Case Studies on Best Practices in Climate Change Adaptation in Pakistan

Rural Support Programmes Network (RSPN), and International Centre for Integrated Mountain Development (ICIMOD)

IMPRINT

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The authors' views expressed in this publication do not necessarily reflect the views of the Rural Support Programmes Network (RSPN), International Centre for Integrated Mountain Development (ICIMOD), and the European Union

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Acronyms and Glossary

ADB	Asian Development Bank
ADP	Annual Development Programme
AEDB	Alternate Energy Development Board
AKRSP	Aga Khan Rural Support Project
Barani	Rain-fed
BMZ	German Federal Ministry for Economic Cooperation and Development
CBO	Community Based Organization
CIDA	Canadian Agency for International Development
DDMA	District Disaster Management Authority
DDMUs	District Disaster Management Units
DFID	[UK] Department for International Development
DMCs	Disaster Management Committees
DRM	Disaster Risk Management
Ehtesab	Accountability
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FATA	Federally Administered Tribal Area
FDMA	FATA Disaster Management Authority
FOs	Farmers Organizations
FPA	Foreign Project Assistance
FRs	Frontier Regions
GBP	Great Britain Pound
GCISC	Global Change Impact Study Centre
GHG	Green House Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German Society for International Cooperation)
GLOF	Glacial Lake Outburst Flood
GoKP	Government of Khyber Pakhtunkhwa
GoP	Government of Pakistan
ICIMOD	International Centre for Integrated Mountain Development
IEE	Initial Environmental Examination
IFAD	International Fund for Agricultural Development
IPPs	Independent Power Produceres
IRSA	Indus River System Authority
IUCN	International Union for Conservation of Nature

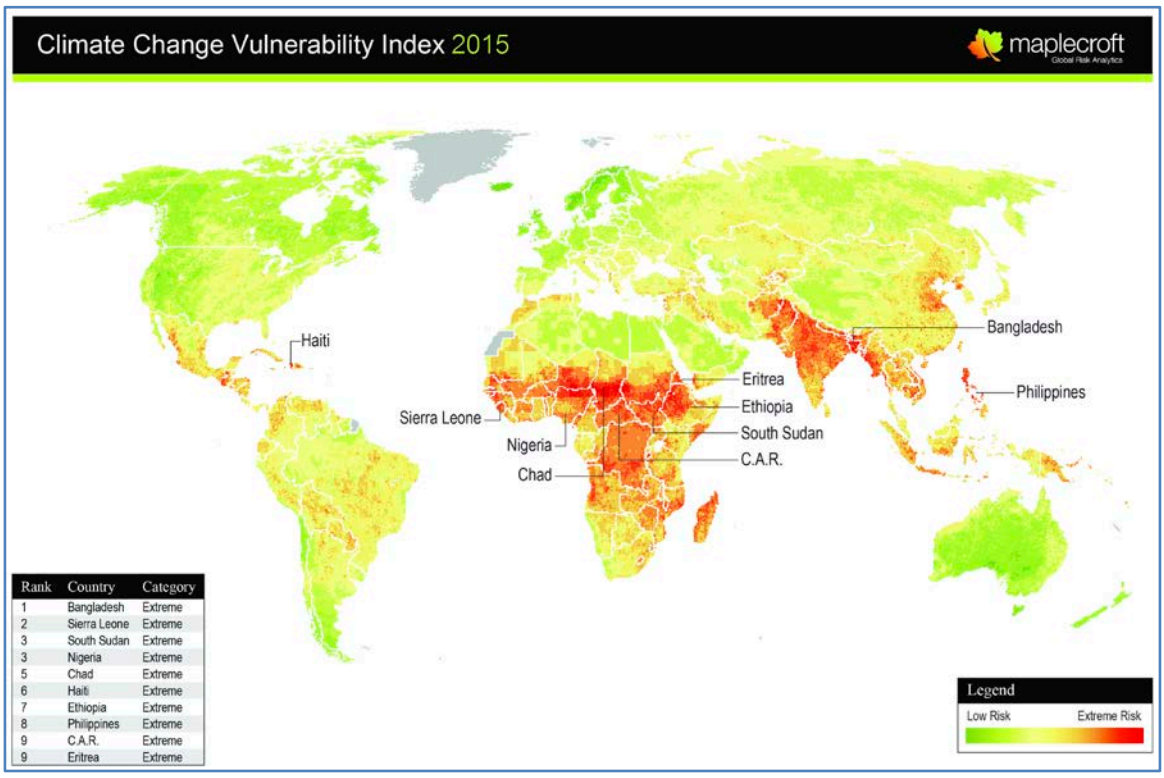
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
Katcha	Unpaved, made of mud
KfW	Kreditanstalt für Wiederaufbau ([German] Reconstruction Credit Institute)
KP	Khyber Pakhtunkhwa
kWhr	Kilo-watt-hour
LG&RDD	Local Government and Rural Development Department
lps	Litters per second
MAF	Million Acre Feet
MDTF	Multi-Donor Trust Fund
Naccas	Openings on a water channel
NADP	Northern Areas Development Programme
NDMA	National Disaster Management Authority
NDMC	National Disaster Management Commission
NDP	National Drainage Programme
NOC	No Objection Certificate
NWFP	North-Western Frontier Province
O&M	Operation and Maintenance
OECD-DAC	[UN] Organization for Economic Cooperation and Development – Development Assistance Committee
OFWM	On-Farm Water Management
P&DD	Planning and Development Department
Pacca	Bricked, lined
PARC	Pakistan Agricultural Research Council
PATA	Provincially Administered Tribal Areas
PCNA	Post Crisis Need Assessment
PDMA	Provincial Disaster Management Authority
PDWP	Provincial Development Working Party
PFI	Pakistan Forest Institute
PHED	Public Health Engineering Department
PKR	Pakistani Rupees
PPAF	Pakistan Poverty Alleviation Fund
PSDP	Public Sector Development Programme
PVC	Polyvinyl chloride [pipes]
Rod-Kohi	Mountain channel; a form of irrigation system in Pakistan
RSPN	Rural Support Programmes Network

