodic salinity data in the coastal areas. Therefore Project based studies are conducted for erosion and sedimentation. Presently, Centre for Environment and Geographic Information Services (CEGIS) maintains database for hydrologic, water quality, and morphological data of the coastal areas but these are not adequate

C.2 Technology characteristics

Water/ Monitoring of sea and coastal changes

C.3 Country specific / applicability

- Planning, installation of network establishment and monitoring for water level, salinity and sediment measurement.
- Supply & installation of auto gauges at suitable locations.
- Skill development

C.4 Status of technology in country

There is no adequate database to ascertain the effect of sea level rise at different dimension. It is essential to record the water level, discharge, salinity and sedimentation for monitoring the substantial changes in the respective dimension

C.5 Barriers

Financial barrier

- Development of robust monitoring system of sea level rise, tidal fluctuation, salinity intrusion, sedimentation coastal erosion etc. will require increased investment and operational and management fund.

Non-financial barriers

- New institutions and monitoring stations will be required in three different locations in the coastal areas.
- There is no integrated programme for monitoring hydrological, water quality and coastal geomorphology that can assist sea level monitoring.
- Lack of institutional capacity for networking with global networking systems for sea-level monitoring.
- Lack of expertise and capacity for climate-modeling and satellite-based sea-level rise monitoring mechanism

C.6 Benefits to economic / social and environmental development

The monitoring program will build up awareness to guide for taking action by the decision makers to ensure future sustainability. Moreover, the program will help ensuing healthy, economic and agricultural productive environment.

C.7 Costs

Capital costs:

Approx cost of planning Tk 50.00 lakh/ polder
Approx cost Tk 5.00 Lakhs/ number for supply and installation of auto gauges

Total: 55 lahks/ polder; (USD 68750)

Operational and Maintenance costs

Approx cost Tk 02.00 Lakhs/ number for operation and management; (USD 2500)

D Name of Technology: Tidal river management including Computer simulation of tidal flow

D.1 Introduction

Tidal River Management (TRM) is already being used in a number of polders in Bangladesh but it has to be improved to respond to some of the issues such as acceptability of TRM by the local communities

D.2 Technology characteristics

Water/ Tidal system and infrastructures management

D.3 Country specific / applicability

- Operation of Tidal River Management (TRM) using indigenous method with medium and long term program
- Medium and long term indigenous and modern technology though improved planning, design, construction and gate improvement

D.4 Status of technology in country

Construction of peripheral embankment along the banks of the coastal rivers under Coastal Embankment Project (CEP) has prevented intrusion of silt laden saline water into the poldered area. Moreover, upstream flow of these rivers reduced drastically due to construction and operation of Farakka Barrage. As a result, silt is coming up with saline water during high tide in dry season which is being deposited in the river bed, starting from the downstream of the sluice gates. This is the identified main reason of drainage congestion/ water logging in the coastal polders. The solution to this problem is the operationalization of Tidal River Management (TRM) using indigenous method with medium and long term program.

D.5 Barriers

The economic, technical and environmental barriers, identified in the transfer and diffusion of technology related to Tidal river management including Computer simulation of tidal flow include:

Financial barriers

- Tidal river management technology which requires high investment and O & M costs for new equipment and regular dredging

Non-financial barriers

- Lack of community participation in decision-making may cause unacceptability of the TRM by the local land owners
- Lack of technological measures for effective sediment deposition in the tidal basin to increase acceptability by the land owners.

D.6 Benefits to economic / social and environmental development

TRM has the benefits of (i) reducing siltation in the river, increasing drainage capacity and tidal prism, (ii) reducing drainage congestion / water logging within the polder and

peripheral rivers, (iii) increasing ground level of the TRM basin, (iv) providing quick drainage and (v) increasing operating efficiency.

D.7 Costs

Capital costs:

Approx cost = Tk 50.00 lakhs/ polder
Approx cost model simulation = Tk 25.00 lakhs/ polder
Approx cost of TRM operation = Tk 1200 lakhs/ TRM basin
New sluices: TK 100.00 lakhs per vent

Total: Taka 1375 lakh/ TRM basin; (USD 1718750)

Operational and Maintenance costs

Rehabilitation / repair of sluice gate = Tk 25 lakh /per vent(Approx)
Approx planning and design cost = Tk 30 Lakhs
Approx cost for installation of up-graded gates & hoists= Tk 3.0 lakhs/ no

Total: Taka 58 lakh; (USD 72500)

E Name of Technology: Rehabilitation of Tidal barriers (Sluice gates)

E.1 Introduction

A large number of sluice gates are in use in the coastal areas for controlling tidal flow and retention of fresh water. Most of the sluice gates in the coastal area were constructed in the early 60's and 70's. Due to prolonged use, and salinity effect, many of the existing sluices, including flap gates have become weak and fragile and lost their draining efficiency. Therefore, it is required to build new sluice gates as well upscale existing ones

E.2 Technology characteristics

Water/ Infrastructure development

E.3 Country specific / applicability

Construction of new sluice gates/ rehabilitation incorporating the effect of sea level rise, subsidence, and cyclonic/ tidal surge.

E.4 Status of technology in country

All the coastal embankments and sea dykes were constructed under Coastal Embankment Project (CEP) in the early 60's and 70's. Due to prolonged use and weather effects the cross sections of the existing embankments including the crest level have been reduced significantly. In addition, sea-level rise due to global warming effect these embankments and dykes are under serious threats to breach.

E.5 Barriers

Financial barrier

- High investment for the construction of new sluice gates

Non-financial barriers

- Sometimes tidal barrier causes water-logging which may lead to unacceptability of the technology by the local people
- Lack of regular maintenance may cause operational deficiency due to prolonged use

E.6 Benefits to economic / social and environmental development

The advantages of the proposed sluice gate are (i) it will reduce siltation process through river bed erosion, (ii) will increase operating efficiency and (iii) will be durable.

E.7 Costs

Capital Costs: Approximate cost of TK 100.00 lakhs per vent; (USD 125000)

Operational and Maintenance costs: Rehabilitation / repair of sluice gate = Tk 25 lakh /per vent (Approx); (USD 31250)

F Name of Technology: Unban Infrastructure Development

F.1 Introduction

Except in the Capital city, most of the urban areas are dependent on natural drainage that is now grossly inadequate due to rapid urbanization and climate change induced erratic rainfall

F.2 Technology characteristics

Water/ Urban resilience improvement

F.3 Country specific / applicability

- Identification of the reaches vulnerable to cyclonic surge and river erosion of the coastal cities/ towns
- Planning and design of flood wall, spar and river bank revetment works.
- Re-excavation of canals by excavator/manual.
- Rehabilitation of sluices with radial gates
- Monitoring of the stability of flood wall, spur and river bank revetment works.
- Construction /implementation of bank revetment work

F.4 Status of technology in country

This implies urban infrastructure improvement to include urban drainage for sustainable urban drainage system. Most of the canals in urban areas of the coastal region have been silted up due to deposition of incoming silt with high tide twice a day during dry season. The old drainage structures are weaker and fragile due to salinity effect and prolonged use. The solution to the problem can be addressed through medium and long-term program using traditional technology.

F.5 Barriers

Financial barrier

- High investment and O&M costs for the modernization of existing drainage infrastructure

Non-financial barriers

- Inadequate capacity and resources of the local government

F.6 Benefits to economic / social and environmental development

Urban infrastructure development will save valuable land and properties, reduce the number of landless people and protect increasing number of poverty affected people.

F.7 Costs

Capital costs:

- Approx cost = Tk 10.00 Lakh/ town identification of vulnerable reaches to cyclonic surge and river erosion
- Approx cost of Planning Tk 10.00 lakh/ town
- Aprx of re-excavation= Tk.50 lakh/ km
- Aprx cost of sluice = Tk 100.0/- lakh/no.
- Approx cost of revetment bank = Tk 2000 lakh/ km

Total: Taka 2170 lakh; (USD 2712500)

Operational and Maintenance costs

- Approx cost of monitoring = Tk 20.00 lakh/ town

  (USD 25000)

Factsheets for Agriculture Sector Technologies

G. Name of technology: Development of salinity tolerant rice varieties

G.1 Introduction

According to the Intergovernmental Panel on Climate Change (IPCC), Bangladesh is slated to lose the largest amount of cultivated land globally due to rising sea levels. A one meter rise in sea levels would inundate 20 percent of the country's land mass.

G.2 Technology characteristics

Agriculture/ Technology development and knowledge management

G.3 Country specific / applicability

- Development of improved rice variety
- Experimentation of performance in different soil salinity condition
- Field experimentation and demonstration
- Development of dissemination packages and tools
- Monitoring of variety suitability in different coastal regions

G.4 Status of technology in country

In recent decades, rising sea levels in the Bay of Bengal have encroached on vast tracts of agricultural land in the south, undermining rice production, a staple part of the Bangladeshi diet.

Meantime, thousands of small-scale rice farmers have seen their livelihoods decimated due to the effects of climate change in the low-lying area. With soil salinity spreading fast, the key to survival lies in developing salt-resistant agriculture. A new salt-resistant paddy could offer hope to coastal farmers in the coastal regions of Bangladesh whose crops are being affected by increased level of salinity. Though the rice variety 'BRRI -47', developed by the Bangladesh Rice Research Institute (BRRI) is claimed to survive high salinity and water-logging but its capacity of salinity tolerance level require to upscale to that this variety could withstand even in higher salinity level.

G.5 Barriers

Financial Barrier

- Long term research investment is required for the development of salinity tolerant rice variety
- High investment is required for demonstration and extension of this technology to the reaching this technology to the farmers level
- Reduced level of public sector investment for demonstration and extension of agricultural technology

Non- financial barrier

- Lack of skilled human resource for research and development in the public sector institutions

- Lack of policy decision for introducing new farming system with new rice verities in the salinity prone areas.
- Lack of research capacities of the public research organizations for the development of resilient rice varieties e.g. Saline tolerant rice varieties
- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Intellectual properties issues, especially patenting on the high yielding variety (HYV) and genetically modified (GM) variety
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Lack of suitability of the imported technology and variety in the local context
- Limited scope of field testing for environmental risk assessment and disease prevalence of the varieties imported by private sector
- Lack of social acceptance of the new technology
- Lack of efficiency of the seed certification authority
- Insufficient measures to monitor the quality of private sector seed and other agricultural inputs
- Cost of the input services e.g. seed, irrigation etc. for transfer and diffusion of the salinity tolerant rice variety.

