Pakistan

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE ADAPTATION

TECHNOLOGY ACTION PLAN & PROJECT IDEAS

(AGRICULTURE AND WATER SECTORS)

Report-III & IV

Government of Pakistan

Ministry of Climate Change

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TECHNOLOGY ACTION PLAN
& PROJECT IDEAS

(AGRICULTURE AND WATER SECTORS) ADAPTATION TECHNOLOGIES

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Foreword

Pakistan's high vulnerability to adverse impacts of climate change, in particular extreme climatic events, means that the country is in dire need of innovative adaptation technologies to lessen damage to life, property, natural eco-systems and economy of the country.

I am confident that the Technology Needs Assessment (TNA) project initiated by the Ministry of Climate Change in partnership with the United Nations Environment Program (UNEP), Climate Technology Centre & Network (CTCN) and Technical University of Denmark (DTU) will play an effective role in increasing resilience against climate change vulnerabilities through transfer and diffusion of prioritized technologies in agriculture and water sectors and removing barriers in their adoption.

I am pleased to note that the entire TNA process from prioritizing sectors and technologies, setting preliminary targets for transfer and diffusion of technologies, identifying barriers and suggesting an enabling framework for overcoming the barriers and now Technology Action Plan (TAP)/ Project Ideas report in this final phase-III of the TNA project was country-driven. Being highly consultative, it involved a number of stakeholders and experts from the government, private sector and civil society. I strongly believe that the implementation of adaptation technologies prioritized in TNA process and elaborated in TAP Report-III will help the country in building resilience to the impacts of climate change.

I would like to thank the members of the TNA National Team and my colleagues in the Ministry and experts of the Adaptation Working Group for their invaluable contributions to the preparation of this Report.

I also thankfully acknowledge the contributions of Dr. Qamar-uz-Zaman Chaudhry, Lead-Expert and other experts of Global Environment Facility (GEF), United Nations Environment Program (UNEP), UNEP-DTU Partnership and the Asian Institute of Technology, Thailand for their constant support and guidance for implementation of the TNA project.

(Mushahid Ullah Khan)

Federal Minister, Ministry of Climate Change

Government of Pakistan

Preface

Climate change is one of the most daunting threats that humankind faces today. For Pakistan, it is a colossal challenge to achieve its sustainable development goals without compromising on its socio-economic development needs. Due to its exposure to the recurrent episodes of drought, flooding, heatwaves, and glacial lake outburst floods in the past few decades, the country is consistently ranked by multiple climate change vulnerability indices as being one of the most vulnerable to the impacts of climate change.

Building resilience and adaptation to climate change is becoming indispensible for Pakistan. Fortunately, environmentally sound technologies are gaining a high priority in sustainable development policy dialogue and implementing frameworks. Technology Needs Assessment (TNA) is one of the critical steps towards identifying and assessing climate change adaptation challenges for Pakistan in order to align its adaptation needs and opportunities with goals and objectives of its sustainable development. As a climate change adaptation tool this TNA would help the country identify the needs for new equipment, techniques, practical knowledge and skills, that are necessary to successfully pursue climate resilient development.

This report on 'Technology Action Plan/ Project Ideas' is a final output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Program (UNEP) and the UNEP DTU Partnership in collaboration with Asian Institute of Technology Thailand. This TNA process in Pakistan is being undertaken since June 2015, with the Ministry of Climate Change in lead.

This report identifies and provides a list of action needed for adoption of prioritized adaptation technologies in climate vulnerable water and agriculture sectors of Pakistan. The report is the result of a fully country driven, participatory process. Views and information in this report is the product of extensive discussions with technology expert team and stakeholders.

I extend my appreciation to all stakeholders for their constant support and valuable comments throughout the development of this report. I hope that this assessment will go a long way in achieving the climate resilience of country's water and agriculture sectors from climate change vulnerabilities.

(Syed Abu Ahmad Akif)

Federal Secretary, Ministry of Climate Change

Government of Pakistan

Abbreviations

ADP	Annual Development Plan
EPD	Environmental Protection Department
EWS	Early warning system
FFC	Federal Flood Commission
FSC&RD	Federal Seed Certification and Registration Department
GCISC	Global Change Impact Studies Centre
GoP	Government of Pakistan
GEF	Global Environment Facility
GW	Groundwater
GWRF	Ground Water Regulation Framework
GHG	Greenhouse gases
HEIS	High efficiency irrigation system
IBIS	Indus Basin Irrigation System
LID	Low impact development
MOCC	Ministry of Climate Change
NDMA	National Disaster Management Authority
PCRWR	Pakistan Council of Research in Water Resources
PDMA	Provincial Disaster Management Authority
PIDA	Punjab Irrigation and Drainage Authority
PHED	Public Health Engineering Department
PMD	Pakistan Meteorological Department
PSDP	Public sector development program
RWH	Rainwater harvesting
R&D	Research and development
SCARP	Salinity Control and Reclamation Program
TNA	Technology needs assessment
TAP	Technology action plan
UNEP	United Nation Environment Programme
UNFCCC	UN Framework Convention on Climate Change
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Authority
WB	World Bank

Weights and measures

ha	hectare
km^2	square kilometre
m^3/yr	cubic meters per year
MAF	million acre foot
Mh	million hectares

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Executive Summary

Technology Needs Assessments (TNAs) are a key component of the UNFCCC supported technology transfer framework, which was originated in Marrakesh Conference of the Parties (COP)-7 in 2001. The TNA is a set of country-driven activities that support developing countries Parties to the UNFCCC to determine their climate technology priorities in order to mitigate GHG emissions or adapt to the adverse impacts of climate change.

Pakistan started its TNA process in 2015. After following extensive consultation processes with the sectoral stakeholder working group and other experts, it identified water and agriculture as its two most climate vulnerable sectors along with three prioritized climate adaptation technologies for each sector. Three top priority technologies for water sector included rainwater harvesting, stormwater management and groundwater recharge; for agriculture sector, the prioritized technologies identified were high efficiency irrigation system for rainfed and irrigated areas (drip and sprinkler), drought tolerant crops varieties, and climate monitoring and forecasting – early warning system. In the next step, technology barrier analyses were performed to identify different types of key barriers to the diffusion and replication of these prioritized technologies. Based on the findings, a framework for creating technology-enabling environment was constructed and proposed. Subsequently, 'Technology Action Plan (TAP) and Project Ideas (PI)'- were developed for each technology under the prioritized sectors.

This report presents different TAPs & PIs for water and agriculture sectors of Pakistan. TAP and PI represent third and final phase of TNA cycle, and systematically suggests practical actions necessary to mitigate or reduce technology related barriers identified in the earlier phases of the TNA cycle. In addition, the report proposes six project ideas based on each of the prioritized technologies which may attract international donor financing for the implementation of any one, or all of these project ideas.

A brief summary of TAPs, and PIs developed for agriculture and water sectors of Pakistan are given below:

A. Technology action plans

I. Technology action plan for agriculture sector

Pakistan is predominantly an agrarian economy with 42 percent of the labour force employed in the agriculture sector. The sector, however, is the most vulnerable to the impacts of climate change. According to climate model projections for the sector, the agricultural productivity will decline by 8 percent–10 percent by the year 2040.

The Chapter-2 on Agriculture Technology Action Plan, in this report, outlines a brief description of the sector followed by a brief summary of the barriers and enabling measures to the three prioritized agriculture sector technologies. The chapter also identifies some preliminary targets to achieve the successful transfer and diffusion of these technologies in the country. The proposed targets are:

i. Installation of drip/sprinkler irrigation system on around five million hectares of agriculture farmlands by 2020;

ii. Development and promotion of new, yet high productivity drought tolerant wheat and rice seeds varieties for the arid and semi-arid areas of the country by 2025;

iii. Strengthen the institutional structure of water governance in the country, and build capacity of key stakeholders, specifically farmers, through providing training on water efficient irrigation technologies;

iv. Up-gradation of the existing agriculture R&D centers in each province;

v. Up-gradation and modernization of climate monitoring and forecasting system in the country by 2020.

1. Water efficient irrigation technology: Drip and sprinkler irrigation systems were identified as one of the prioritized technologies for agriculture sector with aims to improve efficient water use by the farmers, and to increase the overall agricultural productivity. Several barriers to the diffusion of technology in the country were identified that included high technology cost, lack of technical expertise, small and fragmented domestic market size along with weak regulatory and legislative measures.

The action plan proposes following activities**:** Provision of sufficient financial resources for subsidy on the initial investment cost of the technology to the farmers; strengthening the institutional capacity in terms of human resources and technical expertise; supporting market expansion & strengthening through enhanced public private partnership building, quality control of technology product; Increasing awareness among technology users on the usefulness of technology through conducting workshops, exhibitions etc.

2. Drought tolerant crop varieties: Drought tolerant crop varieties provide an efficient instrument against the limited or unpredicted water supply by ensuring good crop productivity specifically in the dry areas of the country. In Pakistan, the information on drought tolerant crop varieties is patchy, and not easily available that is one of the key reasons for placing this technology very low on agriculture sector development goals and priority agendas. The barriers to the diffusion of this technology identified are: lack of awareness about the usefulness of these crops, high cost of hybrid seeds in the market, low research investment in the development of these improved seeds, and lack of institutional capacity of the relevant R&D public institutions.

The proposed action plan suggest following activities: Design and adopt effective economic and financial tools and instruments to address domestic seed market needs and demands; improve and strengthen local policy and regulatory environment in the country in order to promote hybrid crop adoption; create and promote information and awareness about the necessity of and advantages of the improved seeds varieties especially in the context of climate change; and strengthen the institutional capacity of the agriculture research organizations in the country through ensuring dedicated funding and creating linkages with other local and regional research organizations.

3 Climate monitoring, forecasting and early warning system: The early warning systems play a significant role in disaster (or hazard) planning and prevention. The system has four key operational components: (i) Observation, detection, monitoring, analysis, forecasting and development of hazard warning messages; (ii) Assessment of potential risks and integrating risk information into warning messages; (iii) Dissemination of timely, reliable and understandable warning messages to authorities and public at-risk; and finally (iv) Community-based emergency planning, preparedness and training programmes focused on eliciting an effective response to warnings to reduce potential impact on lives and livelihoods.

Some important barriers to the diffusion of this technology include: high cost of construction and operation, limited human and technical resources and capacities, limited research programs available at the national scale.
To overcome the above barriers, the following actions are proposed:

i. Improve human capacity of the relevant national institutions involved in early waning issuance, emergency preparedness and response;
ii. Increase funding for strengthening technical and institutional capacities of the R&D organizations dealing with multi-hazard monitoring, forecasting and warning services;
iii. Improve early warning communication and dissemination system in the country;
iv. Enhance the level of cooperation and collaboration with other relevant local and regional research organizations.

II. Technology action plan for water sector

The water sector in Pakistan intensively relies on the Indus River and its tributaries to meet the needs and growing demands of the various water-dependent sectors such as agriculture, energy, and industry along with various domestic purposes. Agriculture is the biggest consumer, using almost 90 percent of the total available water, but solely for the irrigation purposes.

Pakistan is among the world's 36 most water-stressed countries. Its per capita surface water availability is estimated to drop to about 860 m^3/yr, with a projected demand-supply gap of approximately 83 MAF by 2025. Climate change is also expected to have long- term severe impacts on water and food securities. The impact will very likely not be uniform in the country, but mainly defined by variations in demographics, agricultural practices and the nature and sustainability of fresh water sources.

In this report, the Chapter-3 on Water Sector Technology Action Plan outlines a brief description of the sector followed by brief summary of the barriers and enabling measures to the three prioritized water sector technologies diffusion. The preliminary targets to achieve the successful transfer and diffusion of these technologies in the country are as under:

i. Construction of 2000 community and public-run surface rainwater harvesting reservoirs each with a capacity between 25, 000 m^3 to 50,000 m^3 depending on the water requirements, catchment area, slope, soil type, vegetative etc. by 2025, particularly in dryland (rainfed) areas of the country;

ii. Modernization and up-gradation urban stormwater drainage infrastructures of 10 major towns by 2022;

iii. Introduction of low impact development (LID) infrastructure in 10 major cities/towns as an approach for urban stormwater management by 2022;

iv. Construction of groundwater recharge systems to improve groundwater situation.

1 Rainwater harvesting from ground surfaces: The TNA process identified rainwater harvesting as the top prioritized climate adaptation technology for water sector. The technology is already in use in arid and semi-arid areas of Pakistan where seasonal rainfall is the major source of water and a permanent or ephemeral surface water body (such as river or spring) is not present. Some important barriers to the diffusion and replication of this technology in the country are identified which include: high cost of construction and maintenance of water reservoirs built to store rainwater, weak technical, institutional and organizational capacity issues.

To mitigate these barriers, the technology action plan proposes the following activities: i) ensure sufficient supply of dedicated funding for the government departments involved in different key aspects of the technology design and management; ii) build and strengthen the institutional capacity of the line ministries and government departments; iii) raise knowledge and awareness on the usefulness of technology; iv) Implement suitable regulatory and legislative statutes.

2 **Groundwater (aquifer) recharge:** Groundwater artificial recharge is a planned activity that aims to increase the natural replenishment or percolation of surface water into ground aquifer, so that groundwater level stays stable relative to its rate of abstraction by the people for different purposes. The technology is a high priority in areas of Pakistan where groundwater is the only easily accessible and highly reliable source of water for both irrigation and domestic purposes such as in case of Balochistan province. The most common recharge techniques employed are surface spreading of rainwater, watershed management, and recharge structures such as check dams, delay action dams, and earthen pond and wells, while bore hole technique is very recently utilized as a test project in one or two locations in the province.

Despite its usefulness, the technology faces certain challenges such as weak governance system at local and national levels due to the absence of sector policy and strategies, lack of reliable technical information, and highly politicized nature of the ground and surface water management issues. The proposed action plan focuses on the following tasks and activities: i) determine priority areas for recharge, based on technical information and measurements; ii) Devise and implement a comprehensive policy framework and strategy on ground water recharge that is completely aligned with and support the surface water regulations; iii) build and strengthen the institutional capacity of the organizations dealing with water management and monitoring at the community, regional and national level.

3 Urban stormwater management

Managing stormwater or runoff is one of the biggest and most expensive challenges that the urban cities around the world face. In Pakistan, combined sewer system predominates that convey both wastewaters and stormwater runoff through a single pipe system to a receiving outlet that is commonly a stream, lake or river, and mostly without any treatment.

Stormwater management choices are tough because they are inextricably linked to other public services; for example, a good storm drain is essential for basic sanitation and decent transportation. Whereas a good drainage system needs proper solid waste management, so ultimately it requires comprehensive land use planning and management. In Pakistan, due to low priority placed on the technology, it fails to capture strong support and visibility from the government agencies involved in service delivery operations at the local scale.

The most significant barrier identified to the diffusion of technology is the high initial and O&M cost of the system, funding and capacity issues of the local government authorities who are primarily responsible for the design and management of the system, and lack of supporting policies and regulations such as land-use policy, zoning codes etc.

To improve stormwater management in urban areas, the proposed action plan focuses on policy and regulatory support for land-use and urban planning, inclusion of new innovative low impact development techniques and infrastructures that support green growth development in the region, availability of dedicated funding, design and implementation of community outreach and communication plans.

B. Project ideas for agriculture & water sectors

Project Idea-1: **Building the resilience of agriculture sector against the impacts of climate change through promotion of (drip and sprinkler) micro-irrigation systems in Pakistan.**

The main objectives of the proposed project are to: i) improve the access of farmers to good quality, yet affordable high efficiency irrigation system (HEIS); ii) build and strengthen the domestic HEIS market through expanding market size and iii) promote climate change adaptation in the context of food and water security. The proposed project will be implemented during a period of seven years with a total budget of US $ 7.8 million.

Project Idea-2: Development and diffusion of drought and heat tolerant crop seed varieties in Pakistan.

The objectives of the proposed project are to (i) develop new drought tolerant crop varieties especially for the rainfed areas (ii) improve availability and access to improved drought tolerant crop cultivar seeds on mass scale for both large and small scale farmers at the affordable price; (iii) build the capacities of the public and private institutions involved in different stages of the technology life cycle .The proposed project will be implemented during a period of 5-years with a total budget of US $ 5.9 million.

Project Idea 3: Strengthening climate monitoring, weather forecasting and early warning system in Pakistan.

The proposed project aims to build up the capacity of the Pakistan Meteorological Department in the field of early warning systems. It is expected to serve the following important objectives: (i) intensify coverage of the hydro-meteorological observational systems (AWS, Radars) to enhance capacities to generate timely, reliable, and geographically relevant early warnings and weather forecasting information to respond to and manage climate impacts; (ii) support climate vulnerability and risk assessments as part of the process to formulate and implement National Action Plan on climate change. The proposed project is scheduled to be implemented during a period of 5-years with a total budget of US $ 19.80 million.

Project Idea 4: Strengthening groundwater resource and its governance system in Pakistan

The project aims to achieve the following objectives: (i) improve and strengthen the governance system of groundwater in Pakistan; (ii) promote science-based policy and decision-making process for resource manager and users.

The proposed project is scheduled to be implemented during a period of 5-years with a total budget of US $ 11.80 million.

Project idea 5: Improving and sustaining water security in climate vulnerable areas of the country through rainwater harvesting from ground surfaces

The project objective is to improve the year-round availability of water to rural households and communities, specifically in drought-vulnerable areas of the country, and improve their livelihood sources and consequently food security in the region. The implementation period for the proposed project is 5-years with a total budget of US $ 7.60 million.

Project Idea 6: Climate Resilient Mountain Villages (CRMV)

The main purpose of the project is to enhance climate resilience of small farmers, particularly in the vulnerable mountain areas. The specific measurable objectives of this project are: (i) enabling sustainable gender inclusive growth in agriculture through climate smart cropping patterns and drought tolerant varieties of crops; (ii) increasing agriculture productivity while saving water and promoting the use of organic fertilizers and pesticides; (iii) addressing water scarcity and uncertainty for irrigation and drinking using simple water conservation and high efficiency irrigation systems; (iv) providing small farmers an easy access to climatic, weather and market information through ICT; (iiv) preparing small farmers for disasters to reduce risk and mitigate their impact on their agriculture and livelihoods.

The proposed project is scheduled to be implemented during a period of 5-years with a total budget of US$ 3,75,000/-.

Chapter 1: Introduction

Climate change is quickly becoming a reality for the world with its increasingly huge negative impacts on societies, people and assets. The countries around the globe are facing huge socio-economic losses due to climate induced natural disasters such as floods, cyclones, and droughts etc. To reduce the degree of exposure to the risk and the subsequent vulnerability, the countries have to gradually move towards climate proofing of their assets and economy through adapting low carbon pathways and climate-resilient approaches and technologies that would provide a substantial support to their goal of sustainable and climate resilient development.