RSPs	Rural Support Programmes
SAARC	South Asian Association for Regional Cooperation
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
SDPI	Sustainable Development Policy Institute
SRSP	Sarhad Rural Support Programme
TOT	Training of Trainers
UC	Union Council
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	US Agency for International Development
VDMCs	Village Disaster Management Committees
WAPDA	Water and Power Development Authority
WB	[The] World Bank
WMD-AD	Water Management Directorate of the Agriculture Department
WSP	Water and Sanitation Programme
WSSP	Water and Sanitation Services Peshawar
WUAs	Water Users Associations

1. INTRODUCTION

Pakistan is not a significant contributor to the global greenhouse gas emissions, with a contribution of 0.8% of world's total in 2008, but it is considered one of the 'most vulnerable countries'. Pakistan is ranked 5th most climate affected country in 2014 on the Global Climate Risk Index 2016 while it was ranked 8th during 1995-2014 period. In 2014 alone, Pakistan suffered 1227 deaths, and around 2220 million USD economic losses due to climate related disasters. On the other hand, a World Bank report suggested that Pakistan is among the 17 countries currently facing water shortages and is among the 36 countries with serious threat of food crisis. Various studies by the Global Change Impact Study Centre suggest that the temporal precipitation distribution patterns will change while climate change will increase the variability of monsoon rains and enhance the frequency of heavy precipitation, which would lead extreme events such as floods and droughts.

Climate Change is a posing serious environmental and developmental challenge to Pakistan, most of which have multiple dimensions in cause and effect. Besides, the Country is already experiencing climate induced phenomena such as high glacial melt, prolonged droughts, flash floods, cyclones and changes in weather patterns. These in turn are affecting Pakistan's water resources and agricultural productivity, which is the backbone of its economy. The Country's vulnerability to such impacts and changes is likely to increase considerably in the coming decades.