G.6 Benefits to economic / social and environmental development

- Coastal farmlands now face loss of rice crop production due to salt water intrusion caused by sea level rise and unusual high tide.
- This technology will allow to protect agriculture based small-holders livelihoods, reduce the number of landless people and protect increasing number of poverty affected people. The introduction of salt-tolerant rice varieties could also help the region cope with another problem — land subsidence**.**

G.7 Costs

Capital Costs

a) Approx cost = Tk 2000.00 Lakh for research and development of new variety
b) Approx cost for experimentation of the performance new rice variety Tk 500 lakh/ town

Total: Taka 2500 lakh; (USD 3125000)

Operational and Maintenance costs

c) Approx cost of field experimentation and demonstration = Tk 500.00 lakh
d) Development of dissemination packages and tools Tk 250 lakh
e) Approx cost of monitoring = Tk 250.00 lakh/ year

Total: Taka 1000 lakh; (USD 1250000)

H. Name of technology: Development of drought tolerant rice varieties

H.1 Introduction

According to the Intergovernmental Panel on Climate Change (IPCC), Bangladesh is slated to lose the largest amount of cultivated land globally due to rising sea levels. A 1m rise in sea levels would inundate 20 percent of the country's landmass

H.2 Technology characteristics

Agriculture/ Technology development and knowledge management

H.3 Country specific / applicability

- Development of improved rice variety
- Experimentation of performance in different soil salinity condition
- Field experimentation and demonstration
- Development of dissemination packages and tools
- Monitoring of variety suitability in different coastal regions

H.4 Status of technology in country

In Bangladesh, drought prone areas are mainly located in the in the North-western part, with very severe areas on centered in the Barind Tract and adjacent to the upper Ganges-Padma river floodplain areas.

A recent study (Shamsuddoha, Md et al, 2012) showed that in the drought prone areas small-scale rice farmers are selling out their pieces of land to the big-farm owners who are converting rice-crop land to mango orchards. Thus, agricultural labors are losing their employment opportunity and migrating to the urban growth centers for a living.

Therefore, a new drought-resistant paddy could offer hope to the farmers in the drought prone regions of Bangladesh, whose crops are being affected by increased level of drought.

While, Bangladesh is trying to increase rice production to meet rising domestic demand it is crucial to develop drought-tolerant variety that will give higher yield in upland areas with a little water.

H.5 Barriers

Financial Barrier

- Long term research investment is required for the development of drought tolerant rice variety
- High investment is required for demonstration and extension of this technology to the spreading this technology to the farmer level
- Reduced level of public sector investment for demonstration and extension of agricultural technology

Non- financial barrier

- Lack of skilled human resource for research and development in the public sector institutions
- Lack of policy decision for introducing new farming system with new rice verities in the drought prone areas.
- Lack of research capacities of the public research organizations for the development of resilient rice varieties e.g. drought tolerant rice varieties
- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Intellectual properties issues, especially patenting on the high yielding variety (HYV) and genetically modified (GM) variety
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Lack of suitability of the imported technology and variety in the local context
- Limited scope of field testing for environmental risk assessment and disease prevalence of the varieties imported by private sector
- Lack of social acceptance of the new technology
- Lack of efficiency of the seed certification authority
- Insufficient measures to monitor the quality of private sector seed and other agricultural inputs
- Cost of the input services e.g. seed, irrigation etc. for transfer and diffusion of the drought tolerant rice variety.

H.6 Benefits to economic / social and environmental development

- The northern part of the country is facing the slow onset of drought that is causing loss of rice crop production and forcing people to migrate in search of alternative livelihoods options.
- This technology will allow protect agriculture based small-holders livelihoods, reduce the number of unemployed people and protect increasing number of poverty affected people.

H.7 Costs

Capital Costs

Approx cost = Tk 2000.00 Lakh for research and development of new variety
Approx cost for experimentation of the performance new rice variety Tk 500 lakh

Total: Taka 2500 lakh ; (USD 3125000)

Operational and Maintenance costs

Approx cost of field experimentation and demonstration = Tk 500.00 lakh/ town
Development of dissemination packages and tools Tk 150 lakh
Approx cost of monitoring = Tk 150.00 lakh/ year

Total: Taka 800 lakh; (USD 1000000)

I. Name of technology: Development of short maturing rice varieties

I.1 Introduction

I.2 Technology characteristics

Agriculture/ Technology development and knowledge management

I.3 Country specific / applicability

- Development of improved rice variety
- Experimentation of performance in different soil salinity condition
- Field experimentation and demonstration
- Development of dissemination packages and tools
- Monitoring of variety suitability in different coastal regions

I.4 Status of technology in country

It has been observed that people of different agro-ecological zones have been experiencing new type of disaster event which they didn't face in the past, at the same time duration of disaster prevalence also has changed or shifted. Different disaster events that damage the standing crops, are:

a) Dense fog: damages seasonal crops and seedling beds.
b) Erratic rainfall: damages standing crops, seed beds and sometimes delays cultivation time due to lack of soil moisture content
c) Excess rainfall: damages standing crops, seed beds and sometimes delays cultivation period.
d) Monsoon flood: damages standing crops, seed beds
e) Storm and hail: damages standing crop resulting to household level food insecurity

Therefore, damages and loss of standing crops from these sudden disaster events could be avoided through replacing the crops with an early maturing variety.

I.5 Barriers

a) Financial Barrier

- Long term research investment is required for the development of short maturing rice variety
- High investment is required for demonstration and extension of this technology to the reaching this technology to the farmers level
- Reduced level of public sector investment for demonstration and extension of agricultural technology

b) Non- financial barrier

- Lack of skilled human resource for research and development in the public sector institutions
- Lack of policy decision for introducing new farming system with new rice verities in the flood and drought prone areas.

- Lack of research capacities of the public research organizations for the development of resilient rice varieties e.g. short maturing rice variety
- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Intellectual properties issues, especially patenting on the high yielding variety (HYV) and genetically modified (GM) variety
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Lack of suitability of the imported technology and variety in the local context
- Limited scope of field testing for environmental risk assessment and disease prevalence of the varieties imported by private sector
- Lack of social acceptance of the new technology
- Lack of efficiency of the seed certification authority
- Insufficient measures to monitor the quality of private sector seed and other agricultural inputs
- Cost of the input services e.g. seed, irrigation etc. for transfer and diffusion of the short maturing rice variety.

I.6 Benefits to economic / social and environmental development

- Introduction of this technology in the specific disaster-prone areas will save standing crops from these sudden disaster events.
- This technology will allow protect agriculture based small-holders livelihoods, reduce the number of unemployed people and protect increasing number of poverty affected people.

I.7 Costs

Capital Costs

Approx cost = Tk 2500.00 Lakh for research and development of new variety
Approx cost for experimentation of the performance new rice variety Tk 500 lakh/ town

Total: Taka 3000 lakh; (USD 3750000)

Operational and Maintenance costs

Approx cost of field experimentation and demonstration = Tk 500.00 lakh
Development of dissemination packages and tools Tk 250 lakh
Approx cost of monitoring = Tk 250.00 lakh/ year

Total: Taka 1000 lakh; (USD 1250000)

J. Name of technology: Training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.

J.1 Introduction

Both the extension and dissemination of technology will require training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.

J.2 Technology characteristics

Agriculture/ Technology development and knowledge management

J.3 Country specific / applicability

Extension and training activities are mainly carried out by government services and NGOs. NGOs provide their services more intensively, but they are generally localized. The government extension has a more extensive coverage, but its impact is less felt.
Thus, extension and training could apply community led and people centered approach like the training-of-trainers approach, farmer to farmer training, farmers' field school etc

J.4 Status of technology in country

The current practice of technology 'extension' and 'dissemination' is mostly top-down. Thus, it is important to make shift from the traditional and top-down dissemination approaches to learning approaches, which will (i) increase partnerships among appropriate stakeholder groups along with modifications or changes in rules/norms that enable working in partnership, (ii) make change in the perspective whereby the ultimate user is not the only beneficiary, but all the actors/organizations are beneficiaries – as learners - with their expectations/gains stated explicitly, and (iii) will increase and enable more and appropriate platforms for learning (say, facilitated capacity development exercises/experiments) in different contexts with location-specific partnerships to enable hands on learning, innovation and development.

J.5 Barriers

Financial barrier

- High operational and management cost for training material development and providing training
- Reduced level of public investment for the technology dissemination to the farmers level

Non- financial barrier

- Lack of skilled extension workers with technical knowhow on the improved farming practices
- Lack of collaboration and networking among the organizations responsible for agricultural extension services, irrigation and water management and soil fertility management

- Lack of government support and strong opposition from the local NGOs on the dissemination of high yielding variety (HYV) and genetically modified (GM) variety
- Farmers ignorance of the advanced farming practices

J.6 Benefits to economic / social and environmental development

- Farmer's capacity building on the production technology know how will increase rice production and will contribute to country's goal of attaining food security
- Will support addressing long-term impacts and variability, technologies in crop agriculture consistence with the predicted changes in climate system
- Promotion of appropriate adaptation technologies will optimize utilization of natural resource base
- Will reduce the risk of mal-adaptation
- Will support conservation of local level biological resources.

J.7 Costs

Capital Costs

Approx cost = Tk 1000.00 lakh for training material development

(USD 1250000)

Operational and Maintenance costs

Approx cost of community based group formation and training implementation = Tk 2000.00 lakh per year, Input support Tk 1000 lakh , Approx cost of monitoring = Tk 250.00 lakh per year

Total: Taka 3250 lakh; (USD 4062500)

K. Name of technology: Establishment of climate smart Agricultural Technology Dissemination Center

K.1 Introduction

The dissemination of new technology is an important factor determining the future of climate smart agriculture. Along with the development of innovative agriculture technology is is important to strengthen technology dissemination services so that the farmer is able to make use of the latest agricultural developments so that these serve a useful purpose to the end user. There is also a greater need for coordination between researchers and technology users. Thus, the institution that bridges the gap between farmers and agricultural research scientists is the Agricultural Technology Dissemination Center. This center will establish a formal management mechanism linking scientists or department in charges of different disciplines (though engaged in interdependent tasks) on the one hand to the technology users on the other

K.2 Technology characteristics

Agriculture/ Technology development and knowledge management

K.3 Country specific / applicability

The climate smart Agricultural Technology Dissemination Center will provide a 'single window' delivery system of the inputs and production technology available from an institution to the farmers and other interested groups. This Center also will facilitate farmer's access to the institutional resources available in terms of technology, advice, technology products, etc. and will provide mechanism for feedback from the users to the institute.

K.4 Status of technology in country

The establishment of an Agricultural Technology Dissemination Centre will provide such a mechanism beyond the individual unit of a research institution to contribute to the dissemination of the information and technical know-how of the climate smart agriculture technologies.

The main objective of Agriculture Technology Dissemination Center is to transmit latest technical know-how to farmers. Besides this, the Center also will focus on enhancing farmers' knowledge about crop techniques and helping them to increase productivity.

K.5 Barriers

Financial barrier

- High investment and operational cost for establishment of center

Non- financial barrier

- Lack of collaboration and networking among the organizations responsible for agricultural extension services
- Lack of technologies that can predict pest and disease and pest outbreak
- Inadequate technical knowhow of the extension workers on the advanced farming practices
- Social acceptance of the new technology and changing cropping pattern/ duration

K.6 Benefits to economic / social and environmental development

- This technology will facilitate farmers' access to the institutional resources available in terms of technology, advice, technology products,
- Development of farmers' technical know-how on the newly innovated technologies will increase production base, which will
  - ultimately increase on-farm employment opportunity and will reduce rural poverty.
  - also support addressing long-term impacts and variability, technologies in crop agriculture consistence with the predicted changes in climate system
- Dissemination of appropriate technologies will increase agricultural production base and will support conservation of local level biological resources.