Understanding the climate technology needs of a country is a good starting point for effective action on climate change. The United Nations Framework Convention on Climate Change (UNFCCC) supports developing countries to identify and assess their needs for climate sensitive technologies through 'Technology needs assessment (TNA)' process, which is a critical element of the technology transfer framework, originated in Marrakesh Conference of the Parties (COP) 7 in 2001. The TNA process follows a three-phase approach:

i. Identification and prioritization of climate sensitive technologies for the climate vulnerable sectors of the economy;

ii. Identification and analysis of different types of barriers to the diffusion and replication of the prioritized technologies and, based on the findings, construction of an enabling environment framework that would address these barrier challenges by proposing some critical system reforms; and

iii. Preparation of technology action plan (TAP) and project ideas as the key outcome of the TNA process. TAP builds upon the recommended enabling environment framework for the uptake and diffusion of prioritized technologies and therefore aims to facilitate identification of good technology transfer projects with links to relevant financing sources.

Pakistan started its TNA process in 2015 under the guidance and leadership of the Ministry of Climate Change. The process thus far has been highly adaptive and country driven with an inclusive institutional support structure and mechanism that ensures the direct and continued engagement and participation of the members of the Sectoral Adaptation Expert Working Group, and other national technical experts.

During the first phase of the TNA process, with the help of key stakeholders, Pakistan identified climate adaptation technology needs of the water and agriculture sectors based on their contribution to the economy, relevance to development priorities and their vulnerability to climate change. Three top priority adaptation technologies were identified for both water and agriculture sectors. The rainwater harvesting, stormwater management and ground water recharge were the three top technologies for water sector While for the agriculture sector, the prioritized technologies were high efficiency irrigation systems for rainfed and irrigated areas (drip and sprinkler), drought tolerant crops varieties, and climate monitoring and forecasting – early warning system.

The second phase of TNA focused on the identification and assessment of most crucial barriers to the diffusion and transfer of these six adaptation technologies in water and agriculture sectors of Pakistan. A brief description of these barriers and the mitigation measures are also provided in the following chapters.

The Technology Action Plan (TAP) & Project Ideas constitute the final stage of the TNA cycle which converts the specific technology strategies, identified during the need assessment phases earlier in the cycle, into implementable actions on the ground. TAP can further support integrating environmentally-friendly technologies into national development plans, climate actions under the Paris agreement, as well as adaptation technology inclusive programs and projects.

The process followed for the development 'TAP and Project Ideas' was similar to the process following during development of first two phases of TNA process. It was also country driven and participatory. Brief methodology followed in the third phase of TNA process –TAP and Project Ideas- is explained as under:

- A small committee of MoCC identified the stakeholders for this final phase.
- Extensive literature review, brainstorming and meeting with experts to identify potential feasible measures and actions.
- Screening and validation of important actions through extensive consultation during Stakeholders/experts group workshop
- Selected policy makers briefing and sensitization of TNA process through one-to one meeting.
- Preparation of 'TAP/Project Ideas Report' by a lead adaptation expert followed by its extensive review by UNEP-DTU and AIT Thailand experts and finally approved by MoCC.

Chapter 2: Technology Action Plan for the Agriculture Sector of Pakistan

2.1 Actions at sector level

2.1.1 Sector overview

Agriculture sector in Pakistan accounts for 19.5 percent of the national GDP and employs 42.3 percent of the total population (GoP, 2017). The sector is essentially central to the growth and development of the national economy, but also one of the most; vulnerable sectors in the country to the impacts of climate change due to its susceptibility to changing weather and climate, and also because mostly rural population is engaged in agriculture where poverty is higher than the urban population.

The future climate projections for Pakistan indicate that, by the end of this century, both temperature and precipitation patterns are likely to change with winters getting warmer and precipitation decreasing in most parts the country (Chaudhry, 2017). This change in rainfall and temperature will have profound impact on the productivity of the agriculture sector ultimately. It is estimated that by 2040, the agricultural productivity will decline by 8 to 10 percent because of projected temperature increase (Dehlavi et al., 2015). Apart from economic impacts on the farmers' income, it is predicted that indirectly various socioeconomic and agronomic factors will also play role in enhancing the vulnerability of the sector. These factors include water availability, pesticides, labour supply, the household characteristics, and their experiences of the past extreme events (Gorst et al., 2015).

The agriculture sector stands as one of the biggest greenhouse gas (GHG) emitter in the country in the past 3 three decades. According to the national GHG inventory of Pakistan for the year 2011–2012, the agriculture sector emissions stood at 44.8 percent of country's total emissions, which was second to the energy sector with emission share standing at 45.9 percent (Mir and Ijaz, 2016). The preliminary projections for the total GHG emissions of the country under the business as usual scenario show a rise of the emission levels by 14 times by the year 2050, compared to the base year GHG emissions of 2011 (Khan et al., 2011). This continued rise in emissions levels in the future reinforces the need for adoption of environmentally friendly technologies that will improve the resilience of the sector against the worst impacts of climate change in the coming decades.

Pakistan acknowledges the introduction of technological innovations in the national and sector development plans and programs. The National Climate Change Policy, for example, recognizes the role of technology in improving the resilience of water and agriculture sectors with emphases on high efficiency water technologies, drought tolerant crops, and various risk management schemes including crop insurance for the farmers. Likewise, the Policy suggests establishing a strong institutional support system for accessing international climate finance and its use in strengthening the local climate actions and programs (GoP, 2012).

During the early technology identification and assessment phase of TNA, the three technologies identified and prioritized in agriculture sector were rainwater harvesting, drought tolerant crops, and climate monitoring and forecasting-early warning system. Many key barriers to the dissemination and replication of these technologies are identified in the second phase of TNA and discussed briefly in the next section (2.1.2).

2.1.2 Preliminary technology targets

To achieve the successful adaptation technology transfer and diffusion in the country, it is important to identify and set some primary targets for the dissemination of technologies specific to the needs and requirements of the agriculture sector. Given below is a list of preliminary targets for the prioritised adaptation technologies in agriculture sector:

1. Install drip/sprinkler irrigation system on around five million hectares of agriculture farmlands in country's arid and semi-arid areas by the year 2020;
2. Develop and promote new but high productivity drought tolerant crop varieties for the arid and semi-arid areas of the country by 2025;
3. Strengthen the institutional structure of water governance in the country, and build capacity of key stakeholders specifically farmers through providing training on water efficient irrigation technologies and other relevant water conservation and management techniques;
4. Up-grade and strengthen the existing agriculture R&D centres and research culture in each province;
5. Modernize and expand the existing climate monitoring and forecasting system in the country by 2020.

2.1.3 Barriers at sector level and proposed measures to overcome barriers

Based on the individual technology barrier analysis techniques and tools utilized during the technology barrier identification phase, an attempt was made to identify the common barriers to the three prioritized technologies of the agriculture sector of Pakistan. It is expected that the existence of commonality in the nature of these technology barriers would allow policy and decision makers to find some common measures to eliminate or reduce these barriers that would ultimately create an enabling environment for the diffusion and mass replication of these technologies in the agriculture sector.

Table 2.1: Common barriers to the diffusion of prioritized adaptation technologies in the agriculture sector of Pakistan

Barrier category	Barriers	Measures to overcome barriers
Economic & financial	- High capital, operation and maintenance costs	- Provide adequate financing in the form of subsidy, soft loans etc. to technology users

Information & awareness	- Limited information and awareness about the existence and usefulness of the technology - Weak communication networks and linkages among technology developer, supplier, dealers and users impeding an efficient market information exchange	- Launch Information and awareness campaigns on the usefulness of technologies through media as well as through workshops - Build effective and efficient communication networks among technology stakeholder groups
Institutional and organizational capacity	Limited institutional capacity	Invest in strengthening governance structures and capacity building of stakeholders
	Limited R&D capacity	Invest in trainings, exchange programs, and joint-research ventures with other regional and international research organizations
Market imperfection	Small underdeveloped market, weak supply chain and distribution mechanisms	Encourage private-public partnerships, provide loans, subsidies, build and expand information networks to improve market functioning

2.1.4 Action plan at sectoral level

Scaling-up agricultural research funding: Presently the allocated budget for agricultural research in Pakistan is very low. Particularly in the face of climate change challenges, country needs to scaled-up agricultural research funding in order to make national agriculture climate resilient.

Efficient use-of water in agriculture: All efforts should be made to ensure efficient use of water and reduction in irrigation water loses in the agriculture sector of Pakistan.

2.2 Action plan for high efficiency irrigation systems (drip and sprinkler)

2. 2.1 About the technology

High efficiency irrigation systems (HEIS) such as drips and sprinklers are efficient technologies highly suitable for the arid and semi-arid areas where water availability is a prime issue. HEIS ensure constant application of a focused and specific amount of water to crop root through a system of pipes, emitters, drippers and other important components that transport water from water sources (wells, tanks or reservoir) to the crops roots. HEIS cater for a wide range of plants and soil types. Drip technology is used best for a wide range of orchards, vegetables, and cotton crop while the sprinkler system is suited to most row, field, and crops that are grown closely such as cereals, wheat, pulses, cotton, vegetables, and fruits. As these pressurized irrigation systems have better uniformity & higher application efficiency and higher crop yields can be obtained with these methods. The technology provides many adaptation benefits such as efficient use of water supply, decreasing the probability of onset of plant diseases such as fungus through liquid fertilization. Moreover, the technology functions under a wide array of topographic and soil conditions with an exception of heavy clay soil.

2.2.2 Target for technology transfer and diffusion

The High Efficiency Irrigation System (HEIS) is a highly suitable technology for the arid and semi-arid areas of Pakistan where a constant supply of water is a major challenge due to the absence of a perennial source of surface water throughout the year, and farmers are forced to conserve whatever little water they receive from seasonal rains and flash floods. The adoption and replication of the technology is emphasized in many sector policy documents; Water and Power Development Authority (WAPDA), for instance, in its "Vision 2025" policy guideline document targets 3.493 million acres (MA) of lands to be brought under drip and sprinkler irrigation systems by the end of year 2015 (WAPDA, 2003). Similarly, the irrigation department of Punjab government aims to install HEIS on 120,000 acres in the province by 2021 (Government of Punjab, 2017).

TAP target: The target is to install drip/ sprinkler irrigation system on 5 million hectares of land in the next 5 years.

2.2.3 Barriers to the diffusion of technology

Based on the literature review, experts judgment, and meetings with the member of the Adaptation Expert Working Group (List attached as Annex-I), many crucial technology barriers were identified which are creating obstacles in country to the quick adoption and replication of this technology. The 'technology barrier analysis and enabling framework' (BAEF) report provides a complete list of these barriers along with several possible measures that would help in eliminating or reducing the technology barriers.

A key barrier identified is a presence of short-term, in-consistent, and conflicting policy outlook resulting in legal and regulatory issues surrounding technology adoption and replication, and consequently its market development and expansion. Pakistan does not have formal "agriculture and water policies", so there is no clear directives on sector specific policy goals and priorities that subsequently put many short- or medium-term development goals of the two sectors in close conflict to each other rendering it a challenge to achieve long-term sustainability in the agriculture sector. One such example is the low canal water pricing system (or abiyana) in the provinces for the farmers; the canal water price fluctuates between 85 PKR per cropped acre in Punjab to 250 PKR per acre for non-food crops in Khyber Pakhtunkhwa (Iqbal and Iqbal, 2015) with the price recovery rate standing at 60 percent only as the national average. This low recovered amount is hardly sufficient to bear the 24 percent of the annual overhaul and maintenance of the vast canal irrigation system by the provincial governments and this eventually forces the irrigation system in Pakistan to require an annual subsidy of around PKR 5.4 billion (GoP, 2012). Another major conflicting policy decision is the provision of solar operated water pumps to the farmers at a higher subsidy rate without serious consideration to its impact on the already declining groundwater levels especially in certain arid areas of the country such as Balochistan. Ultimately, these policies influence farmers' attitude and behaviour towards adopting water saving measures and the innovative technologies at the farm level (OECD, 2012).

Market failure and imperfection is identified as another key barrier to the diffusion of HEIS in the country. The current domestic HEIS market is small, under-developed, and non-competitive resulting in high technology cost and low efficiency. Due to this small market size, there are only a few large technology suppliers in the market, but mostly they are concentrated in some specific regions of the country and therefore it becomes difficult for them to meet the growing demands of local markets located outside their supply and distribution networks. Considering the supply chains, in particular, it is fragmented and highly inefficient due to many factors, including low scale of production and quality issues, capacity of technology suppliers and dealers, efficiency and sophistication of business processes in the country, and poor access to technical information. The result of this inefficient market performance is the high cost of technology, which is generally unaffordable by small landholders.

Likewise, limited institutional capacity is identified as one of the key barrier to the HEIS technology diffusion in Pakistan. The barrier includes many important factors such as: lack of trained technical staff to design and install or supervise technology installation in the field, low availability of credible information on the optimum technology performance under various climatic situations, weak coordination among technology handling organizations, and poor communication policies and mechanisms among the involved government agencies and private actors.

Lastly, the existing social, cultural and behavioural practices, attitudes and faith promote risk-aversion behaviour among farmers when it comes to water conservation technologies such as HEIS. The farmers generally bear a false perception of having low crop productivity and hence income, should they adopt the technology. An underlying reason under this behaviour is lack of credible technology performance information in different agro-ecological zones of the country. As such, this barrier creates a false and unrealistic perception of risks associated with HEIS adoption in the field and masks both the socio-economic and the environmental benefits of technology to the farmers.

The following measures are proposed to address these barriers:

- **i.** Develop long-term, nationally committed and consistent policy frameworks that would create a conducive enabling environment for technology diffusion and replication;
- ii. Increase private investment in the market, offer various incentives such as subsidy, low tariff rates etc., improve marketing and distribution networks connected with local rural markets;
- iii. Invest in R & D activities and programs, build and strengthen both the horizontal and vertical linkages of key organizations in order to improve coordination and communication mechanisms;
- iv. Create a clear communication policy focused on highlighting the benefits of technology to the farmers and to improve functioning of technology dissemination networks at national, regional and local levels.

2.2.4 Proposed action plan for the high efficiency irrigation system

In view of providing an enabling environment to encourage public and private actors to adopt and promote micro-irrigation to improve efficient water use and overall agricultural productivity, it is important to take the following actions:

i. Provision of financial incentives such as subsidy;

ii. Improve legislation and regulatory environment;

iii. Support institutional capacity building;

iv. Support market expansion and strengthening; and

v. Increase awareness and technical support.

Sector: Agriculture						
Technology: High Efficiency Irrigation Systems						
Action1: Introduce various economic and financial incentives for the technology users.						
Justification for the action: To encourage behaviour and attitude change towards adopting innovative water conservation and management practices and techniques.						
S.No	**Activity**	**Priority ranking**	**Implementing Agency**	**Time Scale**	**Cost & Funding Sources**	**Indicators of Success and Risk**
1.1	Provision of financial incentives in the form of subsidy / soft loan to assist farmers in the successful adoption of the HEIS technology.	High	Provincial Agriculture / Irrigation Departments	0-10 years	- National and International climate funding/int'l donors - US$ 3000 per hectare	**Success**: Rate of technology adoption **Risk**- Lack of funding &high dependence on subsidies
1.2	Investment in agricultural research and on-farm pilot projects for field demonstrations of the technology	Medium	Ministry of National Food Security & Research, Provincial Agriculture Departments.	0-5 years	- National and International climate funding/int'l donors - US$ per demonstration project US$ 50,000	**Success**: Rate of technology adoption capacity **Risk**- Lack of funding & insufficient institutional capacity
Action 2: Design and implement formal agriculture and water policies with complete ownership from the government and other stakeholders across various sectors and governance levels						

Justification for the action: To strengthen policy support to the technology adoption and diffusion in water and agriculture sectors of the country so that cross-sector integrated resource management approaches are promoted and adopted in the long-term						
2.1	Build consensus among various catalytic organizations and actors to earn support on policy formulation and implementation	High	Ministry of National Food Security & Research, Ministry of Water and Power	0-1 Years	National Funding US$ 200,000	**Success**: -Revised policy and strategies enacted, -Reduced Import duties. Or easy/enhanced access to spare parts/material or equipment **Risk**: Lack of political will - Unavailability of funding
2.2	Review and upgrade various sector policies, strategies, or programs for conflicting development goals, priorities or actions that would undermine sustainable food production and water security in the near future. It includes, for example, land and water rights, canal water pricing system, energy pricing	High	Ministry of National Food Security & Research, Ministry of Water and Power, (WAPDA).	0-2 Years	National Funding US$ 150,000	
2.3	Review import policy to reduce taxes on imported equipment and materials used in various types of high efficiency irrigation systems	Medium	Ministry of Finance	0-2 years	National funding US$ 10,000	
Action 3: Build a strong, competitive and diversified domestic market for agriculture technologies, in particularly HEIS, with inclusion of rural markets						
Justification for the action: To improve affordability, acceptance, and adoption of innovative water saving technologies (including HEIS) among farmers.						
3.1	Increase public- private partnership (PPP) to increase investment in the agricultural technology market	High	Provincial Agriculture / Irrigation Departments, Finance Departments	0-5 years	National / Foreign Funding US$ 2 million	**Success:** - The amount of investment in the market -Increase in product sale compared to baseline sale figures - Quality control standards established and enforced -Certification facilities are set up
3.2	Provide lucrative financial incentives to technology developers, suppliers, and investors to build their capacity and ultimately the product supply chains	Medium	Provincial Agriculture / Irrigation Departments, Finance Departments	0-5 years	National / Foreign Funding US$ 3.5 million	

3.3	Design, implement and strictly maintain the quality of technology products through the use of product standards, codes, certification, and/or annual licensing system etc.	High	Provincial Agriculture Departments / Irrigation Departments	0-5 years	National Funding US$ 0.5 million	**Risk**: - Limited incentives for private investors to participate - Limited number of technology manufacturers and suppliers
Action 4: Build the capacity of catalytic actors and organizations through the exchange of information, training programs, and investment in research and development activities						
Justification for the action: To enhance the institutional capacity and to overcome the shortage of professional in the area of technology development, management and implementation.						
4.1	Strengthen institutional capacity of government agencies involved in oversight and monitoring in terms of human resources and technical expertise. Capacity building of agriculture extension staff, drip and sprinkle technology suppliers and dealers to serve farmers efficiently, through well-designed training programmes on drip and sprinkler irrigation techniques.	Medium	Provincial Agriculture Departments / Irrigation Departments	0-5 years	National / Foreign Funding US$ 5 million	**Success:** - Increase in number of trained technicians, and staff, - Increased research facilities for agricultural research. **Risk:** - Inadequate funding - Low quality training programs
4.2	Increase investment in public R&D institutions	Medium	Ministry of Finance, Ministry of Food Security and Research,	0-10 years	National / Foreign Funding US$ 1.5 million	
Action 5: Design and implement effective technology information and awareness programs for the technology users						
Justification for the action: To improve the social acceptance of the technology among farmers and other technology beneficiary groups that would build the momentum for the technology adoption and replication in the sector						
5.1	Conduct technology exhibitions, field demonstrations, and workshops on the usefulness of the technology at the national and local levels with special focus on the inclusion of. rural districts and farmers	Medium	Provincial Agriculture Departments	0-5 years	Government and private funds US$ 200,000	**Success:** - Number of trainings, workshops, exhibitions, field demonstrations, TV and radio talks. -Number of persons trained - Number of

5.2	Develop technology use manuals, and fact sheets in local languages; Demonstration of technology on local farms with free distribution of technology related documents	Low	Provincial Agriculture Departments	0-3 years	Government and private funds US$ 150,000	documents developed **Risk:** -Inadequate funding -Lack of support from policy and decision makers .
5.3	Conduct electronic media talks with focus on successful case studies from various regions of the province	Low	Provincial Agriculture Departments, Agriculture Universities	0-3 years	Government and private funds US$ 100,000	

2.3 Proposed action plan for drought tolerant crop varieties

2.3.1 About the technology

Drought is one of the principal physical constraints on crop productivity in dryland areas around the world, with its severe medium and long-term impacts on the income and livelihood sources of households, in particular of poor ones, and trapping them in the vicious cycle of socio-economic insecurity and poverty in due course. Scientists predict that climate change will reduce the performance of staple crops worldwide through increased level of heat and drought stress in the coming decades (Challinor et al., 2014; Asseng et al., 2015).