Rank	Country	Category
1	Bangladesh	Extreme
2	Sierra Leone	Extreme
3	South Sudan	Extreme
3	Nigeria	Extreme
5	Chad	Extreme
6	Haiti	Extreme
7	Ethiopia	Extreme
8	Philippines	Extreme
9	C.A.R.	Extreme
9	Eritrea	Extreme

Unfortunately, not much has been observed and documented on impact of climate change on urban and coastal areas of Pakistan. The report of the Planning Commission's Task Force on Climate Change (TFCC, 2010) has identified the following most important climate change threats to Pakistan:

1. Increased variability of monsoon;
2. Rapid recession of Hindu Kush-Karakoram-Himalayan (HKH) glaciers;

3. Deforestation and loss of biodiversity and risks to other vulnerable ecosystems
4. Increased risks of floods and droughts;
5. Increased siltation of major dams resulting in greater loss of reservoir capacity;
6. Severe water-stress and heat-stress in arid and semi-arid regions, leading to reduced agriculture productivity and power generation;
7. Increased upstream intrusion of saline water in the Indus delta, adversely affecting coastal agriculture, mangroves and breeding grounds of fish;
8. Threat to coastal areas including the city of Karachi due to sea level rise and increased cyclonic activity due to higher sea surface temperatures; and
9. Increased health risks.

This situation warrants thorough understanding of the climate change phenomenon and its impact on human population, especially women, children, and vulnerable groups who have high dependence on nature and natural resources. The chain of events over the last few years dictates the need for concerted action to enhance resilience of vulnerable populations, especially the mountainous communities. Adaptation to climate change and building resilience among ecosystems and people are relatively new concepts, and there is gross variation in community as well as institutional; responses to the climate change challenge. Hence, there is need for documenting and sharing of experiences and ideas across the country to learn and benefit from best practices in climate change adaptation.

In this backdrop, coupled with low options for climate change mitigation and lack of institutional and financial capacity to forewarn and cope with effects of climate change, adaptation remains the only viable strategy for communities at large, especially in mountainous areas. Hence, the effort by RSPN and ICIMOD to document best practices in climate change adaptation at community as well as institutional levels is a timely intervention, which may lead to a well-designed policy action to ameliorate the situation.

1.1. The project

ICIMOD and RSPN collaborated together for several activities, which included developing a pool of master trainers on climate change adaptation from the RSPs and government departments in each provinces/region of Pakistan. This strategic initiative has helped in developing a pool of human resource at provincial and regional level by conducting six regional trainings across Pakistan for further dissemination and replication of this concept at community level and also for individuals who are active in these communities. Ultimate goal of this initiative was to accelerate climate friendly planning and implementation of related Programme. RSPN is overlooking the management and implementation of the HIMALICA project, housed in its Research and Knowledge Management (RKM) Section and managed by the Specialist Monitoring & Evaluation.

Under the first phase (Nov 2013 – Jun 2014), two key staff members from RSPN participated in a regional TOT organized by ICIMOD in Nepal; the TOT participants adopted, contextualized the learning materials and approaches disseminated in the TOT and; trained a total of 85 government, non-government staffs and community leaders on adaptation to change including climate change issues in three selected districts (Abbottabad, Kotli and Gilgit) of Pakistan.

Under the current phase (Jan 2015 – Jun 2016), the following results have been achieved so far:

- Training of Master Trainer (TOT) on CCA as a four days residential event for 22 participants from ICIMOD, RSPN, AKRSP, SRSP, NRSP, WWF, NARC, BEEJ, TRDP, MARC, FOCUS, BRSP, IRM, SRSO and Central Forest Office, AJK (including 10 women).

- Training of RSP's Communication and Monitoring & Evaluation (M&E) staff on Knowledge Management for Climate Change Adaptation.
- Three-day residential Regional workshops on Climate Change Adaptation at Sukkur, Peshawar, Bahawalpur, Quetta, Muzaffarabad and Gilgit in collaboration with Sindh Rural Support Programme (SRSO) and Thardeep Rural Development Programme (TRDP), Sarhad Rural Support Programme (SRSP), National Rural Support Programme (NRSP), Balochistan Rural Support Programme (BRSP), Aga Khan Rural Support Programme (AKRSP) and FOCUS.

Through these trainings, a pool of experts of climate change has been created. Some communication material aimed at creating awareness on causes and impacts of climate change has also been produced. For example, the posters (in Urdu) were produced on what are the reasons for climate change, what are the effects of climate change, and how to prevent climate change. The effort to document the case studies on climate change adaptation is in the same suite.

1.2. Study methodology

As an approach, we believe in participatory development and management of climate change adaptation, which mainstreams inclusion of all relevant stakeholders including women and marginalised groups, ensures thorough scientific basis for review and analysis of available information and data and beef-up with diagnostics of best and local practices in adaptation to climate change, and remains pragmatic to achieve the desired results within the given timeframe and financial resources.