K.7 Costs

Capital Costs

Approx cost = Tk 5000.00 Lakh for Center establishment
Approx cost = Tk 2500.00 Lakh for tools and appliances

Total: Taka 7500 lakh; (USD 9375000)

Operational and Maintenance costs

Approx cost of field experimentation and demonstration = Tk 500.00 lakh
Development of dissemination packages and tools Tk 250 lakh
Approx cost of HR and monitoring = Tk 250.00 lakh/year

Total: Taka 1000 lakh; (USD 1250000)

L Name of technology: Establishment of special agricultural R & D centre

L.1 Introduction

The agriculture sector is vulnerable due to both the primary effects (variation in rainfall and temperature) and secondary effects (drought, flood, cyclone and storm surge, saline intrusion etc) of climate change. In addition, climate change related phenomena such as variation in temperature and rainfall may enhance spread of pest attacks or crop diseases that affect crop production. In the changing climatic context, it is necessary to either modify or develop new agricultural (mainly crops) technologies and introduce them at the farmers level.

L.2 Technology characteristics

Agriculture/ Technology development and knowledge management

L.3 Country specific / applicability

- Research on the development of context specific or climate-resilient crop production technologies
- Identify technological needs for sustainable agricultural production in different stress conditions caused by climate change.
- Establish a smooth institutional and coordination mechanisms of all the existing agricultural research institutions in country and abroad to consolidate all agricultural success stories on adaptation technologies in government, non-government and private initiatives.
- Conduct agricultural and food security related policy research.

L.4 Status of technology in country

The available technologies in crop agriculture are likely to address current climate variability. To address the long-term impacts and variability, technologies in crop agriculture have to be consistence with the predicted changes in climate system.

Meantime, a number of policy and institutional initiatives have been taken on sustainable agriculture technologies and management in order to change from traditional to context specific or climate resilient practices. For instance, the International Rice Research Institute (IRRI), International Center for Agriculture in the Dry Land Areas (ICARDA), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), International Food Policy Research Institute (IFPRI), International Institute of Tropical Agriculture (IITA) etc. are putting efforts into facilitating increases in productivity and resilience in crop agriculture through technological innovation.

Aside with the international effort, it is equally important to strengthen national effort on research and development of climate resilience crop varieties and farming system.
This special research and development (R & D) center will develop adaptation technologies that are environmentally sustainable, culturally compatible, socially acceptable, economically feasible and technically viable.

L.5 Barriers

Financial Barrier

- Lack of long-term and predicted funds for research for climate change resilient agricultural technology development, transfer and diffusion
- High investment is required for demonstration and extension of this technology to reaching this technology to the farmers
- Reduced level of public sector investment for research and development of agricultural technology

Non -financial Barrier

- Lack of collaboration and networking among the organizations responsible for agricultural research and development
- Limited and fragmented research networks
- Lack of skilled human resource for research and development in the public sector institutions
- Lack of high quality tools for agronomic research
- Lack of biological database e.g. genetic bank of local indigenous economic crops that can be used for developing new varieties
- Inadequate technical knowhow of the extension workers on the advanced farming practices
- Lack of pest and disease database
- Lack of social acceptance of the new technology and changing cropping pattern/ duration

L.6 Benefits to economic / social and environmental development

- Will expand agriculture based employment opportunity
- Will reduce joblessness of small farm holders and agricultural labors.
- Research and development in agriculture will increase rice production and will contribute to country's goal of attaining food security
- Will support addressing long-term impacts and variability, technologies in crop agriculture consistence with the predicted changes in climate system
- Appropriate adaptation technologies will optimize utilization of natural resource base
- Will support conservation of local level biological resources.

LJ.7 Costs

Capital Costs

Approx cost = Tk 3000.00 Lakh for Center establishment
Approx cost = Tk 2000.00 Lakh for tools and appliances

Total: Taka 5000 lakh; (USD 6250000)

Operational and Maintenance costs

Approx cost of field experimentation and demonstration = Tk 1000.00 lakh/ year
Development of dissemination packages and tools Tk 250 lakh
Approx cost of HR = Tk 250.00 lakh/ year

Total: Taka 1500 lakh; (USD 187500)

M. Name of Technology: Land use planning

M.1 Introduction

Land-use planning refers to the process by which land is allocated between competing and sometimes conflicting uses in order to secure the rational and orderly development of land in an environmentally sound manner to ensure the creation of sustainable human settlements. In Bangladesh, due to not having land-use planning, agricultural lands are often been encroached for residential development, pockets of farmland remain between residential communities. On the other hand, in the coastal areas the agricultural lands, even the coastal swaps and mangrove areas are often converted to shrimp farms. Rapid extension of such shrimp farms are destroying environmental sustainability through increasing soil and surface water salinity and destroying aquatic and terrestrial bio-diversity.

M.2 Technology characteristics

Agriculture/ Technology development and knowledge management

M.3 Country specific / applicability

Land-use planning should be considered as an integral part of the process of national growth and development. Among other things, this process seeks to identify, articulate and satisfy the basic social/human needs of a country's population within the context of available economic/financial resources and technical knowledge

M.4 Status of technology in country

Conversion of agricultural land to residential use removes fertile land from productive agriculture; splits large tracts of agricultural land, thereby reducing its potential for viable farming; and restricts the use of certain production methods etc.

In the absence of a land-use policy that reserves specific areas for agriculture, shrimp farms, housing and other commercial activities, it is likely that development control decisions will continue to alienate productive agricultural lands; compromise the economic and financial

viability of the agriculture sector; and inadvertently increase the possibility of unsustainable development practices in the long run

M.5 Barriers

Financial barrier

- High investment and operational cost

Non-financial barrier

- Lack of skilled personnel in GIS based planning
- Limited application of GIS and remote sensing technologies
- Lack of policies in land zoning and utilization

M.6 Benefits to economic / social and environmental development

Land use planning will serve as an important regulation of land use in an efficient and ethical way, thus preventing land-use conflicts

M.7 Costs

Capital costs:

Approx cost = Tk 2000.00 Lakh for the development of land use planning

Policy analysis of other development activities Tk 200.00 lakh

Total: Taka 2200 lakh ; (USD 2750000)

Operational and Maintenance costs

Approx cost of policy advocacy and awareness raising Tk 250.00 lakh

Total: Taka 250 lakh; (USD 312500)

Annex II. Market maps for Technologies

The market map of consumer goods has been done to conceptualize, visually represent and communicate knowledge about the entire commercial and institutional environment, in which specific market chains of specific technology operates. In this exercise, stakeholders and experts discussed and exchanged information to build up a comprehensive picture of the entire existing system, while they consider following aspects:

Relating to market demand:
- Consumption trends (prices, volumes and quality expectations)
- Taxes, subsidies and tariff regimes

Relating to transformation activities, i.e., the costs of doing business:
- Infrastructure constraints and investment policies
- Transport policies and licensing
- Technological development
- Trade regime (import/export)

Relating to transaction activities:
- Systems of finance
- Registration of land and property
- Legal requirements for contracts
- Commercial law and practices
- Business licenses and regulation
- Standards quality control and enforcement

The relevant other factors that also are considered include:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational)
- The relevant objects in the system (such as producers, wholesalers, retail dealers, consumers, households producer)
- Supporting services (such as finance, quality management, performance, standard, etc.)

The market mapping is only applied for technologies which are classified by consumer and capital goods. In mitigation technologies, there are three technologies of consumer goods category; they are Salinity Tolerant Rice Variety, Drought Tolerant Rice Variety and Short Maturing Rice Variety.

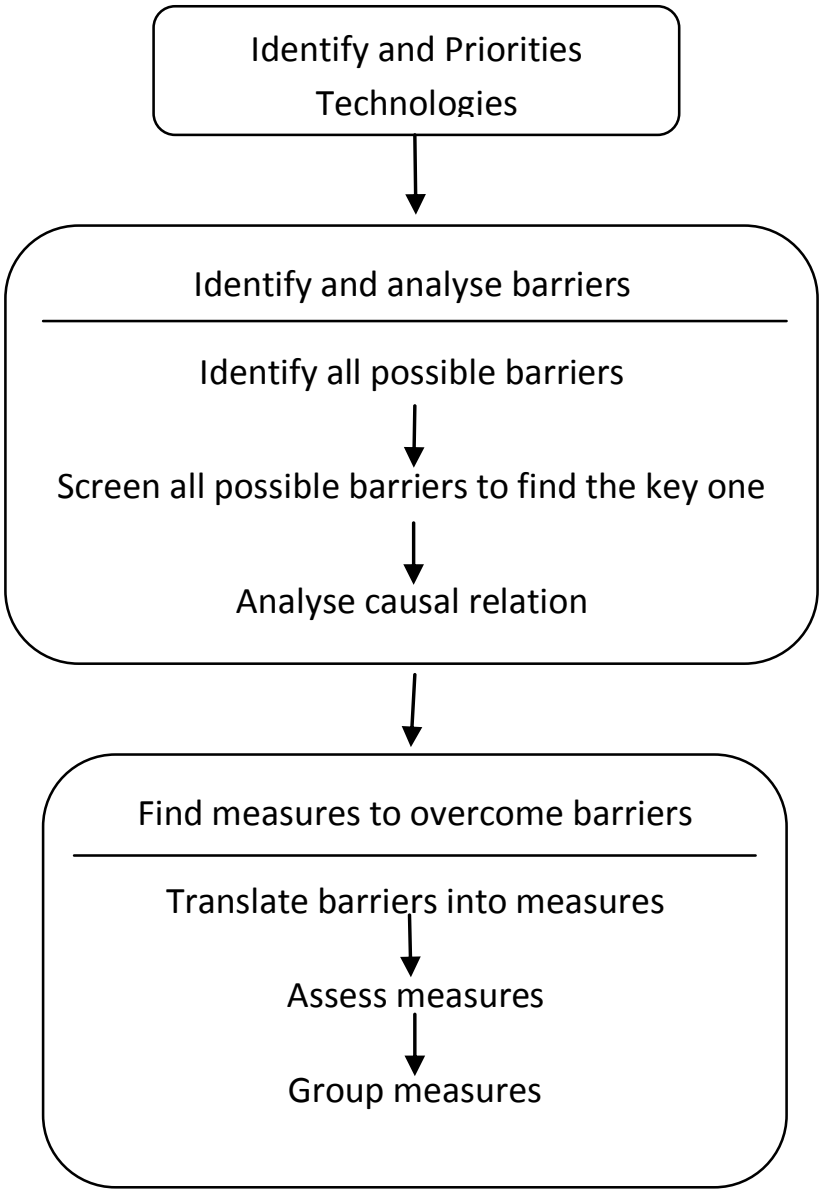
For all three technologies, the market chain includes variety development/ seed production; dealer/whole seller; retailers and consumers/farmers. In the market chain, the factors that influences transfer and diffusion of this new technology includes prices, effect, benefit, quality standards, capital cost etc. Price is a common concern to the dealer, retailers and even to the farmers. If the price is too high compared with the benefits it brings, they will think a lot before buying. Therefore, high price can be considered as a barrier during the transfer and diffusion of this technology.