Drought tolerant crop varieties, as a climate change adaptation technology, present an efficient instrument against the limited water supply in dryland areas by ensuring good crop productivity and diversification. This technology employs both conventional crop breeding and genetic engineering tools and techniques to create stress-tolerant crop varieties. Both techniques however take considerable time, cost, and effort in developing a new crop variety with optimum performance under various filed conditions before it is approved for the mass scale production and delivery to the farmers.

Pakistan has developed many local hybrid varieties of important crops, including wheat, rice and maize, and some fodder crops and vegetables. The local research institutions have paid much attention to wheat due to its prime importance as a staple food. However, the value of additional wheat, produced from various hybrid wheat varieties in use by the farmers in Punjab province alone, is estimated at Rs. 43 billion annually from 2000-2014 (Tabassum, 2016). In spite of this profit gain, the market share for the hybrid seeds is still relatively small and limited. Many reasons are identified such as, limited funding, small number of research institutions and of trained staff, lack of crop performance monitoring and evaluation system at farm level and weak marketing mechanisms among others. These challenges are feeding into many misconceptions about the productivity performance of these plants among the farming community, which ultimately is contributing towards making farmers more risk aversion when it comes to the adoption of hybrid crop varieties at the bigger scale. The information about drought and heat tolerant crop varieties, in particular, is patchy and scattered that is a key reason for placing this technology very low on agriculture sector development goals and priority agendas.

2.3.2 Target for technology transfer and diffusion

Pakistan has 22 mha of cultivated lands, out of which around 84 percent is under irrigation and the rest is rainfed (GoP, 2014). Due to relatively low rainfall occurrences in the rainfed areas of the country in the past, they have been hit hard by the recurring spells of droughts, making the local households and communities highly vulnerable to the impacts of low rainfall and drought. The drought tolerant crop varieties offer a more promising and sustainable solution to the declining water resources in these areas and in turn the low crop productivity and increasing food insecurity specifically for the poor households. To support the sustainable agriculture practices in both rainfed and irrigated areas of Pakistan, the preliminary targets proposed for the transfer and diffusion of these technologies focuses on wheat and rice crops, which are main staple food in Pakistan, and also to encourage large scale olive oil plantation in Baluchistan.

The research on the development of drought resistant crop seed varieties is an on-going process in the country. Some such seed verities have already been developed, while the research work and field trial on the others are in process. But it is important that such developed seeds be used by farmers on large scale especially in arid and in semi-arid areas of the country. At the same time farmers may be encouraged to sow crops needing less water in these areas.

The preliminary target for the transfer and diffusion of drought resistant crop varieties is to introduce the technology to 20 million farmers by the year 2020.

2.3.3 Barriers to the diffusion of technology

The development of drought tolerant crop varieties requires support and engagement of both public and private actors and organizations. As it is clear from the key stages of the technology development life cycle that includes hybrid seed development, field trials for the optimum performance testing under the full supervision of the scientists and technicians, approval and registration of new varieties, mass scale production and distribution to the farmers needs to pass through various market approaches. The technology therefore qualifies both as a public and a market good but in Pakistan, it is only the public research institutions playing the main role in technology development and distribution stage.

Under the original Seed Act of 1976, the private institutions including plant breeders and Seed Corporation were legally denied right to the direct participation in new crop variety development, investment, and claiming of individual property rights. As such, the policy offered no incentives to the private sector to invest in hybrid research programs in the country. To amend this situation, two legislative pieces namely "Seed (Amendment) Bill, 2015" and "the Plant Breeder's Rights Bill, 2016" were approved from both the legislative houses of Pakistan in 2016. The bills in their current status allow private sector to participate in research and development of new crop verities including genetically modified crops. The amendment also forces farmers to buy seeds from a licensed seed company or its agency every time they have to cultivate a new crop.

The Seed Amendment Acts of 2015 and 2016 present a very difficult situation in regard to the seed industry development and expansion in Pakistan and thus root cause of many barriers and challenges to the diffusion of hybrid crop technology in the country. The foremost challenge is setting the clear boundaries of the legal authority and power among the federal and provincial governments. Constitutionally, the provinces bear the supreme right over the federal government to any legislation and amendments related to natural resources and its management including agriculture, environment, energy and water among others. However, the Seed Acts are approved by the Federal government with no participation and consent of the provinces on these acts. Furthermore, the bills have raised strong opposition from the farming communities and allied beneficiaries on possible seed market monopoly by the giant international seed corporations.

The domestic seed market in the country is small with weak supply chains and distribution mechanisms and networks. Market imperfection and failure is therefore identified as another important barrier to the hybrid crop technology in the country. The market is largely unregulated by the government, so hence are the high prices for the tested, good quality seeds in the market. This is particularly a critical issue for small farmers in the rainfed and other irrigated areas with limited access to water resources who are already struck hard by poverty, their land quality is poor, and access to water resources is hard for them and hence they have to spend a high portion of their earnings on land preparation and crop cultivation. Resultantly, the standard agronomic practices of the farmers in such areas determine their risk aversion behaviour and social practices, which ultimately discourage the farmers to prefer and adopt hybrid seed varieties.

Other related barriers include lack of information and awareness on the advantages and benefits of the use of drought tolerant crops, low pool of technical knowledge on various aspects of the technology development, marketing and distribution, limited number of technicians, scientists, and other support staff in public research institutions and seed quality testing laboratories operating at the provincial scales. The research institutions face severe capacity issues due to lack of funding and grants available for development, delivery and monitoring of R & D activities.

To create an enabling environment, following measures have been proposed:

i. Economic and financial measures: Provide financial incentives such as subsidy, soft loans to the farmers; reduce taxes on research instruments, equipment, and other necessary tools used in technology development and innovation; grant dedicated funding to drought sensitive areas of the country.

ii. Market failure and imperfection/ policy, legal and regulatory measures: Review existing laws and acts related to hybrid crop production and distribution and revise the conflicting segments of the proposed amendment bills with consensus to all key stakeholders; to build a strong, competitive market, invest in building public private partnership; create, strengthen and link the networks of technology producers with technology suppliers, investors and users.

iii. Technical capacity/ information and awareness measures: Invest in R & D activities of public institutions, design, deliver and monitor communication strategies among various catalytic actors of the technology life cycle; and offer training programs to build the capacity of technical staff.

2.3.4 Proposed action plan for drought tolerant crop varieties

Based on the identified barriers and proposed measures, the following action plan is proposed to stimulate the adoption and diffusion of drought tolerant crop varieties in Pakistan.

	SECTOR: AGRICULTURE					
	Technology: Drought tolerant crop varieties					
	Action 1: Design and adopt effective economic and financial tools and instruments to address the seed market needs and demands					
	Justification for the action: To encourage farmers to adopt and practice this technology while ensuring immediate, accessible, and need based finance for agriculture sector					
..	**Activity**	**Priority**	**Implementing Agency**	**Time Scale**	**Cost & Funding Source**	**Indicators of success and Risk**
1.1	Review the current subsidy and taxation plan for the agriculture sector specifically seed industry and make a detailed cost estimation for development, transfer and diffusion of the drought tolerant crop varieties with inclusion of subsidies and/or low taxes instruments	High	Ministry of National Food Security & Research / Ministry of Finance & Provincial Finance / Agriculture Departments	0-2 years	Government and Development funding partners US$ 0.15 million	**Success:** Readily available cost estimation for the technology. **Risk:** Inadequate funding
1.2	Provide subsidy to the price of the input services e.g. seed, irrigation etc. for transfer and diffusion of the technology	High	Ministry of National Food Security & Research / Ministry of Finance	0-5 years	Government and Development funding partners. US $ 1.0 million	**Success:** Readily available subsidy **Risk:** Inadequate funding
1.3	Review and increase budgetary allocation for agricultural research to R&D centres for the development of hybrid crop varieties	High	Ministry of National Food Security & Research / Ministry of Finance & Provincial Finance / Agriculture Departments	0-10 years	Government and Development funding partners. US $ 4.5 million	**Success:** Readily available seeds varieties **Risk:** - Inadequate funding -Human & technical capacity
	Action 2: Develop and strengthen the domestic seed market with special attention to the hybrid crop seeds					

	Justification for the action: Strong seed market would encourage participation of private sector, and ensure easy access to low cost, but high quality seeds for the farmers					
2.1	Develop necessary legislation and regulations to support and regulate seed market	High-to-Medium	Ministry of National Food Security & Research / & Provincial Agriculture Departments	0-2 years	Government and Development funding partners. US$ 100,000	**Success**: User-friendly laws and regulations. **Risk**: Lack of political and administrative support and inadequate stakeholders consultations.
2.2	Encourage participation of private sector in building and expansion of seed market through reducing cost of doing business	Medium	Ministry of National Food Security & Research / Ministry of Finance, Provincial Agriculture Departments	0-3 years	Government and Development funding partners US$ 250,000	**Success:** Increase in investment amount by private sector **Risk**: Lack of political will and legislative support, Frequent changes in economic and monetary policies,
Action 3: Improve and strengthen policy and regulatory environment in the country to promote hybrid crop adoption and replication						
Justification for the action: The action is intended to promote regulatory efficiency and effectiveness, improve business environment, and encourage private sector participation						
3.1	Review and update seed laws and acts to make them more consumer friendly and protect the rights of small farmers	Medium	Ministry of National Food Security & Research/ Provincial Agriculture Departments	0-3 years	Government and Development funding partners. US $10,000	**Success:** Consumer friendly laws and regulations. **Risk:** Lack of political and administrative support, Inadequate stakeholder consultations
3.2	Strengthen the role of seed certification authority to monitor and evaluate the quality of seeds in market	Medium	Ministry of National Food Security & Research	0-3 years	Government and Development funding partners. US$ 500,000	**Success:** Availability of quality seeds **Risk**: Lack of trained staff, Lack of or inadequate legislative support
Action 4: Create and promote information and awareness about the necessity and advantages of the improved seeds varieties, in particular, drought tolerant crop varieties in water stressed and dryland areas						

Justification for the action: To increase the social acceptance of the technology among farmers and other technology beneficiary groups that would ultimately build the momentum for a rapid technology adoption and replication						
4.1	Design and strengthen extension education to boost farmer's awareness of climate change and benefits of adaptation technologies	High	Provincial Agriculture Departments including Extension Wings, Public Research Institutions	0-5 years	Government and Development funding partners. US$ 100,000	**Success:** Increase in demand of and share of hybrid seed market, Increase in area of land under hybrid crop cultivation, **Risk:** Programmes not designed to the needs of farmers, Weak policy support
4.2	Design and conduct field demonstration projects under different agro-ecological zones in the country	High	Provincial Agriculture Departments, Public Research Institutions, Private seed companies	0-5 years	Government and Development funding partners. US$ 400,000	**Success:** Number of field-testing projects implemented during five years. **Risk:** Limited funding to do required pilots in different agro-ecological zones; Demonstration projects do not work because of mismatch between seed types and agro-ecological zones
Action 5: Strengthen the institutional capacity of agriculture research organizations in terms of building research infrastructure, human resources, and knowledge transfer Strengthening R&D Institution's human and technical resources						
Justification for the Action: Strengthening of R&D institutional capacity is a key to development and widespread diffusion of this technology in the country**.**						
5.1	Hire additional technical experts in relevant key R&D institutions	High	Ministry of National Food Security & Research/ PARC/ Agriculture Departments in Universities	0-5 years	Government and Development funding partners. US$ 500,000	**Success:** Increase in number of new hybrid crop varieties, **Risk:** Lack of funding, retention of experts for a longer period, lack of technical resources
5.2	Up-grade research laboratories with latest technologies	High	Ministry of National Food Security & Research/ PARC/ Agriculture Departments in Universities	0-3 years	Government and Development funding partners. US$ 800,000	**Success:** Availability of state of the art labs. **Risk:** Technology performance risks & lack of funding.

5.3	Build technical capacity of local staff development through specialized training and workshops	Medium	Ministry of National Food Security & Research/ PARC/ Agriculture Departments in Universities	0-10 years	Government and Development funding partners. US$ 400,000	**Success:** Availability of required trained staff. **Risk:** Low quality training programs & lack of funding.
5.4	Promote knowledge transfer through collaboration and expert exchange programmes with regional and International research institutions	Medium	Ministry of National Food Security & Research/ Public research institutions	0-5 years	Government and Development funding partners. US$ 400,000	**Success:** Increase in collaborative initiatives and programs **Risk**: Non-supportive organizational culture, Human performance risks & lack of funding
5.5	Survey the current status of seed storage houses, and build new if necessary	Low	Ministry of National Food Security & Research/ PARC/ Agriculture Departments in Universities	0-3 years	Government and Development funding partners. US$ 100,000	**Success:** Sufficient storage capacity. **Risk:** Lack of political and administrative support

2.4 Technology: Climate monitoring, forecasting and early warning system

2.4.1 About the technology

Early warning systems (EWS) are an important extension of the climate monitoring and forecasting technology that play a significant role in disaster (or hazard) planning and prevention. The system is designed to relay relevant and timely information to the concerned communities in a systematic way before a disaster strikes in order to help them make informed decisions and take actions. The efficiency and effectiveness of the system largely depends on the close coordination and collaboration with many different agencies and institutions working at the various levels of governance i.e. national, provincial and local. These include institutions that support hazard detection, monitoring and forecasting to emergency planning and hazard mitigation. The system also requires support from policy and regulatory frameworks, planning, budgetary, and operational mechanisms.

According to the World Meteorological Organization (WMO), an effective EWS need four operational components:

(i) Observation, detection, monitoring, analysis, forecasting and development of hazard warning messages;

(ii) Assessing potential risks and integrating risk information into warning messages;

(iii) Dissemination of timely, reliable and understandable warning messages to authorities and public at-risk;

(iv) Community-based emergency planning, preparedness and training programmes focused on eliciting an effective response to warnings to reduce potential impact on lives and livelihoods.

2.4.2 Target for technology transfer and diffusion

Pakistan is highly vulnerable to various types of natural hazards such as earthquake and other climate change linked hazards such as flash floods, drought, and heat waves. It aims to upgrade and expand various technical and institutional aspects of the EWS in order to better prepare for any potential disaster events in the future.

The following are some of the key preliminary targets set for the transfer and diffusion of climate monitoring-forecasting and early warning system to achieve above objectives are as under:

i. Establishment of new meteorological observatories in 20 districts of the country;
ii. Installation of 200 Automatic Weather Stations Network including its communication system;
iii. Installation of Wind Profilers at 5 main airports;
iv. Up-gradation and automation of 50 existing meteorological observatories;
v. Establishment of Flash Flood Warning System in five vulnerable locations in the country;
vi. Establishment of Glacial Lake Outburst Floods warning stations in Gilgit Baltistan and Upper Khyber Pakhtunkhuwa;
vii. Strengthening of the existing hazard information communication system among PMD, NDMA, PDMAs, FFC, and media.

2.4.3 Barriers to the diffusion of technology

EWS is a complex, and multi-tiered system that involves dedicated and strong collaboration and cooperation among various public and private institutions that are involved in disaster risk reduction. Setting up a fully functional EWS is therefore expensive and time-consuming.

Pakistan Meteorological Department (PMD) is the lead national institution responsible for climate monitoring and forecasting activities and initiatives. PMD operates several different kinds of early warning systems, such as for floods, drought, heat wave, and cyclonic storms of which the flood warning system is the most mature and sophisticated one. This system specifically is an alert and management information system that serves multipurpose ranging from flood alert, to flood control and management. Despite the country’s long history of disasters, EWS still needs major up-gradation.

There are many barriers to the expansion of this technology. A key barrier is the availability of technical experts and physical resources such as research labs, equipment etc., This weakness inevitably translates into limited research and development in the area of weather and climate change science that in turn impedes efforts in disaster risk reduction for various specific at-risk communities in the country. Similarly, the institutions, both at national and sub-national scales, suffer from low institutional capacity and inflexibility, which generally results in poor communication and coordination among the government agencies, private sector organizations, hazard prone communities and individuals.

To mitigate or reduce these barriers and create an enabling environment for the diffusion of EWS technology in the country, the following measures are proposed:

i. Increase and ensure funding for the modernization, expansion, and up-gradation of climate monitoring, forecasting, and early warning system in the country;

ii. Build and improve technical and human capacities of the concerned national and local institutions working in the field of emergency preparation and response;

iii. Strengthen and expand the existing early warning communication and dissemination mechanism with emphasis on clear, concise and 'authoritative' warning messages for the to-be-affected communities;

iv. Create close cooperation with other relevant international institutions for sharing knowledge, data and other necessary information that would help to strengthen the technology in the country.

2.4.4 Proposed action plan for climate monitoring and forecasting: Early warning system

SECTOR: AGRICULTUE						
Technology: Climate monitoring and forecasting: Early warning system (EWS)						
Action 1: Improve technical capacity, specifically of human resources, of concerned national institutions involved in early waning issuance, emergency preparedness and response management.						
Justification for the action: Reliable early warning information and trained knowledge based human resources would support informed decisions for emergency planning, response and in managing disaster risks						
Sr. No.	**Activity**	**Priority**	**Implementing Agency**	**Time Scale**	**Cost & Funding Source**	**Indicator of Success and Risk**

1.1	Conduct continuous cycles of need-based trainings for professional staff of meteorological, climate change and DRM related national institutions.	High	PMD, GCISC, NDMA, PDMA	0-4 years	ADP and donors funding. US$ 50,000	**Success**: Availability of qualified professionals **Risk:** Human resources performance risks, lack of funding, poor training quality
1.2	Conduct quality risk assessments to generate new and credible location - based risk data and information	High	PMD, GCISC	0-3 years	ADP and donors funding. US$ 38,000	**Success**: Availability of reliable localised risk information **Risk:** Lack of funding, lack of trained staff
1.3	Training and staff development through specialized training workshops	Medium	PMD, GCISC, NDMA, PDMA,	0-4 years	ADP and donors funding. US$ 10,000	**Success:** Availability of well-trained qualified professionals **Risk**: Low quality training program
1.4	Strengthen modelling approaches by working closely with WMO and other regional and international meteorological networks to reduce uncertainty in climate projections	High	PMD, GCISC	0-5 years	ADP and donors funding. US$ 50,000	**Success:** Availability of reliable local climate projections **Risk:** Lack of funding & Lack of trained staff
Action 2: Increase and ensure dedicated funding for strengthening of organization dealing with multi-hazard monitoring, forecasting and warning services.						
Justification for the action: To ensure improved forecast & warning products for use in efficient disaster risk reduction planning and management mechanisms.						
2.1	Increase budgetary allocations for the EWS relevant departments to build their capacity	High	PMD	0-5 years	ADP and donors funding. US$ 1.0 million	**Success:** Upgraded functional EWS **Risk:** Low funding,
2.2	Establish new meteorological observatories in hazard-prone districts	High	PMD	0-4 years	ADP and donors funding. US$ 0.5 million	**Success:** Expanded network of observatories **Risk:** Poor maintenance, lack of funding

2.3	Installation of 200 new Automatic Weather Stations Network including its communication system.	High	PMD	0-4 years	ADP and donors funding. US$ 6.0 million	**Success:** Fully functional technology **Risk:** : Limited maintenance, lack of funding
2.4	Up-gradation/ automation of 50 existing observatories	High	PMD	0-3 years	ADP and donors funding. US$ 1.0 million	**Success:** Fully functional technology **Risk:** lack of funding
2.5	Establishment of Glacial Lake Outburst Floods warning stations in GB and upper KP.	High	PMD	0-4 years	ADP/GCF funding. US$ 3.5 million	**Success:** Fully functional technology **Risk:** Technology/ human performance risks
2.6	Establishment of Flash Flood Forecasting & Warning System at five vulnerable areas in first phase.	High	PMD	0-5 years	ADP and donors funding. US$ 10.0 million	**Success:** Fully functional technology **Risk:** Technology/ human performance risk
2.7	Installation of weather surveillance radars at strategic location in the country for monitoring and forewarning disastrous weather events	Medium	PMD	0-10 years	ADP and donors funding. US$ 20.0 million	**Success:** Fully functional technology **Risk:** Technology / human performance risks
Action 3: Improve early warning communication and dissemination system in the country						
Justification for the action: To secure more human lives through improving the disaster response timings of to-be-affected communities and disaster management authorities						
3.1	Identify and engage the existing active community groups to participate in emergency preparation drills	Medium	PMD, NDMA, NGOs	0-5 years	ADP and donors funding. US$ 35,000	**Success:** Fully functional community groups **Risk:** Poor training quality, lack of funding
3.2	Dedicate funding for resources and training of the volunteer groups	Medium	PMD, NGOs	0-5 years	ADP and donors funding. US$ 10,000	**Success:** Fully trained volunteer groups **Risk**: Inadequate funding

3.3	Engage media particularly social media networks and platform to create awareness on disasters	Medium	PMD, Media	0-2 years	ADP and donors funding. US$ 10,000	**Success:** Fully involved media groups **Risk:** Inapt media campaigns,
Action.4: Enhance and improve coordination and collaboration with other relevant regional and international institutions.						
Justification for the action: Close cooperation with relevant international institutions for sharing knowledge, data and other necessary information would help to strengthen the knowledge and technology base in the country						
4.1	Promote transfer of knowledge through building research collaborations among experts at regional and international meteorological research institutions	Medium	PMD, GCISC, Met. Dept. in Universities	0-5 years	ADP and donors funding. US$ 35,000	**Success:** New collaborative international research initiatives **Risk:** Lack of funding , geo-political conditions influencing technology transfers
4..2	Collaborate and communicate with local, national and regional initiatives to share data, expertise and information to improve credibility of new information	Medium	PMD, GCISC, FFC, NDMA	0-5 years	ADP and donors funding. US$ 25,000	**Success:** credible risk information **Risk:** Lack of funding

Chapter 3: Technology Action Plan for the Water Sector of Pakistan

3.1 Actions at sector level

3.1.1 Sector overview

The water sector in Pakistan relies intensively on the Indus River and its tributaries to meet the growing needs and demands of various water-dependent sectors such as agriculture, energy, and industry aside from the multitude of domestic purposes. Agriculture is the biggest user of water, consuming nearly 90 percent of the total available water, which is solely for various irrigation purposes. The contiguous Indus Basin Irrigation System (IBIS) is the largest irrigation system in the world that irrigates more than half of the total cultivable area of the country. The Indus is the 12th largest river in the world and its basin areas (both upper and lower) cover 65 percent of the territory of Pakistan and supports 25 million people both directly and indirectly (Sheathe et al., 2017).

Pakistan is among the world's 36 most water-stressed countries, with a projected demand-supply gap of approximately 83 million acre-feet (MAF) by 2025 (IMF, 2015). The per capita surface water availability was 1,036 cubic meters per year (m^3/yr) in 2012 and is projected to drop to about 860 m^3/yr by 2025 representing an acute water shortage condition (WAPDA, 2014). Furthermore, climate change is expected to impact both quality and consumption patterns of water which will have long-term serious repercussions on human health, irrigation practices, and food security.

The recent climate projections for Pakistan indicate complex and mixed patterns of precipitation and temperature change mainly due to diversity in topography and climate of the country. For the Indus basin area, for example, increase in precipitation is expected in the upper Indus basin areas, however a greater degree of uncertainty is observed for the other parts of the Indus Basin areas. In terms of extreme rainfall events, a decrease in the number of rainy days is projected over the southern parts of the basin with an exception of the northern part, where extreme rainfall events will be more frequent causing sudden flash floods (Sheathe et al., 2017).

The climate model projections for temperature change in the upper Indus area show increase between 1^0C to 2.2^0C by 2050, with a considerable certainty, compared to the baseline period of 1998-2007. The Indus is dominated by temperature-driven glacial melts but the projected trends in glacial melt indicate only a small decrease of 20 to 28 percent in the total glaciated area. It is important to note that due to its large glaciated area, the absolute loss is likely considered to be the greatest in this basin (ibid).

The impact of these projected changes on water availability will very likely not be uniform in the country, but mainly defined by variations in demographics, agricultural practices and the nature and sustainability of fresh water source (ibid). Furthermore, any change in temperature will induce a shift in seasonality of water flows that has major implications for regional food security, especially when timing of peak flows and growing seasons do not coincide.

Policy and institutional review

The Water Vision 2025, as a water sector policy roadmap document, identified some key sector priorities that included generation and expansion of hydroelectricity network, prevention of water shortages and drought in the country through construction of water storages such as medium and small dams (WAPDA, 2003). Pakistan approved the National Drinking Water Policy in 2009 that aimed at providing safe and clean drinking water to the entire population by 2025 (GoP, 2009). The National Water Policy was drafted in 2016 that still awaits its final approval and implementation (GoP, 2016). The Policy considers various challenges of water sector to the changing climate and its ensuing impacts on water dependent sectors such as agriculture, energy, and industry. The document identifies regional cooperation on cross-basin water management as a major challenge for the sector.

During the first phase of TNA in the country, with consensus from CC Adaptation Expert Working Group members and other important stakeholders, a set of six adaptation water sector technologies were identified and finally three technologies were prioritize. The prioritized technologies were surface run-off rainwater harvesting, groundwater (aquifer) recharge and urban stormwater management.

3.1.2 Preliminary technology targets

To ensure successful and sustainable adoption and transfer of these three technologies namely surface run-off rainwater harvesting, groundwater (aquifer) recharge and urban stormwater management, this document identifies and lists a set of preliminary targets below:

1. Construct 2000 community and public-run surface rainwater harvesting reservoirs, each with a capacity between 25, 000 m^3 to 50,000 m^3 depending on the water requirements, catchment area, slope, soil type, vegetation type etc. by 2025 particularly in dryland (rainfed) areas of the country;

2. Modernize and upgrade urban stormwater drainage infrastructures of 10 major towns by 2022;

3. Introduce and set standards for low impact development (LID) infrastructure in 10 major cities/towns as an approach for urban stormwater management by 2022;

4. Construct around 200 groundwater recharge systems using innovative but cost-effective groundwater recharge techniques in Balochistan and other dry areas to improve ground (aquifer) water situation.

3.1.3 Barriers at sector level and proposed measures to overcome barriers

This section looks into the barriers common to the diffusion of water sector prioritized technologies, and an attempt has been made to find some common measures that would create an enabling environment for the sustainable diffusion and replication of these technologies in the sector.

Table 3.1: Common barriers and measures to the diffusion of prioritized adaptation technologies in water sector of Pakistan

Barrier category	Barriers	Measures to overcome barriers
Economic & financial	-High capital and maintenance costs -Limited financial allocation -Inadequate donor funding	-Provision of adequate and dedicated funding -Provision of subsidy or loans -Attract more donor funding
Policy, legal and regulatory	-Lack of comprehensive cross-sector policies for resource protection, development and management of water resources	-Approve water sector policy with consensus and government ownership -Devise and implement strong legislative and regulatory measures for surface and groundwater protections - Mainstream climate change considerations into relevant sector polices, plans and strategies
Information & awareness	Limited information and awareness on the existence and usefulness of the water sector prioritized technologies	- Run information and awareness campaigns particularly through social media -Strengthen and operationalize the technology stakeholders networks
Institutional and organizational capacity	-Limited institutional capacity -Limited human skills and training to maintain technologies specially at local level	Strengthen human skills through technical trainings

3.1.4 Action Plan at sectoral level

At the sectoral level, two broad priority actions are proposed:

i. Increasing the water storage capacity in the country in order to ensure water sustainability and the enhanced resilience of the local communities;

ii. Ensuring the sustainable use of underground water resources or aquifers so that the high abstraction in the over-exploited areas of the country are controlled, and recharged, and sustained for the benefits of economically important sectors, communities and individuals.

3.2 Action plan for surface rainwater harvesting technology

3.2.1 About the Technology

Rainwater harvesting (RWH) from ground surfaces is basically a collection, diversion and storing of rainwater to supplement other formal setup of water collection and distribution system for a community for its later use during dry periods. Rainwater collected from ground surface is typically used for non-potable purposes, including irrigation, livestock and general domestic uses

In Pakistan, RWH is commonly practiced either by collecting rainfall from the ground surfaces utilizing 'micro-catchment' to divert or slow runoff for storage purposes, or harvesting floodwater flows from a river, stream, or other natural watercourses through construction of earthen or other structures to dam the watercourse and form a small reservoir. The technology is widely practiced in arid and semi-arid areas of Pakistan where a permanent or ephemeral surface water body (such as river, or spring) is not present, and seasonal rainfall is the only major source of water for irrigation, livestock and various domestic purposes.

Pakistan has the world's largest indigenous rainwater harvesting system commonly called spate irrigation system. This system irrigates around 0.3 mha of cultivated land in the country, while the potential area to bring under this system is estimated to be around 6.935 mha (Ahmed and Steenbergen, 2010).

The technology offers many benefits during seasonal dry periods and droughts especially in the face of climate change that is projected to increase the variability and intensity of rainfall in the long run. Rainwater collection also helps to stabilize the depleting groundwater level, while the storage infrastructure can reduce land erosion and flood inflow to major rivers. It acts as a convenient source of stored water that could enhance agricultural productivity, decrease travel time for rural women to remote water resources, resulting in better health and time for social activities.

3.2.2 Target for technology transfer and diffusion

The main target group for this technology is those communities in dryland areas of the country with high risk of water shortages and face critical challenges in accessing clean water for domestic purposes, livestock and irrigation use.

The preliminary proposed target for the transfer and diffusion of RWH technology is to construct 2,000 community and public-run surface rainwater harvesting reservoirs by 2015, each with a capacity between 25,000 m^3 to 50,000 m^3 depending on the water requirement of the community and other local physical conditions such as size of catchment area, slope angle, soil and vegetation types etc.

3.2.3 Barriers to the diffusion of technology

Some key barriers to the adoption of the technology at local levels are various economic and financial challenges which include insufficient resources such as low program budget compared to high cost of feasibility study, and construction and maintenance of reservoirs. There is also an additional cost of maintenance and repair of water conveyance structures that are damaged during floods. Another important barrier category is associated with weak technical, institutional and organizational capacities of the national and local institutions involved in irrigation and flood management. This includes both government departments and line ministries, and farmers' organizations and water user groups working with the government organizations.

In case of indigenous spate irrigation systems, the local water and land ownership rights are quite ambiguous due to weak, or sometimes non-existent, regulatory and legislative statutes governing water management and distribution at the local levels. The absence of or low understanding of water rights directly translates into an inequitable distribution of water among farmers and other water beneficiary groups at the community level creating some serious conflicts among the community members. The concerned government departments and line ministries typically offer limited external support to the community water managers who already suffer from severe capacity issues.

To overcome these barriers, the following measures are proposed:

i. To offset high initial cost of construction of water channels, diversions and water reservoirs, the government should ensure sufficient funding for the concerned departments through dedicated budgetary allocations in provincial and district level ADPs, and attracting some international donors funding;

ii. Design and implement various strong policy instruments to deal with various regulatory and legislative issues concerning RWH technology. A key starting point could be the review of and necessary amendments in water and land rights in order to support swift and sustainable technology adoption;

iii. Start awareness campaign on the future negative impacts of climate change on our water resources and how it would affect the productivity of key sectors of agriculture, energy and industry, and the resilience of individuals and the society in the long-term future;

iv. To improve ownership of the technology at the national and local levels, the participation and engagement of local community should be held mandatory during the key stages of decision-making processes by government officials;

v. Increase financial support to relevant R&D institutions in order to enhance their technical capacity.

It is expected that the successful implementation of the proposed technology action plan will help in its wider and swifter adoption and diffusion in the society, as well as would ensure easy access to water and improve the overall resilience of the households and communities in the face of climate change.

3.2.4 Proposed action plan for surface rainwater harvesting technology

SECTOR: WATER						
Technology: Rainwater harvesting (from ground surfaces)						
Action 1: Ensure sufficient yet dedicated supply of funding for the government departments involved in different key aspects of the technology						
Justification for the action: This will help mitigate or reduce various economic and financial barriers arising from high cost of project feasibility studies, construction and maintenance of water reservoirs and/or its linked conveyance systems, and engagement of local communities or water user groups						
Sr. No.	**Activity**	**Priority Rank**	**Implementing Agency**	**Time Scale**	**Cost & Funding Source**	**Indicator of Success and Risk**
1.1	Allocate dedicated funding in the annual development budgets, on priority basis for the construction of 2000 water reservoirs	High	Ministry of Planning & Development; Provincial Finance Department, and Agriculture and Irrigation Departments	0-10 years	US$ 0.2-0.5. million for each dam. ADP and donor funding specially ADB	**Success**: 10-30 percent funding increase in the annual budget **Risk**: Lack of funding,
1.2	Advocacy campaign targeting policy makers and legislators for gaining support on funding	Low	Ministry of Planning & Development; Provincial Development, Agriculture and Irrigation Departments	0-3 years	ADP and donor funding specially ADB US$ 30.000	**Success:** Policy support on technology **Risk**: Poor campaign targets
1.3	Strengthen administrative mechanisms for attracting from donor agencies	High	Ministry of Planning & Development & Ministry of Finance	0-5 years	ADP and donor funding specially ADB US$ 50,000	**Success**: Strong administrative mechanisms **Risk:** Change in policy or policy support
1.4	Provide financial and technical assistance on priority bases to farmers harvesting RW	Medium	Provincial Agriculture and Irrigation Departments	0-5 years	ADP and donor funding specially ADB US$ 550,000	**Success:** Number of farmers adopting technology on self-help bases **Risk:** Lack of funding
Action 2: Build and strengthen the institutional capacity of the responsible organizations to undertake pre-feasibility studies and site selection.						