There are also several measures to overcome the barrier such as incentives to seed marketing, demonstration of the new technology, training and capacity building, subsidies, provision of soft loan etc. that could reduce products price and encourage farmers to adopt and replicate the new

technology. Ensuring support and input services are also major important factors for diffusion and transfer of technologies. Besides affordable price factor, the farmers also consider seed quality and standard. To maintain and upscale product quality research, development, international cooperation is required.

Specific market map for all three technologies is presented below.

On the other maps for transfer and diffusion of capital goods of other adaptation technologies has been done following two processes: Identifying and analyzing barriers process and measures to overcome barriers process, which has given in the following figure:



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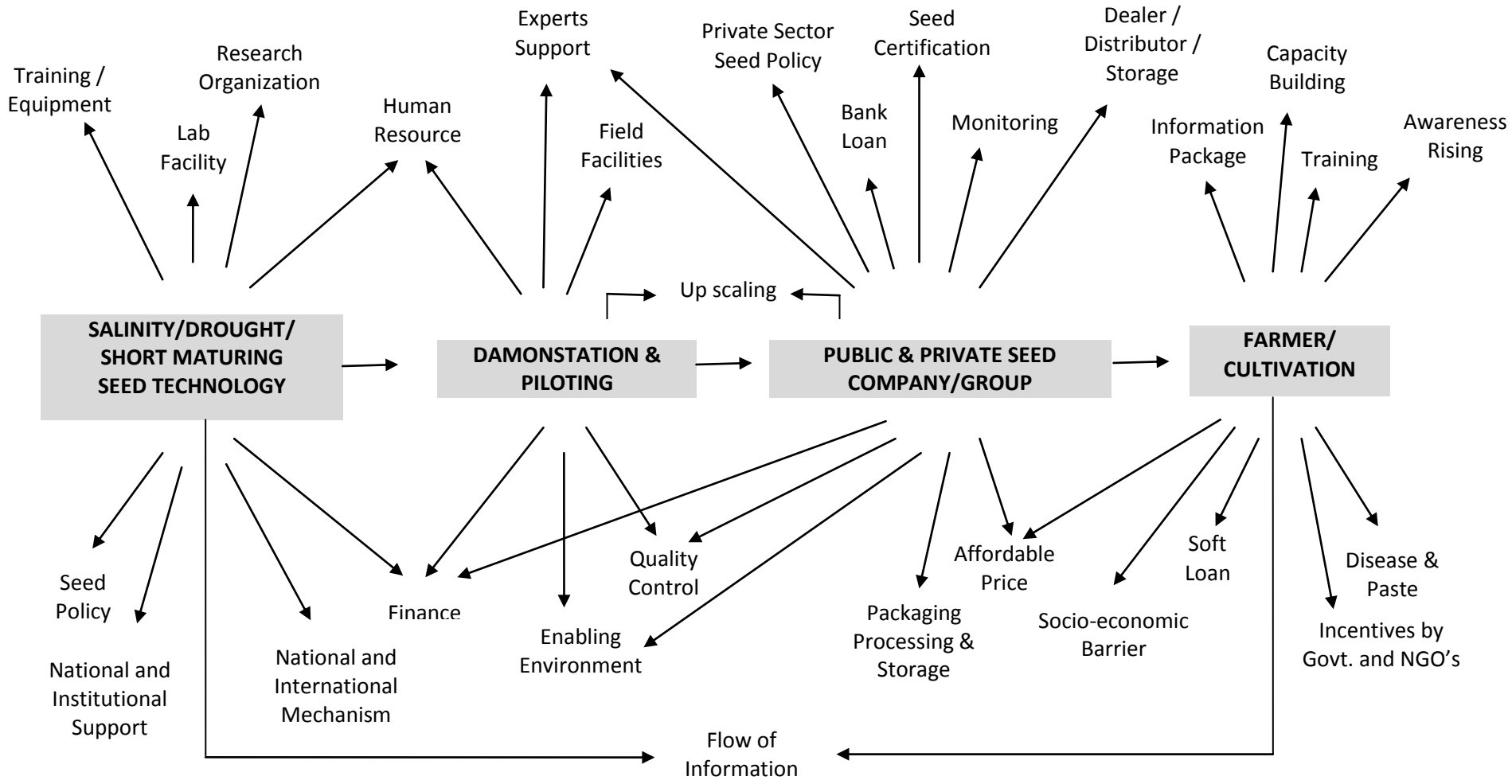

Figure:2 Market map of Salinity Tolerant/ Drought Tolerant/ Short Maturing Rice Variety Technology

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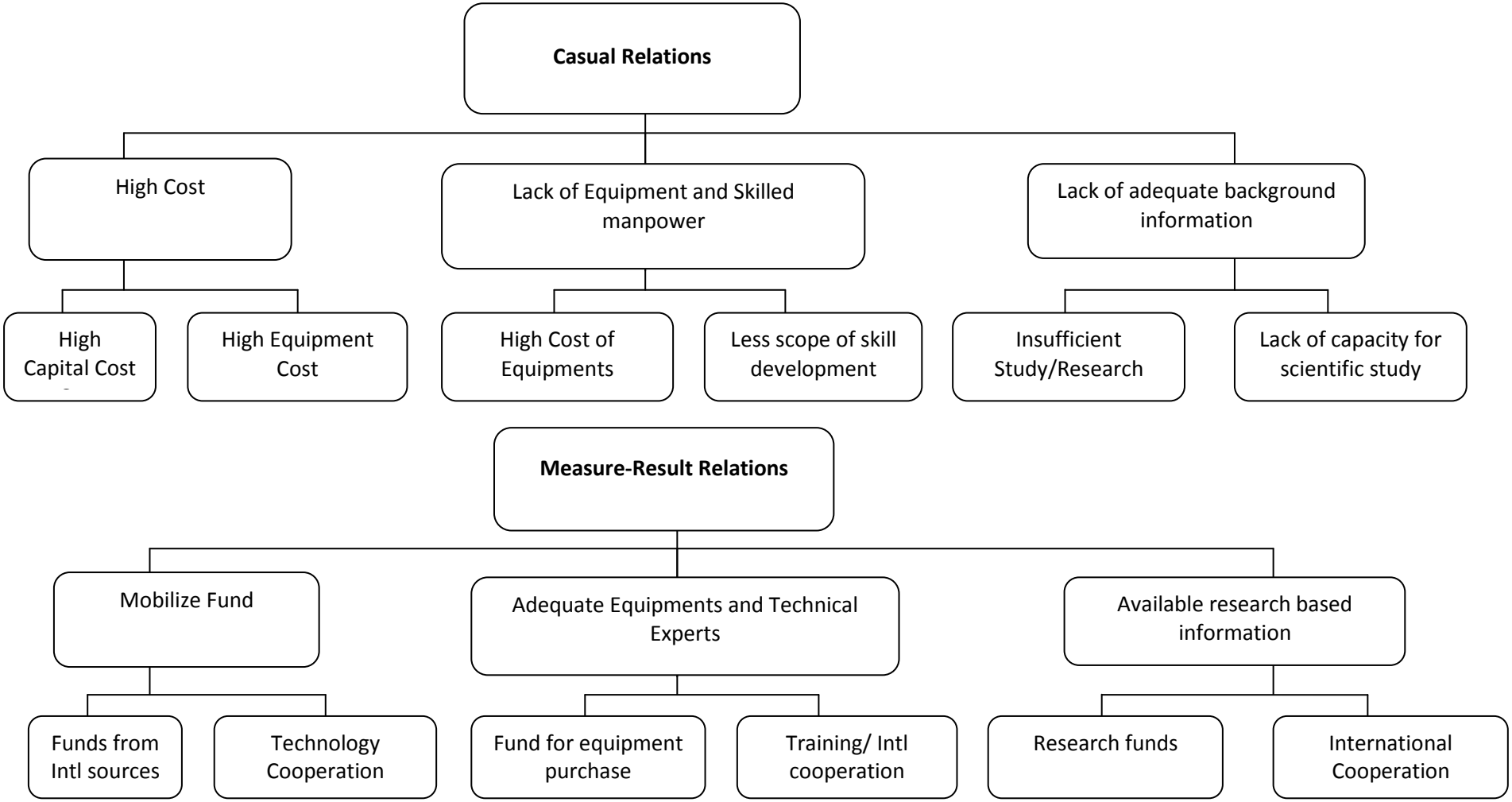

Figure:3 Analysis of framework condition for transfer and diffusion of *Rehabilitation of existing Embankments/ dykes and dredging Technology*

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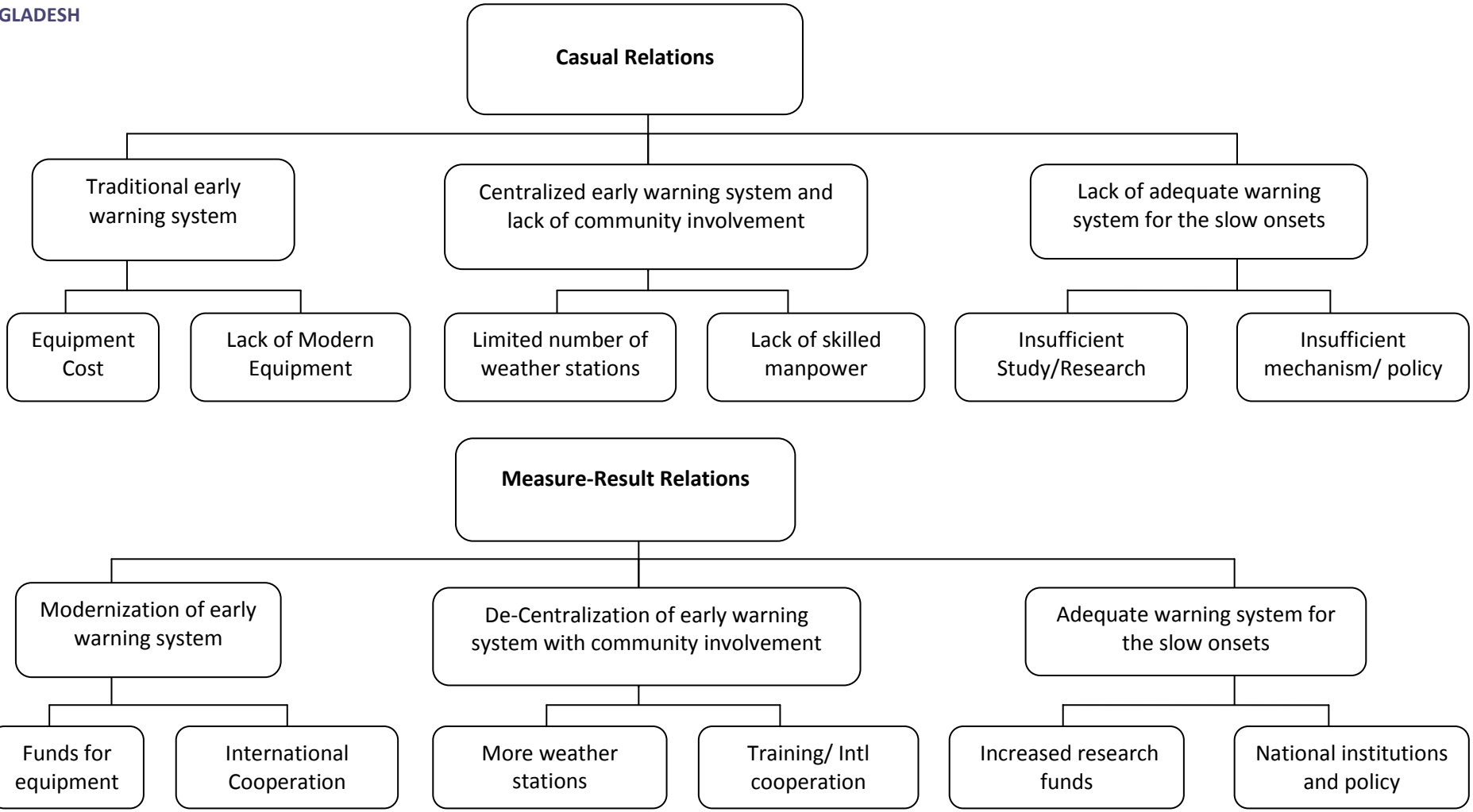