Justification for the action: Current relevant institutions are lacking in terms of human resources and technical expertise

2.1	Enhance financial support to R&D institutions for enhancing their capacity	High	Provincial Development, Agriculture and Irrigation Departments	0-3 years	ADP and donor funding. US$ 2 million	**Success**: Availability of well-trained qualified professionals. **Risk:** Human and technology performance risk
2.2	Arrange prioritization of regions in dire need of rainwater harvesting reservoirs and identification of potential sites.	High	Provincial Development, Agriculture and Irrigation Departments	0-5 years	ADP and donor funding. US$ 1.0 million	**Success:** Availability of well-documented feasibility studies. **Risk:** Human performance risk
2.3	Arrange trainings on need-based manner and also skills of researchers though training / workshops and foreign visits	High	Provincial Development, Agriculture and Irrigation Departments	0-5 years	ADP and donor funding. US$ 200,000	**Success:** Availability of well-trained qualified professionals. **Risk:** Low quality of training programs
2.4	Adopt flexible Communication strategy to promote inter-agency coordination	Medium	Ministry of Climate Change, Provincial Development, Agriculture and Irrigation Departments	1-3 years	ADP and donor funding. US$ 100,000	**Success:** Increased coordination. **Risk:** No appreciable risk
2.5	Promote transfer of knowledge (specifically indigenous one) through building research collaborations among experts at regional and international organization working on the same issues	High	Ministry of Planning & Development; Provincial Development, Agriculture and Irrigation Departments	1-5 Years	ADP and donor funding. US$ 300,000	**Success:** Increased research collaboration. **Risk:** No appreciable risk identified

Action 3: Raising knowledge on operation and management practices of rainwater harvesting systems through involvement of local communities

Justification for the action: This action will add towards the sustainability of the systems because of **enhanced** information, training, or guidance						
3.1	Awareness creating on good operation and management practices and change in water use behaviour by organizing campaigns to raise awareness on importance of rainwater harvesting, water saving and efficiency	High	Provincial Agriculture and Irrigation Departments	2-4 years	ADP and donor funding. US$ 400,000	**Success:** Number of awareness programs. **Risk:** No appreciable risk identified
3.2	Ensure participation of local communities in all stages of decision making process through committees to ensure sustainability of Technology	Medium	Local governments	0-5 years	ADP and donor funding. US$ 400,000	**Success:** Communities active participation **Risk**: Lack of political / administrative support
3.4	Encourage communities to establish reservoir operator organizations.	Mediu m	Local governmen ts	0-3 year s	ADP and donor funding. US$ 500,000	**Success:** Communities active participation **Risk**: Lack political / administrative support
Action 4: Design appropriate legislation/regulation regarding rainwater harvesting policy						
Justification for the action: The lack of policy and regulations makes it challenging to design efficient rain harvesting techniques						
4.1	Develop and implement technology support policy and necessary regulations	High	Ministry of Water & Power; Provincial Development, Agriculture and Irrigation Departments	1-3 yea rs	ADP and donor funding . US$ 250,000	**Success:** Development of technology supporting regulations **Risk:** Lack of political and administrative support
4.2	Develop regulations on the role and responsibilities of stakeholders in management, utilization and operation of rainwater reservoirs.	Medium	Ministry of Water & Power; Provincial Development, Agriculture and Irrigation Departments	0-3 years	ADP and donor funding. US$ 150,000	**Success:** Development of technology supporting regulations **Risk:** Lack of political and administrative support

3.3 Action plan for groundwater recharge

3. 3.1 About the technology

Artificial groundwater (or aquifer) recharge is an activity that aims to increase the natural replenishment or percolation of surface water into the ground aquifer, so that groundwater level stays stable relative to its rate of abstraction by the people for different purposes. The activity is typically confined to the areas with depleting aquifers and the final selection of a recharge technique is therefore site specific and needs extensive hydro-geological studies.

Apart from replenishing groundwater level, the technology offers some other important cross-sector co-benefits, such as conservation or disposal of flood water, control of saltwater intrusion in areas below sea level and with frequent exposure to sea currents, storage of water to reduce pumping and piping cost and water quality improvement (Asano, 1985). The technology has many major applications, such as, in wastewater disposal and treatment, crop development, stream flow augmentation and prevention of land subsidence, among others (Oaksford, 1985).

In Pakistan, agriculture sector is the biggest user of groundwater making up almost 90 percent of the total groundwater use, followed by household and domestic uses. The situation is quite opposite in large urban centres, especially in the province of Punjab, where about 90 percent of population relies on extracted groundwater for their daily domestic needs. This high level use of groundwater for irrigation comes with a high cost however, which is reported to be typically 30 times higher than the cost of surface irrigation water in the Indus Basin irrigation system regions. Nevertheless, it is the most preferred choice by the local farmers due to a very high percentage of crop yields (50-100) as compared to those fully dependent on canal water (Shah, 2007; World Bank, 2007).

The technology is of prime significance and value in areas of Pakistan where groundwater is the only easily accessible and highly reliable source of water for both irrigation and domestic purposes. The province of Balochistan, for example, faces a sharp decline in groundwater table threatening both the survival of human lives in certain hyper dry areas, and the sustainability of irrigated agriculture. To cope with such situation, the province has employed different recharge techniques such as surface spreading of rainwater, watershed management, and construction of recharge structures such as check dams, delay action dams, earthen ponds and wells. In 2007, IUCN Pakistan with the financial support from the Asian Development Bank (ADB), installed boreholes and infiltration galleries for the first time in Pakistan under a groundwater aquifer rejuvenation demonstration pilot project in Balochistan. The technology installation aimed at increasing recharge flow of 'karezes' [1] and water levels in open wells in the study area (ADB, 2007). The experience with full-scale artificial recharge operations in the country is almost non-existent, and hence poses a great challenge to fully estimate the cost effectiveness of such operations at a large scale specifically under the looming uncertainty of climate change.

3.3.2 Targets for technology transfer and diffusion

[1] Karez is an indigenous under-ground water conveyance system, which is present only in the province of Balochistan. The system however is not functional anymore in the most parts of the province due to the critically low water tables and the prevalent extreme dry conditions.

The main target group for this technology is those communities in dryland areas of the country with high risk of water shortages and face critical challenges in accessing clean water for domestic purposes, livestock and irrigation use.

i. Set-up groundwater monitoring network for those critically vulnerable areas where groundwater is below a certain threshold value;

ii. Undertake detailed feasibility studies for the selection of suitable sites for various groundwater recharge structures such as check-dams, delay action dams and injection wells etc.;

iii. Construct demonstration and pilot groundwater recharge projects to improve visibility of declining groundwater issue in the country, and gain support from the concerned communities.

3.3.3 Barriers to the diffusion of technology

A major barrier to the diffusion of the technology is the absence of any comprehensive, consistent, and collaborated management strategy that would monitor and evaluate the sustainability of groundwater resource with full participation and guidance from various key stakeholders present both at local and national levels. The current groundwater governance system is amorphous in nature with no single management body overseeing the management of the resource at the national level. This lack of coordinated efforts have led to the preferences for some short-term policy solutions in the past that have resulted in some conflicting policy choices and resource management strategies. For example, electricity in Pakistan is one of the most subsidized items for the farmers with tube-wells to support them expand their agricultural cropping area, but on the other hand, this has led to extensive abstraction of groundwater by the same farmers.

Another important barrier is the high cost of construction and management of community based water reservoirs, such as check dams, and action relay dams. In some cases in the past, their monitoring and management have been, completely (or partially), left to the community water mangers leading to the rapid deterioration of the physical structures and creating serious conflicts among different water user groups over the ownership rights to water. Consequently, this situation very likely has weaken the voluntary or advisory policy instruments that were offered to motivate voluntary actions such as voluntary participation of groundwater user groups and associations to manage the resource at the community scale. However, a challenge identified in this respect was, the lack of proper technical knowledge among the community members.

Finally, another important barrier identified is the reliability and adequacy of the current data and information on groundwater quantity and quality. The data is sparse, scattered, and with a degree of questionable authenticity. The hydrological boundaries of groundwater aquifers in the country, in particularly in areas with a high decline rate of the resource, are still not precisely defined that makes it extremely complicated and challenging to specify and set both the technical and social boundary of the resource in an area. Due to the importance of water as a key livelihood and economic resource, the issue is highly political in nature that adds to the challenge of managing authorities to plan for a long-term.

To improve the groundwater recharge condition in the country and mitigate or reduce these barriers, some key approaches are identified and proposed:

i. Introduce and implement market based water permitting and licensing systems, with suitable subsidies or loans, to bring the high cost of construction and maintenance of water reservoir systems down;

ii. Promote and regulate conjunctive use of available surface water (canal or runoff water) with groundwater to manage water quality and cost for the irrigation purposes;

iii. Adopt whole-aquifer approach for R&D activities; a good starting point could be developing and maintaining a comprehensive database of information on groundwater users, various types of uses, groundwater abstraction quantity, aquifer conditions, water table depth and groundwater quality;

iv. Favour traditional local practices and indigenous knowledge in the participatory decision-making processes at the local level;

v. Integrate strong conflict resolution mechanisms in groundwater governance system in order to resolve regulatory and advisory policy issues at the community level.

3.3.4 Proposed action plan for the groundwater recharge system

SECTOR: WATER

Technology: Groundwater (aquifer) recharge system

Action 1: Determine priority critical areas for groundwater recharge using the available technical information and measurements with constant up-gradation in case of new set of available information

Justification for the action: Identifying the region-based critical areas will provide a focus for the policy makers to design pertinent water management solutions

Sr. No.	**Activity**	**Priority**	**Implementing Agency**	**Time Scale**	**Cost & Funding Source**	**Indicator of Success and Risk**
1.1	Develop an open-source database of aquifer systems in over-exploited areas: some potential information includes groundwater regime, quality, climatic condition, physiographic and drainage aspects	High	PCRWR, Provincial irrigation & Agriculture Departments	0-5 years	ADP and donor funding. US$ 500,000	**Success:** Availability of open source, reliable groundwater information. **Risk:** Lack of funding and technical expertise, lack of political support.

1.2	Determine priority recharge areas with critical blocks based on the "quantified" artificial recharge potential	High	PCRWR, Provincial irrigation & Agriculture Departments	0-3 years	ADP and donor funding. US$ 800,000	**Success**: Widely available reliable groundwater information. **Risk**: Lack of funding and technical expertise, lack of political support
1.3	Construct permanent ground water recharge system based on the area specific recharge technique and design	High	PCRWR, Provincial irrigation & Agriculture Departments	0-5 years	ADP and donor funding. US$ 1-3 million for each site	**Success**: Increase in groundwater level. **Risk**: Lack of funding
Action 2: Devise a holistic policy framework on ground water recharge that is completely aligned with, and supports the surface water regulations and strategies						
Justification for the action: This will help to employ a conjunctive use of surface and groundwater in the irrigation sector and will bring a multitude of stakeholders on one platform for a collective action on water management						
2.1	Coordinate, harmonize, synergize roles and functions of some key government departments involved in groundwater/surface water management	Medium	PCRWR, Provincial irrigation & Agriculture Departments	0-2years	ADP and donor funding. US$ 100,000	**Success:** Well defined roles of the departments **Risk**: Lack of political and administrative support
2.2	Approve plans for the recharge of groundwater resources with an emphasis on a balanced utilization of surface and groundwater.	Medium	PCRWR, Provincial irrigation & Agriculture Departments	0-3 years	ADP and donor funding. US$ 70,000	**Success:** Detailed approved plans of groundwater recharge. **Risk:** Lack of political
2.3	Place a special water conservation cell with advisory role to the government on conflicting policies/ action plans on surface and groundwater.	Medium	PCRWR, Provincial irrigation & Agriculture Departments	0-5 years	ADP and donor funding. US$ 200,000	**Success:** Well functioning special water conservation cell. **Risk**: No appreciable risk identified
Action 3: Build and strengthen the institutional capacity of the organizations dealing with water management and monitoring at the community, regional and national levels						
Justification for the action: To ensure efficient integrated planning and management among various agencies, departments and private sector in order to enhance resource use efficiency						

3.1	Continuous need-based training and education of professional staff of the relevant institutions.	Medium	PCRWR, Provincial irrigation & Agriculture Departments, water user associations,	0-5 years	ADP and donor funding. US$ 400,000	**Success:** Availability of well trained professionals **Risk**: Low quality training programs
3.2	Connect water organizations with weather/ climate monitoring organizations such as PMD	Low	PCRWR, PMD, Provincial irrigation & Agriculture Departments, water user associations	0-3 years	ADP and donor funding. US$ 50,000	**Success**: Strong institutional networking **Risk**: Lack of administrative support.
3.3	Promote transfer of knowledge through building research collaborations among experts in various organizations	Medium	PCRWR, PMD, Provincial irrigation & Agriculture Departments, water user associations	0-3 years	ADP and donor funding. US$ 100,000	**Success**: Strong institutional networking. **Risk**: No appreciable risk identified

3.4 Action plan for urban stormwater management

3. 4.1 About the Technology

Managing stormwater is one of the biggest and most expensive challenge that the urban cities around the world face today. Regardless of high construction and maintenance costs of the system, stormwater management is quickly becoming a high development priority for local government authorities in regions where high intensity rainfalls or cyclones frequently inundate the local properties and other important infrastructures or unleash flash floods resulting in unexpected yet high socio-economic damages.

In Pakistan, cities and towns typically utilise a combined sewer system that convey both domestic and industrial wastewaters and stormwater runoff through a single pipe system to a receiving outlet, that is commonly a stream, lake or river, and mostly without any prior treatment for contaminations or pollutants. Due to this poor management of the system, the waste drainage pipes are frequently choked, resulting in overflows in the surrounding areas, and finally infiltrating groundwater sources. This situation is of high concern in areas where groundwater is a drinking water source and the infiltrated pollutants may cause various human health issues.

Stormwater management choices are tough, in that it is inextricably linked to other public services. A good storm drain, for example, is essential for basic sanitation and decent transportation, and so it needs proper solid waste management, in particular in case of combined sewer systems. Ultimately, it may demand and require a comprehensive and effective land use planning and management mechanism functional at the individual city and town level.

Because of high costs of managing conventional stormwater systems, cities currently around the world are looking for and experimenting with new innovative and low cost techniques, such as Low Impact Development or LID practices. LIDs manage stormwater by minimizing impervious cover and by using natural or man-made systems to capture, filter, and recharge stormwater into the ground, replenishing groundwater supplies for future use. Roads, parking lots, and other types of impervious cover are the most important contributor to stormwater runoff (EPA, 2009). Some examples of LID practices are measures such as green roofs, rain gardens, vegetated areas, pocket wetlands, curb extensions, permeable pavements, reforestation, protection and enhancement of riparian buffers and floodplains (ibid).

3.4.2 Target for technology transfer and diffusion

Some preliminary targets identified for the diffusion of urban stormwater management technology in the country are given below:

i. Modernize and upgrade urban stormwater drainage infrastructures of 10 major towns by 2022;
ii. Introduce and set standards for low impact development (LID) infrastructure in 10 major cities/towns as a climate adaptation approach for urban stormwater management by 2022.

3.4.3 Barriers to the diffusion of the technology

The most significant barrier identified for this technology is high initial and O&M cost of the system needed for undertaking construction or repair of a citywide existing stormwater drainage infrastructure. The water and sanitation related services primarily falls under the jurisdiction and authority of local government authorities, which typically face funding and capacity issues in order to design and implement such high cost projects. Moreover, there is uncertainty over costs as well as cost-effectiveness of system, specifically in case of LIDs. In the absence of concrete and comprehensive land use and water policies at the local government scale, the government officials generally find weak regulatory power to develop, or increase, or enforce stormwater fees on the users that would generate local revenue for them to go ahead with their local programs projects.

3.4.4 Proposed action plan for the urban stormwater management system

SECTOR: WATER
Technology: Urban stormwater management
Action 1: Provide policy support through design and implementation of various efficient policy instruments and strategies
Justification for the action: The policy will support integrated water resource management, as well as green growth in the urban centres building towards the resilience of communities in the future

Sr. No.	Activity	Priority	Implementing Agency	Time Scale	Cost & Funding Source	Indicator of Success and Risk
1.1	Prepare urban planning policy with integrated elements of support from other sectors such as water, waste management, transportation, and environmental quality	High	Ministry of Planning and Development, concerned provincial departments and/or city development authorities	0-3 years	ADP funding. US$ 50,000	**Success:** Urban policy enacted. **Risk:** Lack of political support
1.2	Identify focus areas and specific actions through linking it with other existing policies, strategies such as green growth policy, sustainable development plan, or local watershed management plans	Medium	Provincial and local government departments	0-2 years	ADP funding. US$ 35,000 (per city)	**Success:** Action plans implemented **Risk:** Lack of political support, lack of funding,
1.3	Develop and/or update the urban zoning plans, master plans of transportation, watershed restoration plans	Medium	Provincial and local government departments	0-3 years	ADP funding. US$ 50,000 (Per city)	**Success**: Updated urban plans **Risk:** lack of funding, lack of technical experts
1.4	Establish and implement comprehensive set of Low Impact Development (LID) tools tailored to different land use types	Medium	Provincial and local government departments	0-3 years	ADP funding. US$ 50,000 (per city)	**Success:** LID tools established **Risk:** Lack of technical experts, lack of funding
1.5	Design and implement pilot projects in various cities with focus on existing urban infrastructure facilities to determine their significance to achieve stormwater neutrality	Medium	Local government departments or city development authorities	0-5 years	ADP funding. US$ 0.5 million for each city	**Success**: High visibility of the LIDs **Risk:** Lack of technical expertise
Action 2: Ensure sufficient and dedicated funding for the technology through taking integrated approach in its design and implementation						
Justification for the action: Availability of funds will handle high cost of project that is one of the key barriers to the implementation of storm water management projects in urban centres around the country						
2.1	Combine regular street improvements retrofits with development of enhanced city stormwater management infrastructure	Low	Local government departments, city development authorities	0-5 years	ADP funding. US$ 3.0 million for each city	**Success:** Improved urban infrastructure **Risk:** Lack of political and administrative support and lack of funding

2.2	Perform climate change risk & vulnerability assessments for the future urban infrastructure development projects	High	Local government departments/ city development authorities	0-10 years	ADP funding. US$ 0.1 million for each city	**Success:** Improved climate resilient urban infrastructure **Risk:** Lack of funding and technical expertise
2.3	Develop and practice robust planning procedures to ensure green infrastructure priorities are included in on-going and future infrastructure plans and programs	Low	Local government departments/ city development authorities	0-2 years	ADP funding. US$ 0.3 million for each city	**Success:** Robust planning procedures **Risk:** Lack of or weak legislative and regulatory support
2.4	Identify public and private financing sources such as grants, loans, tax-sharing agreements, bonds, community development tools etc. to fund stormwater management projects	High	Local government departments/ city development authorities	0-2 years	ADP funding. US$ 10.000	**Success:** Sources of funding identified **Risk**: No appreciable risk identified
2.5	Build partnerships with local and regional organizations to ensure support in innovative research and future implementation of green infrastructure improvements	Medium	Provincial and local government departments/ city development authorities	0-2 years	ADP funding/ US$ 0.1 million	**Success:** Strong partnership network **Risk:** Lack of funding

Action 3: Develop and implement a community outreach and communication plan with continuous follow-up evaluation and adjustments to meet the needs of target audience

Justification for the action: To ensure efficient integrated planning and management among various agencies, departments and private sector in order to enhance resource use efficiency

3.1	Identify and engage program support partners at national and local levels	Medium	Local government departments, city development authorities & NGOs	0-3 years	ADP funding. US$ 0.1 million	**Success**: support network built and operationalized. **Risk: No** appreciable risk identified
3.2	Develop and distribute guide books, brochures etc. on the benefits of green and LID infrastructure in the context of stormwater management	Medium	Local government departments, city development authorities, partner NGOs	0-2 years	ADP funding, US$ 10.000	**Success**: Improved urban landscape. **Risk:** Lack of funding

3.3	Promote environmental education, with special focus on climate change, for students, local town residents and business owners	Low	Local government department, city development authorities, and partner NGOs	0-3 years	ADP funding. US$ 20,000 for each city	**Success:** Improved understanding of environmental issues. **Risk:** Lack of funding
3.4	Arrange landscape designer challenge where the designers are paired up with home-owners to transform the landscaping of a block/street with the key aim to improve stormwater condition in the areas	Low	Local government department, city development authorities, and partner NGOs	0-3 years	ADP funding. US$ 10,000	**Success**: Improved urban landscape. **Risk**: Lack of funding

Report-IV

Project ideas for the Agriculture & Water sectors of Pakistan

Project Idea-1: Building the resilience of agriculture sector against the impacts of climate change through promotion of (drip and sprinkler) micro-irrigation systems in Pakistan

1.1 Introduction

Agriculture sector is one of the most vulnerable sectors of Pakistan to the impacts of climate change. The downscaled climate models for the country project 3°C–6°C rise in mean temperature, with a sharper rise noted after the year 2020, under different GHG scenarios by the end of this century. The rainfall, however is highly variable both in spatial and temporal domains, with some areas facing extreme precipitation events while other suffering from drought (PMD, 2015). This change in climate has serious bearing on the productivity of the agriculture sector. Research studies for Pakistan show that by increase in temperature from 0.5°C–1°C the agricultural productivity will decline by 8 percent - 10 percent by 2040. In case of major crops, 6 percent reduction in wheat and 15 percent–18 percent for fine-grain aromatic basmati rice yields will occur in all agro-climatic zones of the country except in the northern areas where temperature rise is projected to be the highest by the end of the next century (Iqbal et al., 2009).

The total cropped area in Pakistan is 23.4 Mha, of which irrigated areas make up 18.63 Mha (24 percent of the total cropped area) and 3.8 Mha areas is Barani or rainfed farming systems (GoP, 2014). Pakistan relies heavily on canal irrigation system for its horizontal expansion in order to ensure food security for its fast growing population but the water losses from the system is quite high. In case of Punjab province only, for example, which holds 77 percent of total irrigated areas of the country, water loses reaches up to 45 MAF out of 90 MAF of total available water to crops (Government of Punjab, 2015). Likewise, a major part of the country is arid to semi-arid with little available water. Water conservation and management therefore emerges as the top most need of the country to help the farmers to adapt to the negative impacts of climate change.

1.2 Background and rational

HEIS were introduced in Pakistan around early 80s and since then have been tested and implemented in all provinces with a heavily subsidized support by all the provincial governments. Despite their long history of use, HEIS are still not a go-to technology by the farmers. The research on barriers to the technology’s transfer and rapid replication in Pakistan has indicated many challenges, such as the underdeveloped market with a fragmented supply chain, policy and institutional capacity issues along with little awareness and information on the benefits of technology, particularly in the context of climate change.

HEIS are in high demand in all parts of the four provinces of Punjab, Sindh, KP and Balochistan that are either under irrigated canal systems or rainfed agriculture.

Climate change impacts on the country are real and it has already seeing some of its negative consequences threatening water security of the country.

The implementation possibility is quite high as HEIS projects have been constantly part of resource development and management projects and programs in all the four provinces in the past few decades. In fact, the government of Punjab is running one of the largest HEIS diffusion program in the country under Punjab Irrigated-agriculture Productivity Improvement Project (PIPIP) since 2011 with financial assistance from the World Bank. The project aims to install HEIS on 13,991 acres by the end of the project in 2017. An important component of this project is the identification of qualified HEIS companies, registering them with the Punjab Agriculture Department, and using their services to design and install HEIS system for farmers along with a provision of constant support services for the next two years of the technology life (Government of Punjab, n.d.).

1.3 Purpose and Objective

This project aims to create an enabling environment in the country for the successful diffusion and replication of the technology in order to improve the resilience of the sector against impacts of climate change in the medium and long-term future.

The project carries the following objectives:

i. Improve access of farmers, particularly smallholders, to good quality and low cost HEIS technology;
ii. Enhance awareness and information on climate change impacts on food and water security and the role of HEIS to achieve these objectives;
iii. Build and increase efficiency, quality and diversity of HEIS market through regulating market;
iv. Achieve the capacity building of key catalytic actors and institutions in the country.

1.4 Project deliverables

It is expected that the project will deliver the following outcomes:

i. HEIS is installed on 10,000 small landholders farmers, with special consideration to rainfed and dryland areas;
ii. Under the capacity building activities, 5,000 farmers and 180 local government/extension departments staffs are trained in the different aspects and use of technology;
iii. The HEIS domestic market share is increased, at least by 5-10 percent, in the overall agricultural products/technologies market.

1.5 Relationship to the country’s sustainable development priorities

Pakistan Vision 2025, as a focal policy guidance document, identifies energy, water and food security as its fourth key policy area that would help the country to achieve its sustainable development goals. The document emphases on increasing the water storage capacity of the dams to 90 days, improving the efficiency of water usage in agriculture by 20 percent, and reducing the size of food insecure population from 60 percent to 30 percent. This efficiency in water use in agriculture sector can be achieved successfully through the use and expansion of HEIS technology in the country. Similarly, some other key policy documents such as the National Climate Change Policy (2012) and its Implementation Framework (2014) also acknowledge the importance of HEIS in the context of climate change (GoP, 2012).

1.6 Project benefits

The project will improve food security, livelihood and resilience of vulnerable communities using efficient water conservation technology to counter the effects of climate change in Pakistan. The activities designed will also help in creating a stable, functional and competitive HEIS market in the country that would have the capability and capacity to expand the traditional HEIS market beyond their original boundary or sector such as from agriculture to urban setup, natural and built green spaces, etc. It is also expected that the market would develop robust supply chains to target specific market segment with specific products while maintaining a high product quality or brand reputation. Project will also benefit farmers, and other technology users to learn about climate change adaptation and improve their resilience scale while increasing the institutional capacity of the catalytic actors. In the long term, the project would create more jobs, skilled labor forces, and a well-functioning dynamic domestic HEIS market.

1.7 Monitoring and evaluation

Project would be supervised and its implementation closely monitored by the Project Steering Committee jointly chaired by the TNA National Coordinator and Representative of respective Federal / Provincial Ministries of Agriculture. Other members would include representatives from relevant government institutions, NGOs, development partners and project beneficiaries. Project manager would be required to submit quarterly progress report to the steering committee. This would provide an opportunity to keep a track on progress made in relation to project objective set and to make necessary adjustment where necessary. A mid-term and final project evaluation will also be undertaken to assess its effectiveness that will form a basis for lesson learnt and its replication.

1.8 Project activities and timelines

Sr. No.	Activity	Time-Frame	Budget	Relevant Agency
1.0	**Expand capacity of relevant stakeholders:** Identify the training needs of beneficiaries in the subject areas of water management, technology operation and maintenance, and climate information Increase R & D and training facilities Improve coordination and information sharing among	2-3 years	US$ 0.5 million	Ministry of National Food Security and Research (MNFSR) and Provincial Agriculture Departments

	stakeholder organizations			
2.0	**Improve financial incentives:** Enhance availability of financial resources such as grants, subsides, loans or other forms of assistance to install and maintain HEIS Improve investment risk insurance	0-5 years	US$ 6.0 million	Ministry of Finance and provincial Finance Departments
3.0	**Market strengthening and expansion** -Conduct market situation analysis -Design and implement HEIS product certification and quality assurance procedures -Design and implement a HEIS product manufacturing training programs -Support enforcement of product monitoring and regulation policies, laws and regulations.	0-2 years	US$ 0.6 million	MNFSR and Provincial Agriculture Departments
4.0	**Improve policy coordination to build resilience of the sector** -Review and analyze respective national/sectoral policies to support agriculture and related sectors (e.g. water) Integration of climate change component into national budgeting and planning processes -Generate new climate information and increase awareness on the impacts of climate change on the country	1-3 years	US$ 70,000	Ministry of Climate Change, MNFSR,, Provincial Agriculture Departments and PMD

1.9 Possible Challenges

The key challenges in the implementation of this project could be:

i. In the absence of attractive financial incentives, the high cost of these systems may result in limited adoption by the framers;

ii. Low cost of irrigation water leading to its unscrupulous use and little attraction for investment in water saving technologies;

iii. Low interest in joining the training programs by local business owners may be leading to weaker human capacity

iv. Resistance of local businesses to quality control certification programs may lead to the supply of low quality HEIS in the market;

v. Operational risks including weak technical design of the project that could later threaten project sustainability.

Project Idea-2: Development and diffusion of drought and heat tolerant crop seed varieties in Pakistan

2.1 Introduction

Climate change, particularly heat and drought stress, will continue to reduce the performance of staple crops worldwide (Challinor et. al., 2014; Asseng et. al. 2015). Economists project that by 2050 – in the absence of unprecedented, coordinated measures to raise productivity, consumers will pay 50 percent more for cereals in real terms, and climate change is also predicted to add another 60 million hungry people to the world (Wiebe et. al., 2015). Wheat, which provides 20 percent of food calories globally, must increase productivity by more than 60 percent in this timeframe in order to match demand. This represents a major challenge to food security globally, and particularly in Asia, where more than half of the developing world's wheat crop is planted. Scientists across different disciplines have argued that the opportunity exists to improve the leverage of knowledge, expertise, and physical infrastructure to achieve greater returns on investment from biotechnology and breeding (Reynolds et al., 2016).

Plant response to physiological stresses such as drought is very complex phenomenon, the research shows it could be enhanced through improving crop selection efficiency through various conventional breeding and genetic tools (Barnahas et al., 2008). Drought tolerant crop varieties are rather a less researched area in Pakistan due to a relatively low priority placed on dryland agriculture. In the past few decades, some prolonged occurrences of drought have been noted across the country, which has seriously affected the crop production capacity even in the irrigated agriculture zones of the country. It is therefore, important to consider developing and disseminating drought tolerant crop varieties seeds that offer food and livelihood security to the millions of small farm holders in Pakistan.

2.2 Background and rational

Hybrid crop varieties are a less-researched area in the country; little information is available on hybrid crop varieties in general and drought tolerant crop varieties in specific, including its market share and size. According to an estimate however, the seed industry, as a whole, in the country was worth US$ 2.5 billion in 2013-2014 only. The seed requirement for various crops was calculated to be around1.67 million tons, and farmers were short of 1.3 million tons of quality seeds (Hussain, 2011).

Nevertheless, the seed industry, in general, remains small in size, fragmented and mostly unregulated in Pakistan. The use of certified seeds are only 20 percent among the farming community, and most of the farmers either use uncertified seeds with unknown quality or depends on their own indigenous seeds. The data and information on the share of market occupied by the drought tolerant crop varieties in the national seed industry is almost non-existent.

According to the future climate change projections for the region, with a change of 3°C–6°C rise in mean annual temperature under different GHG scenarios by the end of this century expected, a wider region of the country could be impacted by drought

(PMD, 2015). This projection calls for a serious attention of policy and decisions makers to hybrid drought crop varieties in order to ensure food & livelihood securities of households and individuals in the future.

2.3 Purpose and Objectives

The project aims to meet the demand of, and improve access to good quality, yet affordable drought tolerant crops seeds through strengthening the seed variety development programmes in the public research institutes. The project also focuses on the development of potential new drought tolerant varieties, its testing, registration, and wide dissemination in the country. The project puts strong emphasis on leveraging and capitalizing on current public-private partnership networks existing among international and national research organizations and other stakeholders for the implementation of program.

Some common objectives of the project are:

i. Develop new local drought tolerant crop varieties especially for the rainfed ecologies to improve food security in the face of climate change;

ii. Improve availability of, and access to the improved drought tolerant crop cultivar seeds by farmers, particularly in rainfed, and drought-threatened areas of the country, at the affordable price;

iii. Create awareness on drought tolerant crop varieties among farmers, and policy makers;

2.4 Project deliverables

After the implementation of the project, the following deliverables are expected:

i. 20 new certified seed varieties of important cereal crops and vegetables are released and available to the farmers in the domestic market;

ii. Drought tolerant crop (cereal and vegetables) are cultivated on 50,000 ha of land in the country;

iii. Independent seed act enforcement wings, with all requisite infrastructure, are established and operational at provincial levels.

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2.5 Relationship to the country’s sustainable development priorities

Pakistan Vision 2025, as a policy road map document, identifies energy, water and food securities as one of the seven pillars of change and transformation in the socio-economic condition of the country. The document identifies Pakistan’s challenge to attain food security as it ranks 76th of the 107countries on the Global Food Security Index. To tackle this situation, it proposes to improve water efficiency in agriculture by 20 percent; reduce food insecure population from 60 percent to 30 percent. The development of drought and heat tolerant crop varieties have also been strongly recommended in the National Climate Change Policy (2012) and it's Implementation Framework.

2.6 Project benefits

The following benefits are expected:

i. Contributing towards food, livelihood and nutrition security of farming communities in the rainfed ecologies;

ii. Increasing the share of stress tolerant seed market in the country;

iii. Institutional and technical strengthening of research institutes and organizations involved in various steps of stress tolerant seed production;

iv. Supporting the development and dissemination of new technologies, also enabling spill over to other crops facing climate change related problems;

2.7 Monitoring and evaluation

Project would be supervised and its implementation closely monitored by a Project Steering Committee chaired by TNA National Coordinator. Other members would include representatives from relevant government institutions, NGOs, development partners and project beneficiaries. Project manager would be required to submit quarterly progress report to the steering committee. This would provide an opportunity to keep a track on progress made in relation to project objective set and to make necessary adjustment where necessary. A mid-term and final project evaluation will also be undertaken to assess its effectiveness that will form a basis for lesson learnt and its replication.

2.8 Project activities and timeline

Sr. No	Activity	Time Frame	Budget	Relevant Implementing Agency
1	Capacity building of the staff of existing plant breeding and genetic engineering institutes, concerned certification and registration departments, seed multiplication agencies at the federal and provincial levels	0-4 years	US$0.8 million	Ministry of National Food Security and Research, PARC, Provincial Agriculture Departments, Universities Agriculture Departments
2	Dedicated funding grant for the research institutes involved in the development of drought tolerant crops seed varieties	0-5 years	US$2.5 million	Ministry of National Food Security and Research, PARC, Provincial Agriculture Departments, Universities Agriculture Departments
3	Establishment of strong partnership with public and private seed companies, Community based organizations, NGOs and national extension systems	0-4 years	US$0.2 million	Provincial Agriculture Departments, NGOs, CBOs and Agriculture Extension Services
4	Provision of incentive to large seed companies to accelerate the commercialization of drought tolerant seeds	0-3 years	US$0.4 million	Provincial Agriculture Departments & seed companies

5	Provision of subsidies to ensure easy and cost-effective availability of these seeds to farmers	0-3 years	US$1.0 million	Provincial Agriculture Departments and Extension Services
6	Farmers' awareness raising and sensitization programs about the usefulness of these improved seeds	0-4 years	US$0.1 million	Provincial Agriculture Departments and Extension Services
7	Strengthen federal and provincial seed councils to develop and commercialize improved seeds at affordable rates	0-3 years	US$0.4 million	Provincial Agriculture Departments and Extension Services
8	Capacity building of private sector seed companies and public sector seed inspectors to improve overall quality and seed marketing processes.	0-5 years	US$0.5 million	Provincial Agriculture Departments & seed companies
Total cost = US $5.9 million				

2.9 Possible challenges

The key challenges in the project may be:

i. The high cost of these new seeds and crops varieties may result in limited adoption by framers in the absence of attractive financial incentives;

ii. Limited technical institutional or human capacity to develop new seeds varieties may affect the achievement of project objectives;

iii. Capacity building of all the stakeholder groups may be a challenge for the implementing agency or department, if it has severe capacity issues;

iv. Possible delays in the implementation of the pilot projects due to administrative and technical capacity issues.

Project Idea 3: Strengthening climate monitoring, weather forecasting and early warning system in Pakistan

3.1 Introduction

Due to its unique physical and demographic conditions, Pakistan is highly vulnerable to a wide spectrum of disasters like floods including flash floods and glacial lake outburst floods (GLOFs), landslides, droughts, cyclones, and heatwaves. Based on the quantified impacts of extreme weather events – both in terms of fatalities as well as economic losses, the Global Climate Risk Index (CRI) ranks Pakistan among the top ten most affected countries to the disasters in the world over the past two decades (1995-2014) (Kreft, 2015). This high ranking on CRI comes as a warning to the country that it is at a high risk to future catastrophes and therefore in need of a strong and effective early warning system operating at the community levels.

In the recent years, Pakistan is seeing impacts of climate variability in the form of some recurring hazards such as flooding. A strong contributing factor identified in this regard is the onset of strong pre-monsoon rains, and when coupled with heavy monsoon spell, it leads to both flash and normal flooding inundating urban areas, damaging crucial infrastructures destroying vast agricultural lands along with loss of human lives. In 2016, for example, pre-Monsoon rains resulted in 267 deaths besides damages to 3,028 houses (NDMA, 2016). Other important contributing factors identified are changes in the upstream land-use and a continuously increasing concentration of population and assets in flood prone areas.

To deal with these hazards, it is exceedingly important to strengthen Early Warning System (EWS) in the country, particularly at the community levels. This would involve building and enhancing the capacities of the institutions involved in managing the different aspects of EWS. A timely generated and disseminated warning information is the basic element of this system that helps to enable the individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately to reduce the possibility of harm or loss.

3.2. Purpose and objectives

The proposed project focuses on building the capacity of PMD, which is responsible for the development and operation of EWS in Pakistan. The project aims to:

i. Strengthen the technical capacity of the organization through expanding its network of regional flood forecasting and warning centres at the regional scale;

ii. Improve the working mechanism of warning information and communication networks;

iv. Build the institutional capacity though creating and strengthening the linkages with partner organizations and key stakeholder groups.

It is expected that this scaling up of EWS will Improve the coverage of the hydro-meteorological observational systems to generate timely, reliable, and geographically relevant early warnings and weather forecasting information to respond to and manage climate impacts. This will also support climate vulnerability and risk assessments as part of the process to meet the objectives of the National Climate Change Policy and help its mainstreaming in sector specific plans and strategies.

3.3 Background and rational

The Pakistan Meteorological Department (PMD), at present, is the only organization in the country that deals with the weather forecasting and early warning systems. Currently, PMD operates a network of around 97 meteorological observatories but still leaves out most part of Balochistan, hilly terrains of Khyber Pakhtunkhwa (KPK), Gilgit Baltistan (GB), and Azad Kashmir (AJK). The existing system is old, and with a limited capacity to generate accurate and reliable weather data for the whole country essential for effective forecasting and disaster risk management.