Figure: 4 Analysis of framework condition for transfer and diffusion of Comprehensive disaster management incorporating early warning systems and involving community

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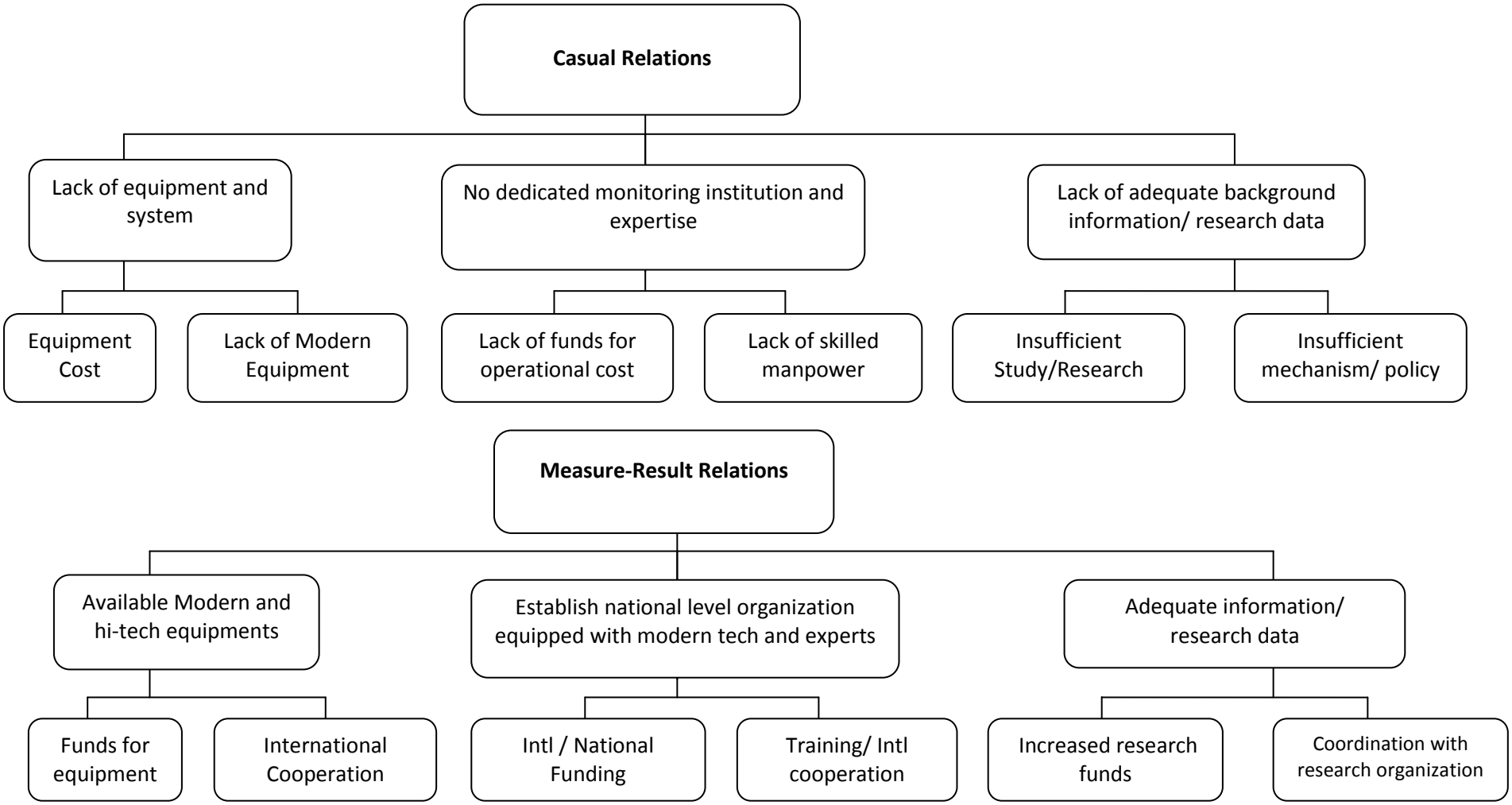

Figure: 5 Analysis of framework condition for transfer and diffusion of *Monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion*

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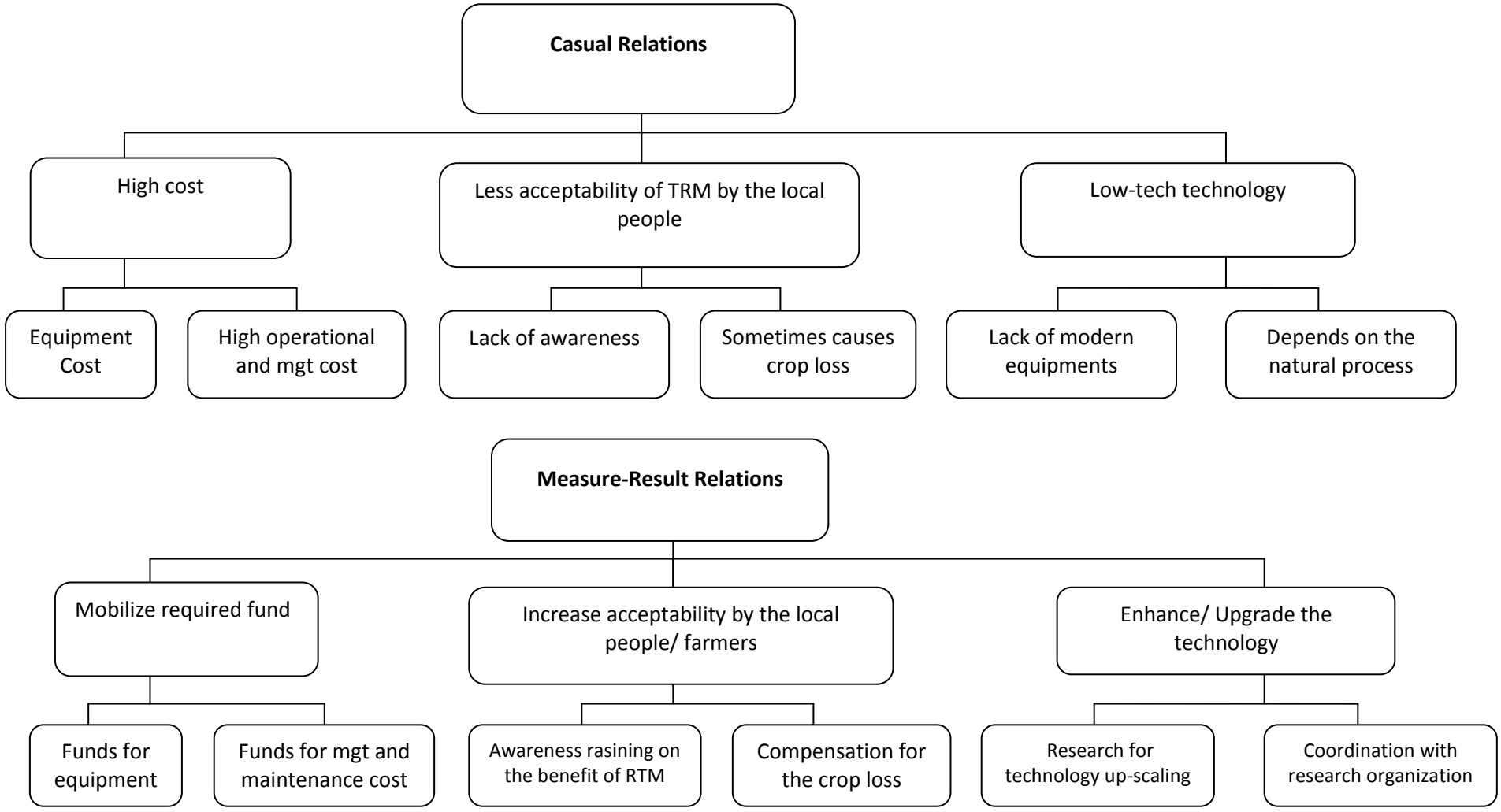

Figure: 6 Analysis of framework condition for transfer and diffusion *Tidal river management including Computer simulation of tidal flow*

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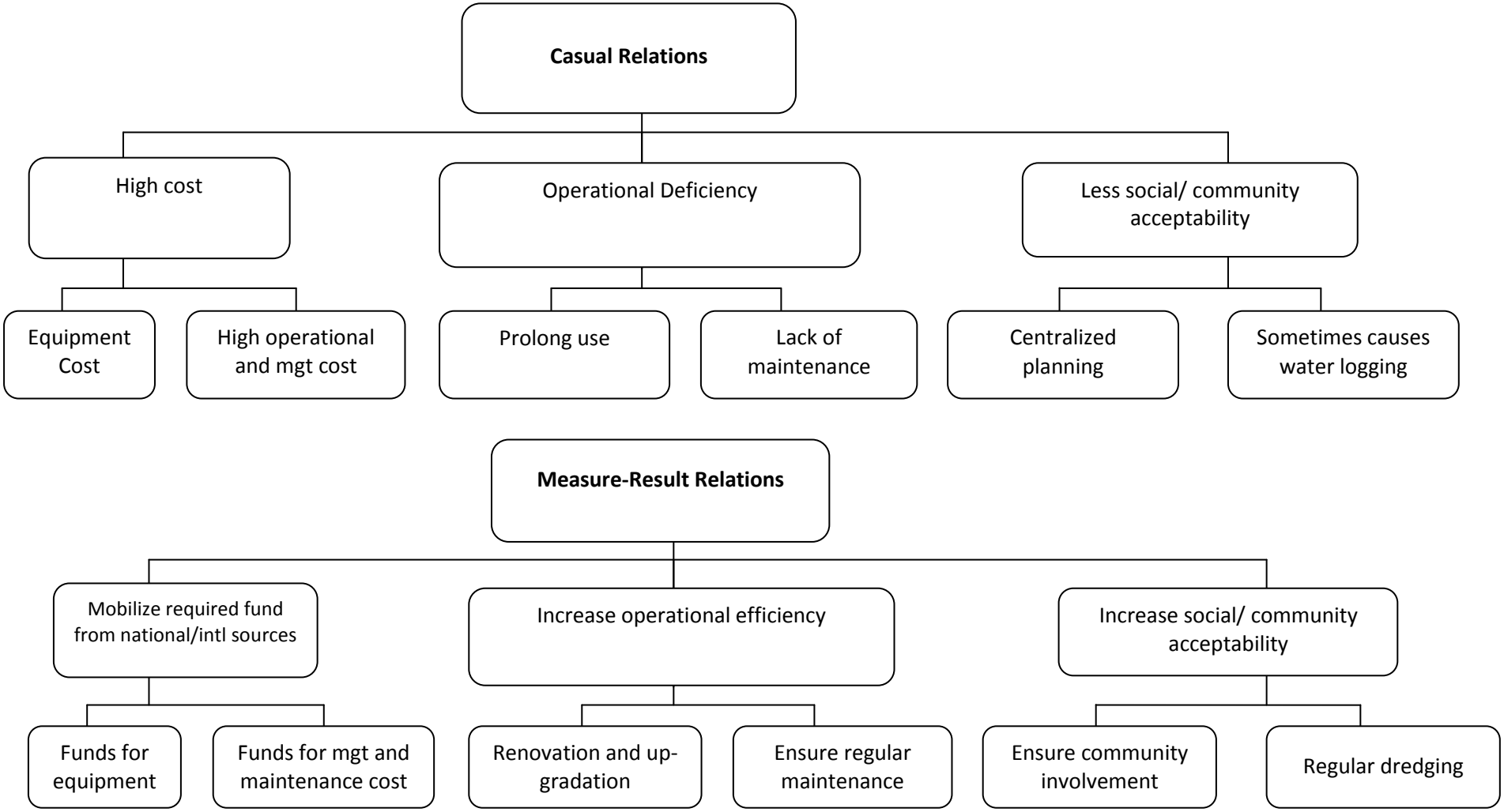

Figure: 7 Analysis of framework condition for transfer and diffusion of Tidal barriers (Sluice gates) Technology

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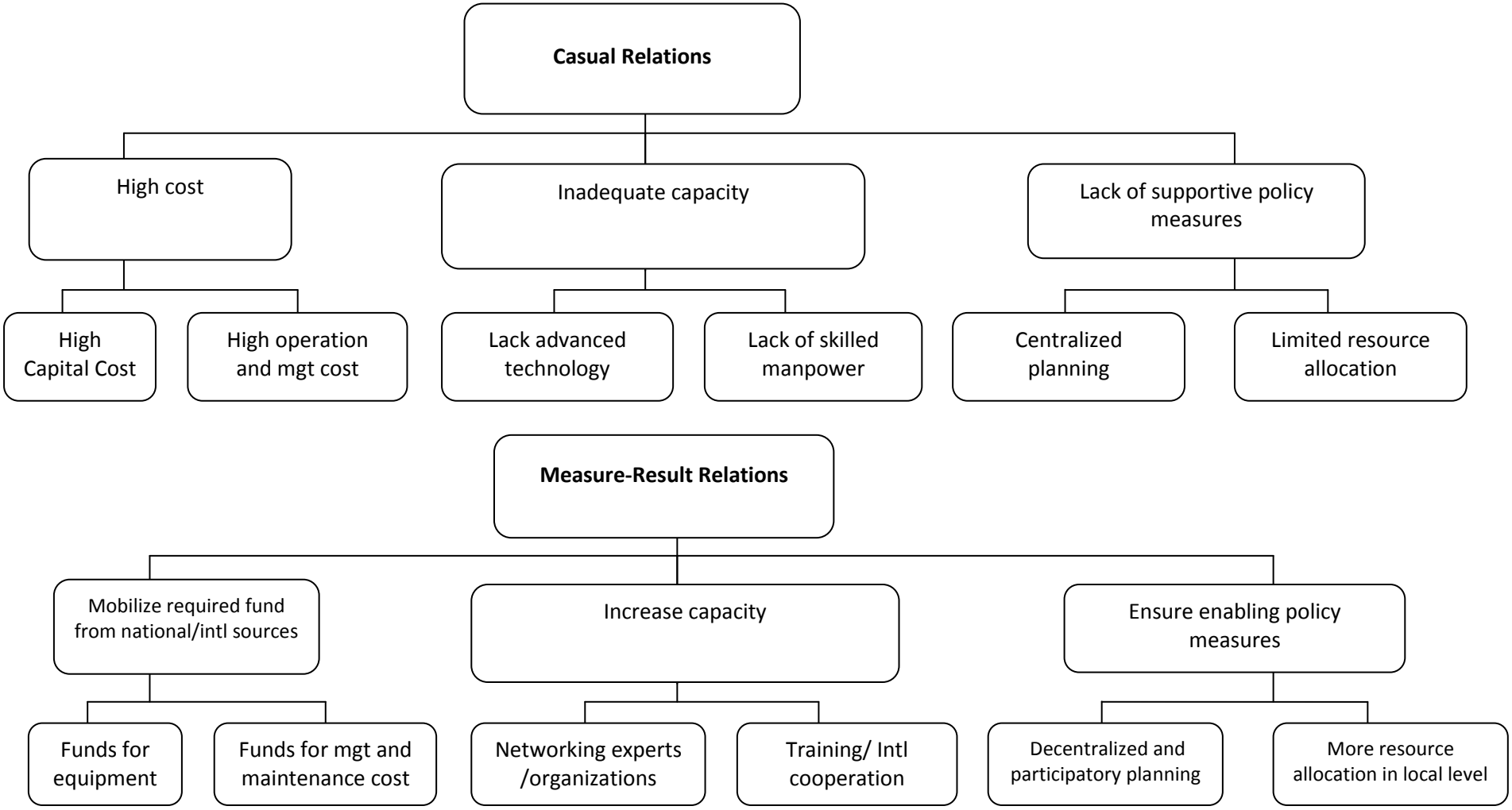

Figure: 8 Analysis of framework condition for transfer and diffusion of *Urban Infrastructure development technology*

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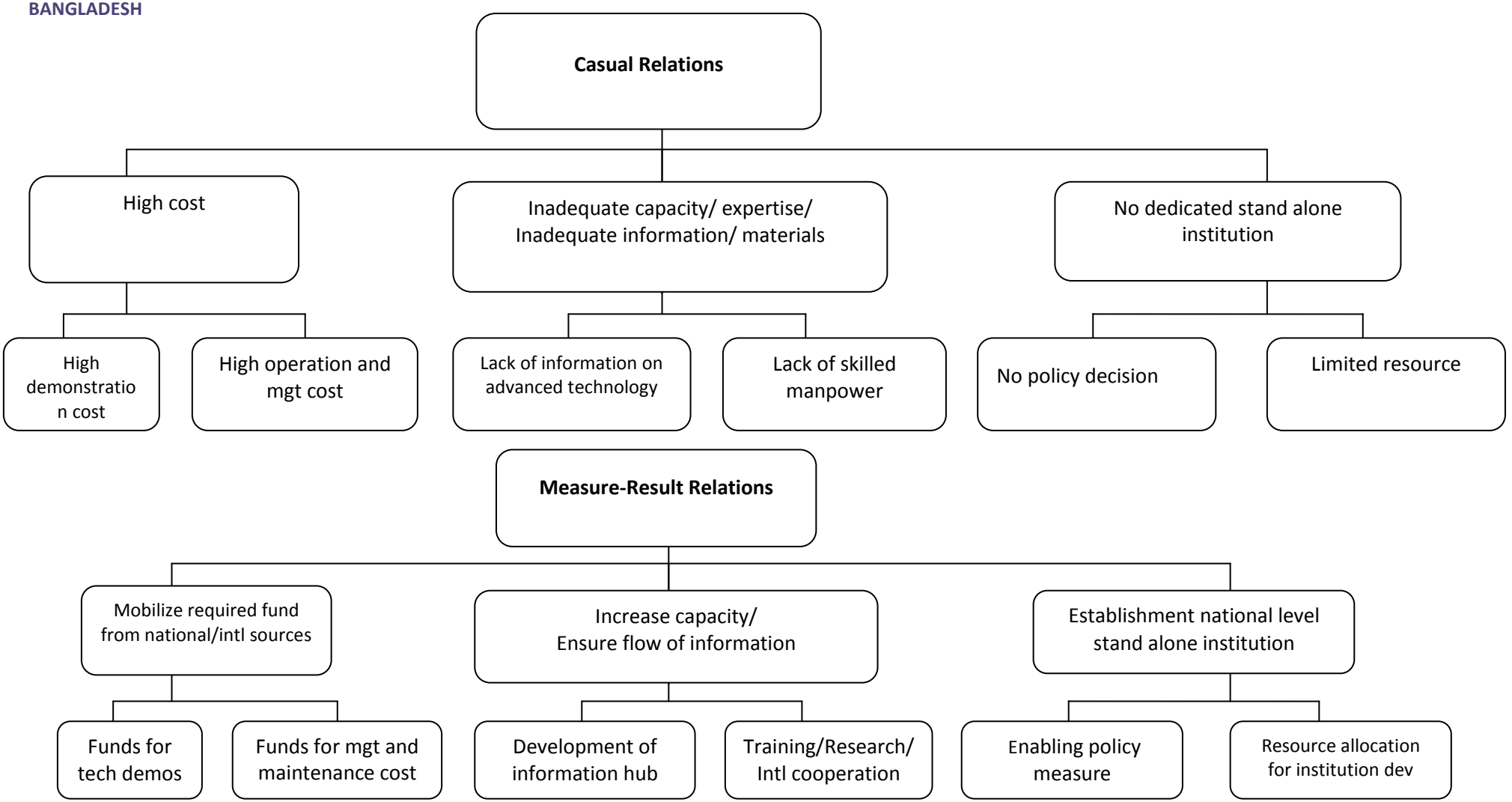

Figure: 9 Analysis of framework condition for transfer and diffusion of training on improved farming practices for crops, irrigation and water management, soil fertility management (conservation and restoration of soil quality) etc.