The organization has a specialized Flood Forecasting Division (FFD) – the only specialized center in Pakistan but with no regional wings or centers. This situation inevitably creates a huge vacuum in multi-hazard EWS in terms of updated information generation and dissemination to the local communities. A good example of this challenge is dealing with GLOFs or flash floods. According to an estimate, there are 2,420 glacial lakes in the Indus Basin, of which 52 are identified as potentially dangerous and could result in GLOF with serious damages to the human lives and infrastructure.. The capacity and reach of EWS dealing with GLOF is currently limited, weak and slow. Overall, there is a dire need to establish well equipped and advanced regional flood forecasting centers at the provincial levels, including Karachi, Peshawar, Quetta and Gilgit along with Automatic Weather Stations Network (AWS) covering all the country

3.4 Project deliverables

i. Strengthened technical capacity of PMD through installation of 200 automatic weather stations, wind profilers at 5 main airports, automation of 50 existing observatories, and establishment of observatories in 20 new districts round the country;

ii. Efficient communication system is established among PMD, NDMA, PDMAs, FFC, and Media.

3.5 Relationship to the country's sustainable development priorities

To protect vulnerable communities, and help them build their resilience against climate-related disasters, it is imperative for a country to design and implement a strong disaster management system and strategy plans. Pakistan acknowledges the power of disasters in weakening the local and national economies, and therefore eroding the collective gains of the socio-economic growth of the society. Early warning system, in the overarching context of disaster management, gets highlighted in many policy frameworks and strategies.

The National Disaster Management Authority (NDMA) prepared a 'multi-hazard early warning system plan' in 2012, with a 10-years implementation time period until the year 2022. The plan mandates to review the plan after every five year. The initial short to medium term projects emphasizes on the rehabilitation and new installation and/or establishment of new equipment, facilities, and systems including community-based risk management (NDMA, 2012).

This plan became the initial stimulus for the formulation of the first National Disaster Risk Reduction Policy in 2013. The Policy aims to build the resilience of Pakistan against both natural and man-made hazards with a sense of urgency. One of the major policy objectives is to "create multi-hazard warning capacity while building upon existing systems and emphasizing the information and warning needs of vulnerable and end-users" (NDMA, 2013).

Similarly, The National Climate Change Policy (2012) also identifies and acknowledges the strong linkages of climate change and disaster risk reduction for the sake of climate resilient development. Therefore, disaster preparedness and management appears as one of the focal climate policy area that the Policy urges the government to consider in building the adaptive capacity of the communities in the face of climate variability.

3.6 Project benefits

The project is expected to benefit the vulnerable communities in the targeted districts of the country. The decentralization of the flood forecasting and warning system to the provinces will promote the sense of ownership and authority among local stakeholders, which is expected to motivate the provinces to invest in the strengthening of EWS. Likewise, the relay of flood warnings in local languages will help improve the understanding of the warning messages clearly and will lead to more effective and better emergency responses by the local communities.

3.7 Monitoring and evaluation

The project would be supervised and its implementation closely monitored by a project steering committee jointly chaired by TNA National Coordinator and DG PMD. Other members would include representatives from relevant government institutions, NGOs, development partners and project beneficiaries. Project manager would be required to submit quarterly progress report to the steering committee. This would provide an opportunity to keep a track on progress made in relation to project objective set and to make necessary adjustment where necessary. A mid-term and final project evaluation will also be undertaken to assess its effectiveness that will form a basis for lesson learnt and its replication.

3.8 Project activities and timeline

Sr. No.	Activity	Time Frame	Budget	Relevant Implementation Agency
1	Strengthening human resources and institutional structure of the organization including its research arms	2-5 years	US$ 2.0 million	PMD
2	Establishment of meteorological observatories in 20 districts of the country	2-years	US$3.0 million	PMD
3	Installation of 200 Automatic Weather Stations Network including its communication system	2-3 years	US$ 0.80 million	PMD
4	Wind Profiler at 5 main airports	4-years	US$ 1.0 million	PMD
5	Up-gradation/ automation of 50 existing observatories.	3-years	US$ 2.50 million	PMD
6	Improve risk communication system among PMD, NDMA, PDMAs, FFC, and Media.	3 years	US$ 1.00 million	PMD
7	Establishment of Flash Flood Forecasting & Warning System at five most vulnerable areas of country	4-years	US$ 5.0 million	PMD/PDMAs
Total Estimate Budget: US$ 18.30 million				

3.9 Possible challenges

The key challenges expected in the project are:

i. Delay in the availability of required financial support for the purchase of required technological equipment;

ii. Limited trained human resources and skills to run and maintain the advance technological equipment and, other systems.

Project Idea 4: Strengthening groundwater resource and its governance system in Pakistan

4.1 Background and rational

Groundwater is depleting fast in many areas of Pakistan, in particularly, dense urban centres, and arid and semi-arid areas due to high abstraction rates that exceeds the recharge levels. In Pakistan, about 10 percent of the total groundwater is used to meet domestic and industrial requirements while the rest is utilized for the irrigation purposes. Historically, due to the high priority placed on the canal irrigation system in the country, the management of groundwater resource was largely ignored for over the long period of time that has eventually led to serious governance challenges both at the national and sub-national levels.

The groundwater governance and management initiatives in the country largely have remained fragmented, and un-coordinated among the organizations responsible for managing the resource. Many important governance challenges are identified such as lack of a central oversight authority, coverage and reliability of data on water quality and quantity, weak and non-robust regulatory frameworks, and a nascent monitoring network. At the national scale, there have been some efforts to generate new information necessary to take some sound policy actions. The Pakistan Council of Research in Water Resources (PCRWR), for example, has mapped the entire upper Indus basin during 10-years period from 2004-2014. The research results were to be delivered in the form of a groundwater atlas to pass on the information to farmers, policy makers, development agencies, and other user groups but the task thus far remains incomplete.

The groundwater mapping efforts have not paid any attention to do a complete groundwater profiling at the aquifer scale; or linking it up with climate change projections in order to better assess the resource quantity in the future, that would help in designing a robust communication and outreach program to transfer the knowledge to water user groups and managers. This project idea, therefore, aims to strengthen the groundwater resource governance in the country though policy and institutional reforms, creation and dissemination of technical resource status knowledge to a vast group of water users through participatory approaches.

4.2 Purpose and objectives

The project aims to improve the current critical groundwater situation in the country; groundwater is depleting very fast in most parts of the country, in particular in those areas which are outside IBIS network and prone to drought.

The project has the following important objectives:

i. To identify groundwater recharge areas where water table is critically low under a certain threshold level;
ii. To establish a systematic groundwater monitoring system in order to support its governance structures and mechanisms at national, sub-national and local levels;

iii. To improve knowledge of innovative recharge technologies through setting up 8 pilot demonstration projects in critical recharge areas.

4.3 Project deliverables

i. An open-access online database is set-up with accurate regional hydro-met data with continuous upgrades upon the availability of new data;

ii. A groundwater atlas is available which shows the critical recharge areas region-wise;

iii. An updated groundwater regulatory framework is developed and available for both urban and rural areas of the country;

iv. Training curricula available on training and skill development of the staff involved in integrated water resource management.

4.4 Project benefits

The project will contribute towards improving the institutional structure and governance mechanisms of the groundwater resource managing organizations present at the national and provincial levels. Particularly, the government staff with responsibilities of water management and planning across all sectors will directly benefit from training and generation of new data and information.

4.5 Project scope and possible implementation

Groundwater situation is more critical in Balochistan, Punjab and some urban areas of Sindh. Therefore, the implementation possibility is quite high as the issue of groundwater depletion in the recent years is gaining a lot of attention at the policy scale, particularly in the context of climate change. Balochistan has recently approved a water resource management project in two river basin areas with a financial assistance from the World Bank, with a component of groundwater monitoring and management. The government intends to expand the groundwater-monitoring network to other 18 river basins ultimately. Similarly, the government of Punjab with the help of the Irrigation Department has approved a 4-years groundwater recharge project in Feb 2016 with an estimated cost of PKR 582 million. It is expected that this project will support the on-going efforts in both provinces.

4.6 Monitoring and evaluation

Project would be supervised and its implementation closely monitored by a project steering committee jointly chaired by TNA National Coordinator and Representative of respective Provincial Irrigation Departments. Other members would include representatives from relevant government institutions, NGOs, development partners and project beneficiaries. Project manager would be required to submit quarterly progress report to the steering committee. This would provide an opportunity to keep a track on progress made in relation to project objective set and to make necessary adjustment where necessary. A mid-term and final project evaluation will also be undertaken to assess its effectiveness that will form a basis for lesson learnt and its replication.

4.7 Project activities and timeline

Sr. No	Activity	Time Frame	Budget	Relevant Implementation Agency
1	Strengthening human resources and institutional capacity of the relevant institutions for under taking detailed groundwater monitoring and management	0-3 years	US$ 1.0 million	PCRWR, Provincial Agriculture & Irrigation Departments
2	Develop an open-source database of aquifer systems in over-exploited areas: some potential information includes groundwater regime, quality, climatic condition, physiographic and drainage aspects	3-years	US$1.0 million	PCRWR, Provincial Agriculture & Irrigation Departments
3	Determine priority recharge areas with critical blocks based on the "quantified" artificial recharge potential	2-3 years	US$ 0.8 million	PCRWR, Provincial Agriculture & Irrigation Departments
4	Construct eight permanent ground water recharge system based on the area specific recharge technique and design	5-years	US$ 9.0 million	PCRWR, Provincial Agriculture & Irrigation Departments
Total Estimate Budget: 11.80 million				

4.8 Possible challenges

i. Designing suitable incentive structure and benefit sharing to foster community participation and ownership of ground water resource in the long run;

ii. Limited technical institutional or human capacity to develop ground water recharge facilities may affect the achievement of project objectives;

iii Lack of or delay in availability of required financial support for the design and development of required technological solutions and construction of such facilities.

Project Idea-5: Improving and sustaining water security in climate vulnerable areas of the country through rainwater harvesting from ground surfaces

5.1 Introduction and rational

Pakistan is a semi-arid country where most of the areas receive less than 200mm annual rainfall, except for the high altitude northern mountains. Water therefore is a precious commodity and the most crucial factor in determining the source of livelihood for the people in dry arid and semi-arid areas (ASAL) of the country.

Pakistan has the world's largest indigenous rainwater harvesting system commonly called as the spate irrigation system. The system irrigates around 0.3 million hectare (mha) of cultivated land in the country while the potential area to bring under this system is estimated to be around 6.935 mha (Ahmed and Steenbergen, 2010). To sustain and expand the system, there is a need to ensure water security through its conservation and utilization of rainwater.

There are many barriers to the replication of technology such as high cost of construction and maintenance, inadequate technical capacity, lack of policy and regulatory support. The purpose of this project is to address some of the key barrier elements and through implementation of various activities, create an enabling environment to replicate this technology successfully in climate vulnerable areas of the country.

5.2 Purpose and objectives

The main aim of the project is to improve the availability of water all year round for households and other water beneficiary groups such as farmers, specifically in drought-vulnerable areas of the country. The project will also contribute towards promoting awareness on climate change and importance of water conservation for a sustained livelihood in the future.

5.3 Project deliverables

Once implemented, it is expected that project will deliver the following items or activities:

i. 500 rainwater harvesting reservoirs are built within the life of the project, each with a capacity of 25,000 m^3 to 50,000 m^3 ;
ii. Increase in local crop production resulting in 30-40 percent increase in income of farmers;
iii. A communication strategy is created and implemented for improved collaboration of irrigation departments with other key stakeholder groups;

5.4 Project benefits

The technology offers many benefits during seasonal dry periods and droughts especially in the face of climate change that is projected to increase the variability and intensity of rainfall in the long run. Rainwater collection helps to stabilize the depleting groundwater level while the storage infrastructure can reduce land erosion and flood inflow to major rivers. It acts as a convenient source of stored water that could enhance agricultural productivity, decrease travel time for rural women to remote water resources that would result in better health and time for social activities.

There is some other additional benefits such as socio-economic uplift of the local communities due to increased employment opportunities, and diversification of cropping pattern in the area. The collaborative linkage built with various other public institutions will help community members and households to increase their participation in decision-making processes during the life of project.

5.5 Project scope and possible implementation

The project scope is national but it target arid and semi-arid areas particularly those affected by drought in the past few decades. The project has link with some other on-going water conservation initiatives in the dryland areas so the concerned departmental staffs already exhibits a fair level of skill and knowledge in water reservoir construction and maintenance. In the past, the former efforts also had focused on creating, and activating farmer organizations specifically with stress on the participation of women in water conservation efforts. So, as a whole, it is expected that the combined collaborative efforts of the various key stakeholders and consumer groups may contribute towards sustainability and success of this project.

5.6 Project activities and timeline

Sr.No.	Activity	Time Frame	Budget	Responsible Implementing Agency
1.0	**Improve policy integration and coordination** Review and analysis of respective national/sectoral policies to support water related sectors and sub-sectors such as agriculture, industry, household Develop a collaborative mechanism between provincial Irrigation department with related sections, local government and farmer association	0-2 years	US$ 0.4 million	PCRWR, Provincial Agriculture and Irrigation Departments; Ministry of Finance; Ministry of Planning, Development, Ministry of Climate Change; Pakistan Meteorological Department, GCISC
2.0	**Awareness creation and capacity building** Assess capacity needs of key stakeholders such as	0-3 years	US$ 0.2 million	PCRWR, Provincial Agriculture and Irrigation Departments; Ministry of Finance; Ministry of

	government departments, technology suppliers and users. Arrange need-based trainings on climate change education, awareness and behaviour			Planning, Development, Ministry of Climate Change; Pakistan Meteorological Department, GCISC
3.0	**Feasibility Studies** Prioritization of regions needing rain harvesting reservoirs Feasibility studies to identify feasible catchments and sites for construction of reservoirs.	0-3 years	US$ 1.0 million	PCRWR, Provincial Irrigation and Agriculture Departments
4.0	**Reservoirs construction** Construction of 500 rainwater harvesting channels and reservoirs each with a capacity of around 25,000 m^3 to 50,000 m^3.	2-5 years	US$ 6.0 million	Provincial Irrigation and Agriculture Departments
Total cost US$ 7.6 million				

5.7 Project challenges

Potential challenges for achieving targets are lack of a national water policy, lack of support on this technology or political intervention in decision-making, specifically in the silting of the reservoirs. Another challenge could be the climate related factor such as prolonged drought in the project areas, which will potentially impact the level of rainwater available to the communities and households.

Project Idea-6: Climate Resilient Mountain Villages (CRMV)

6.1 Introduction

In recent decades, climate change has resulted in a significant loss of ecosystem services in terms of soil nutrients, water and biomass, ultimately leading to a decline in food productivity in the Hindu-Kush Himalayan (HKH) region. Particularly in the Upper Indus Basin (UIB) of Pakistan, climate change has directly and indirectly impacted the food security and livelihoods of millions of people residing not only in the upstream but also the midstream and downstream areas of the basin through influencing agricultural productivity and resulting in increased outmigration to midstream and downstream areas. It has also led to increased pressure on natural resources and production systems, and competition for food, accommodation and income opportunities in the midstream and downstream areas. Agriculture, livestock, vegetables, fruits and nuts are the main sources of food security and livelihoods of the mountain communities in the UIB. In recent years, climate change has posed a situation of 'too much - too little water', which has led to higher vulnerability of the local people. Since 2000–01, the frequency and magnitude of floods in the UIB have increased due to increased incidence of intense rainfalls in the Indus catchments and these are also occasionally increased by snowmelt.

Food and livelihoods of the mountain people mainly depend on agriculture and water. These sectors are highly vulnerable sectors to climate change risks in the UIB, and need special attention from researchers and policy makers. Therefore, there is need to adopt an integrated approach to enhance the resilience of these two sectors to climate induced risks. In 2013, ICIMOD experimented the idea of 'Mountain Resilient Villages' (MRVs) in the mountain areas of Nepal to enhance the climate resilience of small farmers in four villages. There are two key aspects to climate resilience in the RMV model: adapting to climate variability, and becoming more climate friendly. RMV interventions for climate resilience focus on the areas of farming systems, water, and energy.

Prioritized technologies of Water and Agriculture sectors in Technology Need Assessment (TNA) of Pakistan are almost similar to those, which were introduced in the MRVs. The idea of MRVs played a very important role in both adaptation and mitigation aspects of climate change in selected pilot villages of Kavre district of Nepal. It resulted in sustainable growth in agriculture through better soil and pest management and by improving cropping patterns to increase yields while saving water, as well as mitigating the negative effects of chemical fertilizers and pesticides. It addressed water scarcity and uncertainty for irrigation and drinking water using simple water conservation and efficient irrigation methods. Recently, the government of Nepal has taken up this idea, and has initiated the process of out-scaling this in almost all regions of Nepal. In view of the similarity of hydrological and agro-ecological aspects of Nepal and Pakistan, the implementation of MRVs in Pakistan can also improve the climate resilience in the mountain areas, particularly in water and agriculture sectors. The package of activities in MRVs will cover most of the prioritized technologies and practices in TNA for water and agriculture sectors. For instance, MRVs can adopt (as a package) the tested technologies of surface rainwater harvesting, groundwater recharge, high efficiency irrigation systems, drought tolerant crops varieties, and climate monitoring and forecasting – early warning system.

6.2 Purpose and objectives

The main purpose of the MRVs is to enhance climate resilience of small farmers, particularly in the vulnerable mountain areas. The specific measurable objectives of this project are presented below.

i. Enabling sustainable gender inclusive growth in agriculture through climate smart cropping patterns and drought tolerant varieties of crops.

ii. Increasing agriculture productivity while saving water and promoting the use of organic fertilizers and pesticides.

iii. Addressing water scarcity and uncertainty for irrigation and drinking using simple water conservation and high efficiency irrigation systems.

iv. Providing small farmers an easy access to climatic, weather and market information through ICT.

v. Preparing small farmers for disasters to reduce risk and mitigate their impact on their agriculture and livelihoods.

6.3 Relationship to the country's sustainable development priorities

The RMV is an integrated approach to development in mountain areas that combines economic, social, and environmental dimensions of sustainable development with climate change adaptation, resilience, and preparedness for future risks. Being a solution to both adaptation and mitigation risks, the success of RMVs will contribute to Pakistan's Intended Nationally Determined Contributions (Pak-INDCs) submitted in compliance to the decision (1/CO.20) taken at the 20th Session of the Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) held in Lima, Peru. RMVs will also contribute to achieve the goals of Vision 2025 of Pakistan – a roadmap of economic growth, social inclusion and sustainable development. It is also aligned with the country's continued commitment to the issue of climate change as reflected in the National Climate Change Policy as well as national policies on agriculture, power, energy, energy efficiency, water and other sectors. RMVs are also key to in achieving several Sustainable Development Goals (SDGs) in Pakistan. RMVs can directly contribute to achievement of SDG 1 (no poverty), 2 (zero hunger), 3 (good health and wellbeing), 5, (gender equality), 6 (clean water and sanitation), and 13 (climate action). If renewable energy sources are integrated with high efficiency irrigation systems, it will contribute to achieve SDG 7 (affordable and clean energy).