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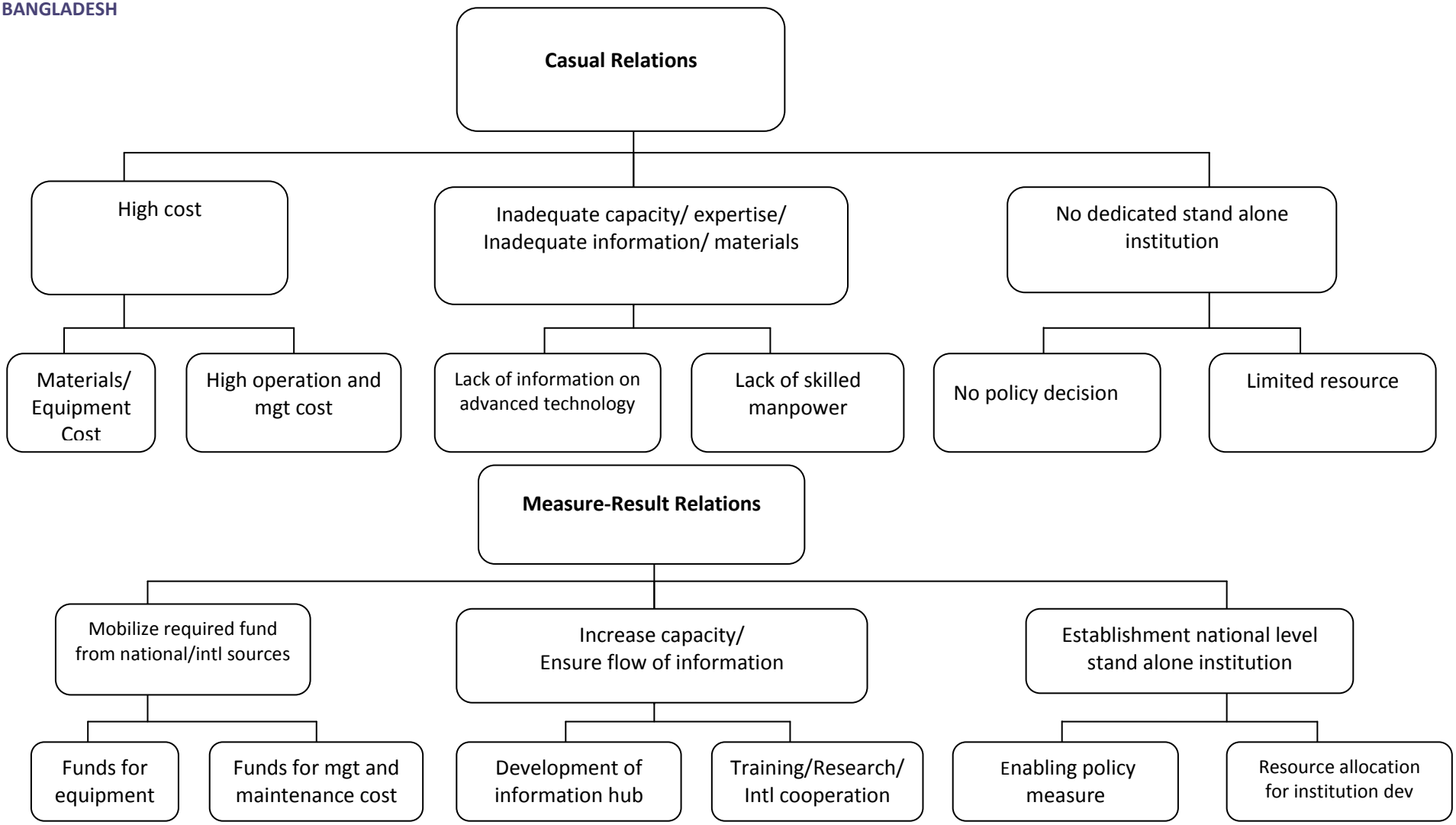

Figure: 10 Analysis of framework condition for transfer and diffusion climate smart Agriculture Technology Dissemination Center

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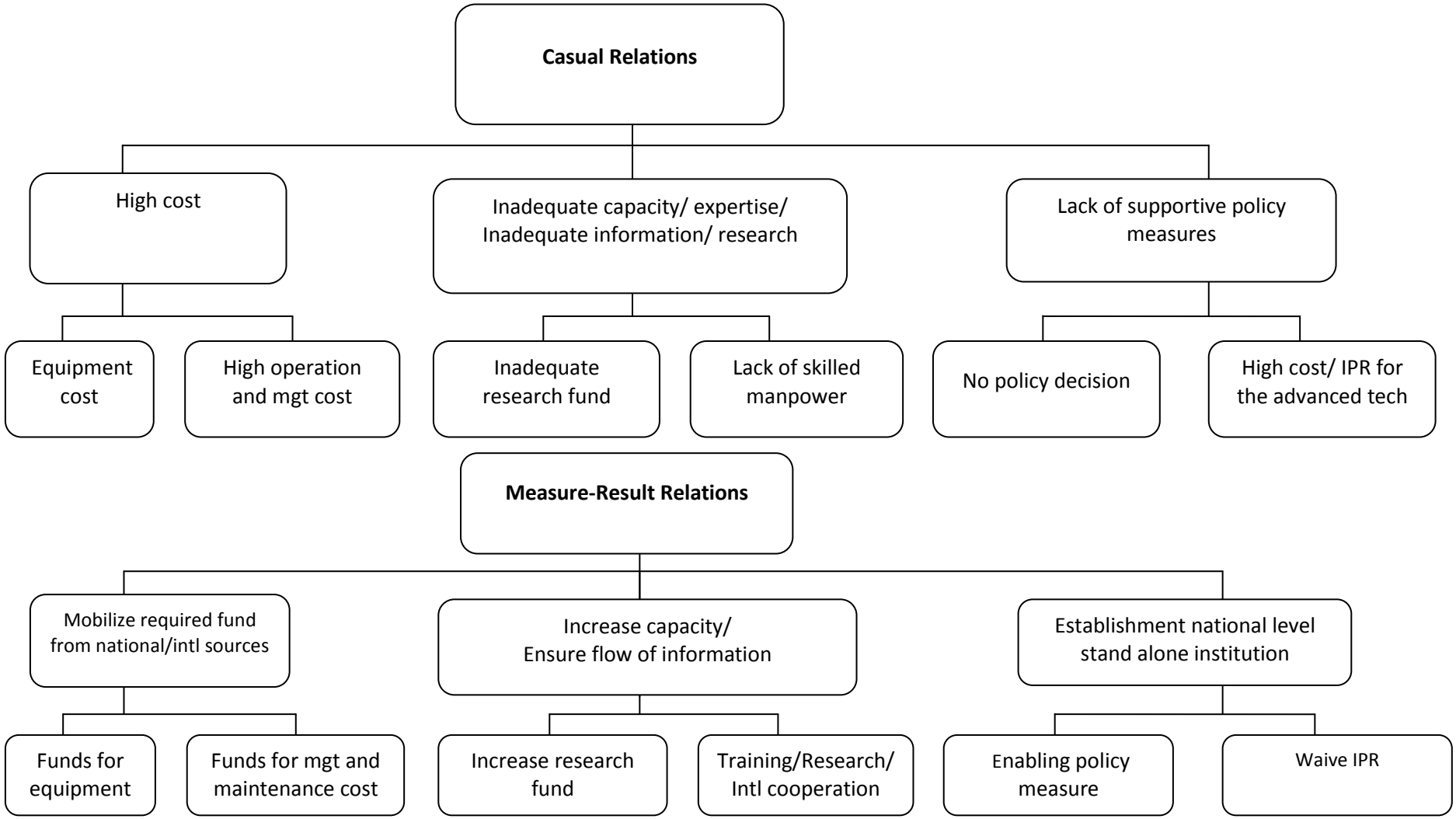

Figure: 11 Analysis of framework condition for transfer and diffusion special agricultural R & D centre

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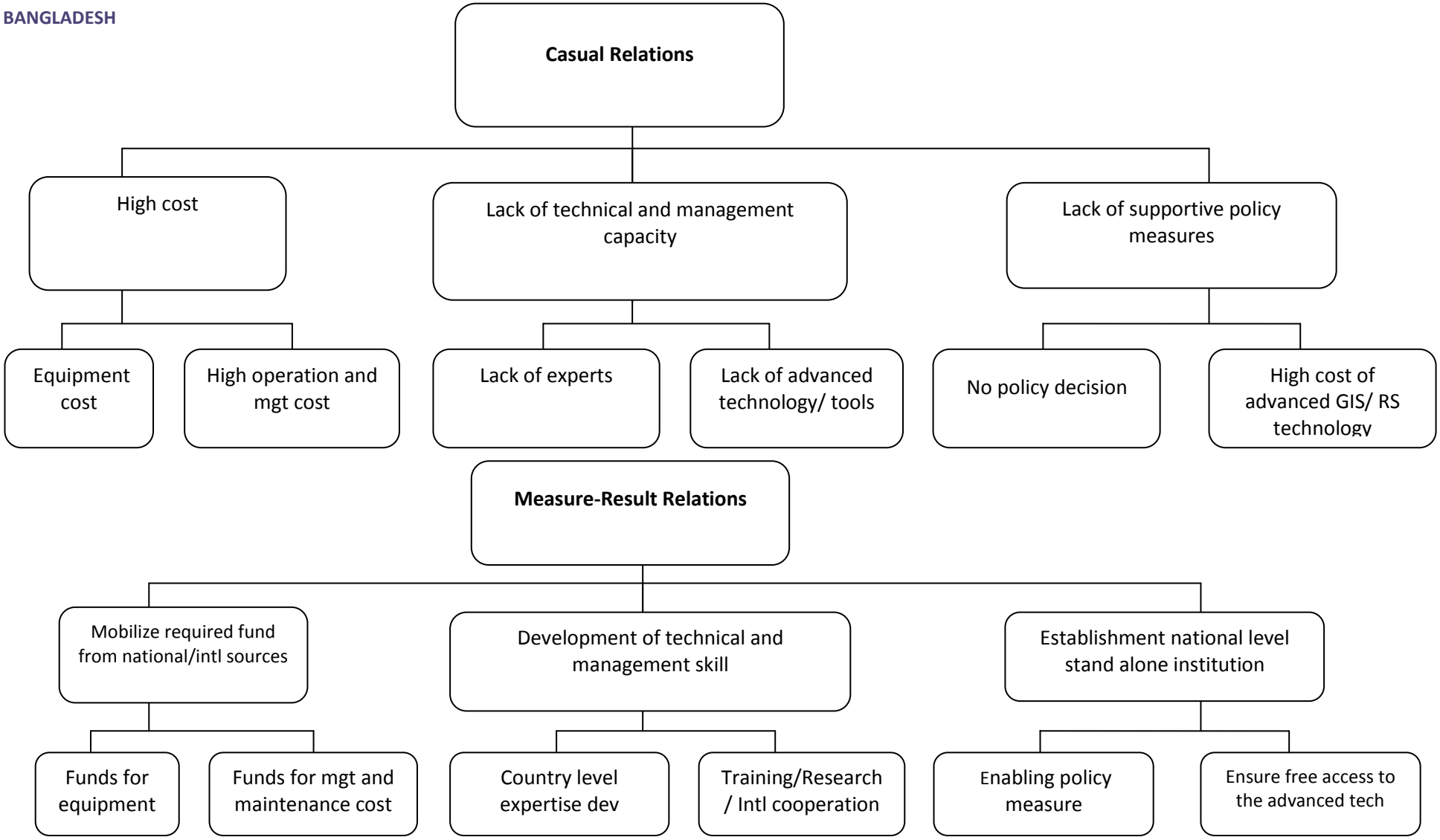

Figure: 12 Analysis of framework condition for transfer and diffusion of Land use planning technology

Annex III. Project Ideas

Project Idea for Water Sector Technology

A.1 Project Title:

Tidal river management including computer simulation of tidal flow

A.2 Introduction/Background (Briefly describe the project and how it developed):

Construction of peripheral embankment along the banks of the coastal rivers under Coastal Embankment Project (CEP) has prevented intrusion of silt laden saline water into the poldered area. Moreover, upstream flow of these rivers reduced drastically due to construction and operation of Farakka Barrage. As a result silt coming up with saline water during high tide in dry season being deposited in the river bed starting from the downstream of the sluice gates. This is the identified main reason of drainage congestion/ water logging in the coastal polders. The solution to this problem is the operation of Tidal River Management (TRM) using indigenous method with medium and long term program

A.3 Purpose and Objectives of the project

Major objectives are:

- Operationalization of Tidal River Management (TRM) using indigenous method with medium and long- term programme
- Medium and long-term indigenous and modern technology though improved planning, design, construction and gate improvement

A.4 Relationship to the country's sustainable development priorities:

Country social development priorities:

- Will provide healthy, economic and agricultural productive environment.
- Will provide early cropping in greater areas

Country economic development priorities:

- Will increase agricultural productivity, which will contribute to the country's goal of attaining food security.
- Will reduce economic loss caused by weather extreme events

Country environmental development priorities

- Will reduce siltation process. Will increase river cross section by bed erosion and will increase tidal prism.
- Will reduce drainage congestion / water logging.
- Will increase ground level of the TRM basin.
- Will provide quick drainage
- Will increase operating efficiency

A.5 Project Deliverables e.g. Value/Benefits/Messages:

TRM has the benefits of (i) reducing siltation in the river, increasing drainage capacity and tidal prism, (ii) reducing drainage congestion / water logging within the polder and peripheral rivers, (iii) increasing ground level of the TRM basin, (iv) providing quick drainage and (v) increasing operating efficiency.

A.6 Project Scope and Possible Implementation:

During the 60's and '70s, 123 polders of varying sizes and extending up to 100 km inland were constructed to protect low lying coastal areas against tidal flood and salinity intrusion. These polders, of which forty-nine are sea-facing, provide a first line of defense for millions of people in the coastal belt. All these polders are not functioning the way these were intended due to siltation in the river bed causing water logging with loss of agricultural production. These problems are being addressed by introducing an age-old approach that is practiced in the Netherlands, the Tidal River Management (TRM) to take advantage of the natural tide movement in rivers to address the drainage problems in the polders. During flood tide, the tide is allowed to enter into an embanked low-lying area (tidal basin) where the sediment carried in by flood tide is deposited. During ebb tide, water flows out of the tidal basin with greatly reduced sediment load and eventually erodes the downstream river bed. The natural movement of flood and ebb tide along the tidal basin and along the downstream river maintains a proper drainage capacity in that river.

A.7 Timelines (What are the timelines e.g. one quarter, one year, multiple years?):

Multiple Years

A.8 Budget/Resource requirements (What is the budget? How is the project to be funded? (Staff, Engage consultants, partnership, etc.) :

A.9 Capital Costs:

- Approx cost = Tk 50.00 lakhs/ polder
- Approx cost model simulation = Tk 25.00 lakhs/ polder
- Approx cost of TRM operation = Tk 1200 lakhs/ TRM basin
- New sluices: TK 100.00 lakhs per vent

Total: Taka 1375 lakh/ TRM basin; (USD 1718750)

Operational and Maintenance Costs:

- Rehabilitation / repair of sluice gate = Tk 25 lakh /per vent(Approx)
- Approx planning and design cost = Tk 30 Lakhs
- Approx cost for installation of up-graded gates & hoists= Tk 3.0 lakhs/ no

Total: Taka 58 lakh; (USD 72500)

A.9. Measurement/Evaluation (What tangible evaluation of accomplishments are there?):

Solving of water logging problem in the polder areas.

A.10 Possible Complications/Challenges (What are the potential challenges and complications?):

TRM is already being used in a number of polders in Bangladesh. But it has to be improved to respond to some of the issues such as acceptability of TRM by the local communities. The economic, technical and environmental barriers those are indentified in the transfer and diffusion of technology related to Tidal river management including Computer simulation of tidal flow includes;

- Acceptability of the TRM by the local land owners poses to be a major obstacle.
- Further technological improvement for effective sediment deposition in the tidal basin to increase acceptability by the land owners.
- Lack of dealing with the problem with the polders as a whole instead of individually as an alternative to the present problem of water-logging.

A.11 Responsibilities and Coordination

- The Ministry of Water Resources
- Ministry of Fisheries and Livestock
- Ministry of Environment and Forests
- Local Government Engineering Department
- Bangladesh Water Development Board (BWDB)
- Water Resource Planning Organisation (WARPO)
- River Research Institute (RRI)
- Bangladesh Haor and Wetland Development Board (BHWDB)
- Institute of Water Modeling for mathematical water modeling (IWM)
- Center for Environmental and Geographic Information Services (CEGIS)

Project Idea for Agriculture Sector Technology

B.1 Project Title:

Establishment of special agricultural R & D centre

B.2 Introduction/Background (Briefly describe the project and how it developed) :

The agriculture sector is vulnerable due to both the primary effects (variation in rainfall and temperature) and secondary effects (drought, flood, cyclone and storm surge, saline intrusion etc) of climate change. In addition, climate change related phenomena such as variation in temperature and rainfall may enhance spread of pest attacks or crop diseases that affect crop production. In the changing climatic context, it is necessary to either modify or develop new agricultural (mainly crops) technologies and introduce them at the farmers level.

The available technologies in crop agriculture are likely to address current climate variability. To address the long-term impacts and variability, technologies in crop agriculture have to be consistence with the predicted changes in climate system.

Aside with the international effort, it is equally important to strengthen national effort on research and development of climate resilience crop varieties and farming system.

B.3 Purpose and Objectives:

Main objectives of the projects are:

- Research on the development of context specific or climate resilient crop production technologies
- Identify the technological needs for sustainable agricultural production in different stress conditions caused by climate change.
- Establish a smooth institutional and coordination mechanisms of all the existing agricultural research institutions in country and abroad to consolidate all agricultural success stories on adaptation technologies in government, non-government and private initiative
- Conduct agricultural and food security related policy research.

C.3 Relationship to the country's sustainable development priorities

Country social development priorities

- Will expand agriculture based employment opportunity
- Will reduce joblessness of small farm holders and agricultural labors.
- Will contribute to country's goal of expanding farm based income and rural poverty eradication

Country economic development priorities

- Will increase rice production and will contribute to country's goal of attaining food security
- Will support addressing long-term impacts and variability, technologies in crop agriculture consistence with the predicted changes in climate system

Country environmental development priorities

- Development of appropriate adaptation technologies will optimize utilization of natural resource base
- Will support conservation of local level biological resources

C.4 Project Deliverables:

This special research and development (R & D) center will develop adaptation technologies that are environmentally sustainable, culturally compatible, socially acceptable, economically feasible and technically viable.

C.5 Project Scope and Possible Implementation

The major scopes under the project are:

- Development of context specific or climate resilient crop production technologies through research
- Identification of technological needs for sustainable agricultural production in different stress conditions caused by climate change.
- Establishment of smooth institutional and coordination mechanisms of all the existing agricultural research institutions in country and abroad.
- Agricultural and food security related policy research

C.6 Timelines (What are the timelines e.g. one quarter, one year, multiple years?) :

Multiple Years

C.7 Budget/Resource requirements (What is the budget? How is the project to be funded? (Staff, Engage consultants, partnership, etc.) :

Capital Costs:

- Approx cost = Tk 3000.00 Lakh for Center establishment
- Approx cost = Tk 2000.00 Lakh for tools and appliances

Total: Taka 5000 lakh; (USD 6250000)

Operational and maintenance costs:

- Approx cost of field experimentation and demonstration = Tk 1000.00 lakh/ year
- Development of dissemination packages and tools Tk 250 lakh
- Approx cost of HR = Tk 250.00 lakh/ year

Total: Taka 1500 lakh; (USD 187500)

C.8 Measurement/Evaluation (What tangible evaluation of accomplishments are there?):

Development and extension of climate change resilient crop varieties

C.9 Possible Complications/Challenges (What are the potential challenges and complications?):

Possible challenges are

- High investment and operational cost for research activities
- Lack of skilled personnel in the field of agricultural research

C.10 Responsibilities and Coordination (Who does what, when and how?):

Ministry of Agriculture

- Bangladesh Agricultural Research Council (BARC)
- Department of Agricultural Extension (DAE)
- Department of Agricultural Marketing (DAM)
- Agriculture Information Service (AIS)
- Seed Certification Agency (SCA)
- Bangladesh Agricultural Development Corporation (BADC)
- Barind Multi Purpose Development Authority
- Bangladesh Agricultural Research Institute (BARRI)
- Soil Resources Development Institute (SRDI)
- Bangladesh Jute Research Institute (BJRI)
- Bangladesh Institute of Nuclear Agriculture (BINA)
- Bangladesh Sugarcane Research Institute (BSRI)
- Central Extension Resources Development Institute (CERDI)
- Horticulture and Export Foundation (HEF)

Ministry of Environment and Forests

- Department of Environment
- Department of Forest
- Climate Change Trust

Ministry of Fisheries and Livestock

- Department of Fisheries
- Department of Livestock Services
- Bangladesh Fisheries Research Institute
- Bangladesh Livestock Research Institute

Ministry of Water Resources

- Bangladesh Water Development Board
- Water Resource Planning Organisation (WARPO)
- River Research Institute (RRI)
- Bangladesh Haor and Wetland Development Board (BHWDB)
- Institute of Water Modeling for mathematical water modeling (IWM)
- Center for Environmental and Geographic Information Services (CEGIS)

Ministry of Finance

Note: The BCCSAP has provided strategic elaboration of adaptation measures in Bangladesh for the next 10 years

Annex IV. List of stakeholders involved and their contacts

List of stakeholders: Water Sector

NAME	ORGANIZATION
Mr. Aparup Chowdhury	Joint Secretary (Env.) Ministry of Environment and Forests Government of the People's Republic of Bangladesh Building # 6, Level # 13 Bangladesh Secretariat, Dhaka
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Dr. KB Sajjadur Rashid	Retired Professor, University of Dhaka Dhaka, Bangladesh
Dr. Rezaur Rahman	Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh
Dr Fazle Rabbi Sadek Ahmed	Director- Climate Change Department of Environment Agargaon, E-16, Agargaon, Shere Bangla Nagar Dhaka 1207, Bangladesh Phone: +88-02- 8181778 (Office)
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Md. Rafiqul Alam Siddique	Climate Change Unit, (Ministry of Environment and Forests) Mohakhali Ban Bhaban, Ministry of Environment and Forests, Mohakhali, Dhaka, Bangladesh
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Ms Shamima Nasreen	Climate Change Unit, (Ministry of Environment and Forests) Mohakhali Ban Bhaban, Ministry of Environment and Forests, Mohakhali, Dhaka, Bangladesh
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Mr Md Iqbal Hossain	Executive Engineer Barind Multipurpose Development Authority _BMDA Dhaka, Bangladesh
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List of Stakeholders: Agriculture Sector

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List of stakeholders: Cross cutting sectors

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