6.4 Project deliverables

i. Capacity development plan, including training course (both on farm and off farms) on climate resilience practices (MoV: training reports)

ii. At least 750 households adopting various climate resilience practices in pilot sites

iii. Mobile based information system functional and operational in selected pilots sites (weather information, technical message, and market information)

iv. Bio-pesticides and bio-fertilizer package adopted, and in use. Private sector involved in bio-fertilizer and bio-fertilizer businesses

v. Three automatic meteorological stations established, and met data streamlined with national data system

vi Three action research based knowledge products published by the end of pilot sites.

6.5 Project scope and possible implementation

Based on the successful implementation in Nepal, the idea of RMV will be implemented as 'pilot' in the selected sites in the mountain areas of Pakistan. The pilot MRVs will be planned for 5 years to test and evaluate the impacts of introduced climate smart technologies and practices. During the implementation process, following phases will be followed.

6.5.1 Identification of sites/villages and technology Interventions (1st half of 1st year)

In the first phase, sites/villages will be selected in the mountain areas. According to the biophysical and agro-ecological conditions of the sites, a set of most appropriate climate smart practices and technologies will be finalized. During this phase, the researchers will also decide on the evaluation design of the RMVs. Most probably, experimental design of research and evaluation will be selected.

6.5.2 Introductory phase (second half of 1st year)

During this phase, awareness and mobilization of the local people in the selected villages will be done. Moreover, baseline information (socioeconomic, biophysical factors and farm data) of the selected villages (mainly farmers) will be collected. Afterward, intervention technologies will be introduced to the villages. It will allow the villagers to gain a practical understanding of the technology. During this phase, researchers' involvement is very high as the villagers' understanding of the technology is very limited.**6.5.3**

6.5.3 Participation phase (2nd year)

During this phase, management and operations of the introduced technologies will start, and the involvement of the villagers (mainly farmers) in the establishment and management of the technologies will increase to improve their understanding of the introduced technologies.

6.5.4 Monitoring phase (3rd& 4th year)

During this phase, the involvement of researchers in management and other farm operations will be kept limited, and the farmer's involvement will be greatly increased. Farmer will mainly manage the resilient practices in their respective villages. The researchers will only provide some resources and technical input on to villagers. *Importantly, during this phase, the pilot farm will start serving as a Learning Centre for the other farmers and villages in the area.* Formal (i.e. orientation events, exposure visits, demonstration workshops etc.) and informal visits of the formers to the pilot villages will provide good exposure and better understanding to the visiting farmers. It will ultimately lead to an out-scaling of the technology in the vicinity of the RMVs. Frequent visits of government officials and experts will also be arranged to provide a visual evidence of successful operations of the technologies.

6.5.5 **Evaluation phase** (1st half of 5th year)

The researchers will monitor the operations and management of the introduced technology, and its influences on resilience of agricultural practices to climate change, production, income, food security and livelihoods of the villagers. Finally, they will collect the end-line information of the RMVs.

6.5.6 **Out- and up-scaling phase** (2nd half of 5th year)

During the previous phase, if researcher's assessment (impact assessment report) reveal that there are significant positive changes in the climate resilience of villages, their farm production, income, food security and livelihoods, it will open the doors of large scale spreading of the intervention technologies and the idea of RMVs in other hilly and mountain areas with similar topographical, biophysical and hydrological characteristics. Visits of government officials and experts during third phase together with positive assessment report will be so helpful up scaling of the technology.

6.6 Budget and resource requirements

Based on the learning of successful implementation of RMVs in Nepal, total 4 pilot mountain villages may be selected as intervention sites, and 4 villages may also be selected as control sites for evaluation and impact assessment purposes. In total, provisionally USD 375,000/ will be required for RMV project. In the below Table, provisional budget of main heads is presented without details of activities.

Table: 6.1. Main heads of budget/ resource requirement of Climate Resilient Mountain Villages (CRMV) project.

Main Heads	**Estimate Budget (USD)**	**Period/note**
Interventions in RMV		
Cost of intervention technologies	50,000	5 years
Implementation and monitoring cost (by local NGO)	15,000	5 years If local Department or Centre of the government implements and monitors the interventions, this cost may also be used for additional technologies.
Coordination & Logistics		
Other costs (Coordination, logistics, field trips etc.)	10,000	5 years
Total cost per RMV for 5 years	**75,000**	**-**

Total cost for 4 RMVs	**300,000**	**-**	
Research and evaluation **(Rigorous impact evaluation: out of 4 RMVs, the first established village can be considered to compare with selected 3 to 4 control villages.)**			
Baseline data collection from 1 RMV	5,000	1st year	Cost of data collection from 4 control villages is similar to that of 1 RMV because higher number of villages will not result in increase in sample size. Rather, statistically predetermined sample size will be distributed across 4 control villages.
Endline data collection from 1 RMV	5,000	5th year.	
Baseline data collection from 4 control villages	5,000	1st year	
Endline data collection from 4 control villages	5,000	5th year	
Data analysis to compare RMVs with control villages (impact assessment)	5,000	5th year	
Total research & evaluation cost	**25,000**	**-**	
Knowledge products & Communication	**50,000**	Aggregated amount. However the main spending from this head will be in the 5th year.	
Total project cost (A+B+C) = USD 375,000			

ICIMOD has offered to provide technical support to this initiative if some government or donor funding is made available.

6.7 Monitoring and evaluation

RMV pilot will follow the experimental design of evaluation. Four treatment (intervention) and four control villages will be selected. For these, eight villages, baseline and end-line data will be collected to compare the variables of interest (keeping households as unit of analysis) by using Difference-in-Difference method of impact evaluation for introduced technologies and practices.

6.8 Possible challenges

At the moment, no potential challenge is identified. Phases of activities are presented in the section 5 with timeline.

Acknowledgments: *The technical team of this TNA project want to put on record the contributions of particularly two individuals Mr. Imran Khan Head of TNA Technical Support Unit MoCC and Ms. Masooma Hassan, Climate Change Expert, for their deep professional involvement without which the timely completion of this report may not have been easy.*

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Annex I. List of stakeholders involved in TAP process and their contacts

Sr. No	Name	Organization/ Contact	Type of Consultation
1	Mr. Arshad Laghari Member National Assembly (Recently joined as Minister of State-Industries & Production	Chairman, Parliament Standing Committee on Water Resources	One to one
2	Mr. Junnaid Iqbal Chaudhry, Member National Assembly, (Recently joined as Minister of State, Communication)	Member, Parliament Standing Committee on Water Resources	One to one
3	Mr. Afzal Hussain Tarar Progressive Farmer & Former Member National Assembly	H- , Bird wood Road, Lahore	One to One
4	Dr. Yusuf Zafar T.I. Chairman, PARC	Pakistan Agricultural Research Council (PARC), G-5/1, Islamabad	One to One
5	Dr. Muhammad Ashraf, Chairman, Pakistan Council of Research in Water Resources	PCRWR, H-8/1, Islamabad-Pakistan Ph: +92-51-9101275;	One to One
6	Dr. Bashir Ahmad Climate Change & Geo-Informatics Programme Leader	Climate Change, Alternate Energy and Water Resources Institute(CAEWRI), NARC, Shehzad Town, Park Road Islamabad,Tel+92-51-9255580	One to One
7	Mr. Raiz Ahmed Khan	Former Federal Secretary, Ministry of Water & Power	One to one
8	Dr. Muhammad Javed Tareen, DG Research	Agriculture Research Institute, Balochistan, Quetta. 081-2470079 Jdtn69@yahoo.com	One to one
9	Mr. Waqar Hussain Phulpoto, Director (Technical)	Environmental Protection Agency, Government of Sindh, EPA Complex, Korangi Industrial Area, Karachi	One to one
10	Masoud Ahmed Baloch, DG Agriculture Extension Balochistan	Agriculture Extension Balochistan 081-9211500, Email:masoud_baloch2000@yahoo.com	One to one
11	Mr. Irfan Tariq Director General	Ministry of Climate Change, Islamabad	One to one & round table discussion
12	Mr. Seerat Asghar Jaura, Former Federal Secretary	Ministry of Food Security & Research	One to one
13	Dr. Arshad M Khan Former Executive Director	Global Change Impact Study Centre (GCISC), drarshadmkhan@yahoo.co.uk	Round table discussion
14	Dr. Muhammed Hanif	Director, Pakistan Meteorological Department hanifwxc@hotmail.com	Round table discussion
15	Mr. Javed Ali Khan	Former DG Environment dg.moenv@gmail.com	Round table discussion
16	Ms. Hina Lotia, General Manager	LEAD Pakistan hlotia@lead.org.pk	Round table discussion

17	Dr. Arshad Ali, Director,	Land Resources Research institute National Agriculture Research Centre (NARC), Islamabad	Round table discussion
18	Dr. Moshin Iqbal Former Member Agriculture,	Global Change Impact Study Centre (GCISC) drmoshiniqbal@gmail.com	Round table discussion
19	Mr. Munir Shaikh, Former Member Climate Science	Global Change Impact Study Centre (GCISC) mmunirsheikh@yahoo.com	Round table discussion
20	Dr. Ashfaq Ahmed Chattha,	Professor, Agriculture University, Faisalabad aachattha1@yahoo.com	Round table discussion
21	Dr. Hafiz Muhammad Akram, Convener, Climate Change Research Centre	Climate Change Research Centre, Ayub Agriculture Research Institute, Faisalabad. Akramhm62@gmail.com	Round table discussion
22	Mr. Abbas Ali Gill	Climate Change Research Centre, Ayub Agriculture Research Institute, Faisalabad abbassgil@gmail.com	Round table discussion
23	Mr. Ghazanfar Ali,	Former Member Water Section, , Global Change Impact Study Centre (GCISC), ghazanfaar.ali@gmail.com	Round table discussion
24	Dr. Shahina Tariq	Chairman, Head of Department of Meteorology, COMSATS University, shahinatariq@comsats.edu.pk	Round table discussion
25	Dr. Akram Kahlown,	Former Chairman Pakistan Council Research on Water Resources (PCRWR) kahlown@hotmail.com	Round table discussion & One to one interview
26	Mr. Sajjad Yaldram, ,	Dy. Secretary, Ministry of Climate Change yaldramsajjad@yahoo.com	Round table discussion
27	Ms. Masooma Hasan	Environmental Policy and Planning Professional maychid999@gmail.com|	Round table discussion
28	Mr. Muhammad Akram Anjum,	Chief Meteorologist, Pakistan Meteorological Department akram58pmd@gmail.com	Round table discussion
29	Dr. Mohammad Azeem Khan,	Director General, National Agriculture Research Centre (NARC) azparc@yahoo.com	Round table discussion
30	Dr. Inayatullah Chaudhry	Agriculture Department ci@drinayat.com	Round table discussion
31	Dr. Aurangzeb Khan	Director General, Climate Change AJK Planning Department auranzeb_nrm@yahoo.com	Round table discussion
32	Shehzad Hasan Shigri,	Director Environmental Protection Agency, Gilgit-Baltistan shigri_shahzad@yahoo.com	Round table discussion
33	Dr. Qamar uz Zaman Chaudhry	Climate Change Adaptation Expert & Lead Author Pakistan Nation Climate Change Policy. dgmetpak@hotmail.com	Round table discussion
34	Dr. Ashfaq Ahmad Sheikh	Director General, PCRWR. ashfaq-sheikh@hotmail.com	Round table discussion
35	Dr. Abdul Majeed	Project Lead, Pakistan Centre for Advance Studies in Energy, IUCN, Islamabad, abdul.majeed@iucn.org	Round table discussion
36	M.Bashir Khan	Chief Foreign Aid, Agriculture P&DD	Round table

		AJK directorajkepa@gmail.com	discussion
37	Dr. Amjad Virk	Former Project Director SLMP Ministry of Climate Change amjad.virk@slmp.org.pk	Round table discussion
38	Dr. Jawad Ali	Director, Climate Change Centre, University of Agriculture, Peshawar jawad@helvetas.org.pk	Round table discussion
39	Mr. Asad Maken ,	Climate Change Unit, UNDP, Islamabad asad.maken@undp.org	Round table discussion
40	Mr. Mian Shaukat Shafi,	Asian Development Bank(ADB), Islamabad mshafi@adb.org	Round table discussion
41	Dr. M. Zia-ur-Rahman Hashmi,	Head, Water Resources & Glaciology Section, Global Change Impact Study Centre (GCISC), E-mail:ziahashmi77@gmail.com	Round table discussion
42	Ms. Javeria Afzal,	Advisor DRR & Climate Change, Oxfam Novib, Islamabad javeria.afzal@oxfamnovib-pakistan.org	Round table discussion
43	Mr. Muhammad Arif Goheer, Head, Agriculture & Coordination Sections	, Global Change Impact Study Centre (GCISC), E-mail: arifgoheer@gmail.com	Round table discussion
44	Dr. Arshad Ali, Director Land Resources Research Institute	National Agriculture Research Centre (NARC). (arshadalinarc@gmail.com	One to one
45	Dr. Munir Ahmed, Director Climate Change	Alternate Energy and Water Resources Institute, National Agriculture Research Centre (NARC), (munir.wrri@gmail.com	Round table discussion
46	Muhammad Zubair, Deputy Director General	Water and Soil Conservation Unit Planning and Development Department, Government of Khyber Pakhtunkhwa	Round table discussion
47	Dr. Mahmood-ul-Hassan, Senior Scientific Officer,	Land Resources Research Institute, National Agriculture Research Centre (NARC), Islamabad (mmh@comsats.net.pk)	Round table discussion
48	Mr. Khadim Hussain	Supplier, Micro Drip (Pvt) Ltd F-178/3, Kehkashan, Block 5, Clifton, Karachi-Pakistan	One to one interview
49	Ms. Nazima Shaheen	Action Aid Pakistan. House 42A, Orchard Scheme, Murree Road, IslamabadNazima.shaheen@actionaid.org	Round table discussion
50	Engr. Khurram Khaliq Khan	Procurement Consultant, World Bank, Islamabad kkkhaliq@yahoo.com	Round table discussion
51	Mr. Nasir Iqbal Ansari	Agribusiness Consultant, Fauji Foundation nasiriqbalansari@hotmail.com	Round table discussion
52	Mr. Tahawwar Ahmed	Consultant NDMA tahawwar@hotmail.com	Round table discussion
53	Ms. Faiqa Aziz	Ministry of Climate	Round table discussion

		ChangeFaiqaaziz14@gmail.com	
54	Mr.Tayyab Shehzad	Consultant- Ministry of Climate Change tshahzad68@yahoo.com	Round table discussion
55	Mr. Amir Hussain, Director Programs	HASHOO FOUNDATION, St-2, H-8/1, Islamabad, o51-2273621 amirhussain@hashoofoundation.org	Round table discussion
56	Mr. Arif Rahman Sr. Manager, Environment & Climate Change & DRR	HASHOO FOUNDATION, St-2, H-8/1, Islamabad, 0303-8989526 arifrahman@hashoofoundation.org	Round table discussion
57	Mr. Hammad Raza, General Manager	LEAD Pakistan, F-7, Islamabad hraza@lead.org.pk	Round table discussion
58	Mr. Ibad ur Rehman, General Manager	NEC Consultants (Pvt) Ltd. No.55, Aslam Business Square, E-11/2, Islamabad. 051-2305590 ebad.environment@gmail.com	Round table discussion
59	Ms. Kanwal Waqar	ICIMOD, Islamabad o324-8551524 K_waqar@icimod.org	Round table discussion

Annex-II: List of policy makers briefed and sensitized during TAP / Project Ideas development process on one to one basis.

S.No	Name	Organization/ Department	Contact
1	Mr. Hashim Tareen	Secretary, Planning & Development, Government of Balochistan	2nd Floor, Block 6, Civil Secretariat, Zarghoon Road, Quetta, Phone # 081- 9202425
2	Mr. Muhammad Saleem Awan	Secretary, Irrigation and Power Department, Government of Balochistan	Civil Secretariat, Zarghoon Road, Quetta Phone # 081- 9201074
3	Mr. Abdul Rehman Buzdar,	Secretary, Agriculture and cooperative Department, Government of Balochistan	Room 19, Top floor, Block 2, Civil Secretariat, Zarghoon Road, Quetta # 081- 920126
4	Mr. Ghulam M. Sabir	Secretary,Forests and Wildlife Department, Government of Balochistan	1st floor, Block 4, Civil Secretariat, Zarghoon Road, Quetta # 081- 9202264
5	Mr. Naseer Kashani,	Additional Secretary (Regulations and Admin), Department of Finance, Government of Balochistan	Civil Secretariat, Zarghoon Road, Quetta Phone # 081-9201272
6	Mr. Iqbal Muhammad Chuhan	Secretary, Environment Department, Government of Punjab	Gate no. 8, Qaddafi Stadium, Ferozepur Road, Lahore
7	Mr Iftikhar Ali Sahoo	Secretary, Planning & Development, Government of Punjab	Civil Secretariat, Lower Mall, Lahore
8	Mr. Muhammad Mehmood	Secretary, Agriculture Department, Government of Punjab	Civil Secretariat, Lower Mall, Lahore
9	Mr. Muhammad Usman Chudhary,	Special secretary, Finance Department, Government of Punjab	Civil Secretariat, Lower Mall, Lahore
10	Mr. Capt.(retd) Saif Anjum,	Secretary, Irrigation Department, Government of Punjab	Old Anarkali Road, Lahore
11	Mr. Syed Hassan Naqvi,	Additional Secretary, Finance Department, Government of Sindh	Civil Secretariat, No 4-A, Court road, Karachi
12	Mr. Syed Zaheer Haider Shah,	Secretary, Sindh Irrigation, Government of Sindh	Tuglaq House Sharah-kamal-Ata - Turk Karachi
13	Dr. Rahim Samroo, ,	Secretary, Industries and Commerce Department, Government of Sindh	Room no 303, Second Floor, Tuglaq House Sharah-kamal-Ata -Turk Karachi
14	Mr. Mir Ijaz Hussain,	Secretary, Planning & Development, Government of Sindh	Tuglaq House Sharah-kamal-Ata - Turk Karachi
15	Mir. Ijaz Hussain Talpur,	Secretary, Environment, Climate Change & Coastal Development, Government of Sindh	EPA Complex, Plot # FD-2/1, Sector-23, Churangi Korangi, Karachi

Ministry of Climate Change, Government of Pakistan