The methodology for this study was qualitative in nature, including collecting and reviewing available documents, meeting the key informants, conducting in-depth interviews, and synthesising the available information and data into a well-structured report on Best Practices in Climate Change Adaptation.

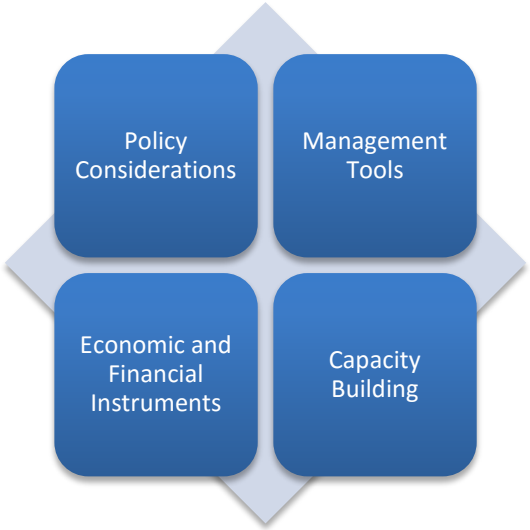
To keep this assignment efficient in terms of time and resources, no primary data was collected and the information synthesised from secondary sources has been used to elaborate the best practices. This, however, has been a limitation of this study.

After a inception meeting with the RSPN staff to understand the context and obtain available documents and reports, relevant studies and reports relevant to the subject were critically

evaluated for the selection of relevant and effective case studies under the this study using criteria of relevance, cost-effectivity and sustainability. The list of relevant literature was expanded through snowball approach using personal knowledge of the climate change adaptation perspectives and practices, and in-depth interviews. The draft report, following the agreed outline was shared with RSPN for review and feedback. Incorporating the comments and suggestions by RSPN, the report has been finalised.

2. POLITICAL ECONOMY OF CLIMATE CHANGE ADAPTATION

The Intergovernmental Panel on Climate Change (IPCC)[1] defines climate change as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use." It also defines the adaptation as "in human systems, the process of adjustment to actual or expected climate, and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate." The challenge of climate change and climatic variability, and the range of adaptation measures to cope with it are complex, interconnected, and interacting phenomena. The drivers of climate change adaptation can be defined in terms of state policy and legal paradigm, institutional mechanisms or management tools, economic and fiscal space available to adaptation actions, and capacity of relevant actors. The interplay of these dynamics and best practices in different geo-physiographical regions and sectors is elaborated in the following sections.



2.1. Physiographic and climatic context[2]

Pakistan with an area of 881,913 km^2 is located approximately within the latitudinal and longitudinal extensions 24°N to 37°N and 61°E to 76°E, respectively, falling in sub-tropics as well as in temperate region. Primarily formed by valleys of Indus River and its tributaries, Pakistan spans from high mountains (part of the Himalayan, Hindukush and Karakoram ranges) in the north to Indus River plains, Balochistan plateau, and around 1046 km coastline in the south. It also hosts around 13680 km^2 glaciated area (Figure 1). With the annual mean minimum and maximum temperatures ranging between sub-zero to 47°C, the rainfall varies from as little as less than 25 mm a year to over 380 mm a year. The average annual river flow is about 141 maf (174 bcm) with a variation from 97 maf in a low- flow year (2002) to 172 maf in a high flow-year

[1] IPCC. 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

[2] This section has benefitted from:

- Rasul, Ghulam, M. Afzal, M. Zahid, and A. A. Bukhari. 2012. *Climate Change in Pakistan*. Islamabad: Pakistan Meteorological Dept., GoP.
- Sheikh, Muhammad Munir. 2009. "Climate Change and Drought in Pakistan." Presentation at 5th meeting of the GEOSS Asian Water Cycle Initiative (AWCI) & International Coordination Group (ICG) on 15-18 Dec 2009, Tokyo, Japan.
- Wikipedia: Geography of Pakistan (https://en.wikipedia.org/wiki/Geography_of_Pakistan).
- Wikipedia: Climate of Pakistan (https://en.wikipedia.org/wiki/Climate_of_Pakistan).

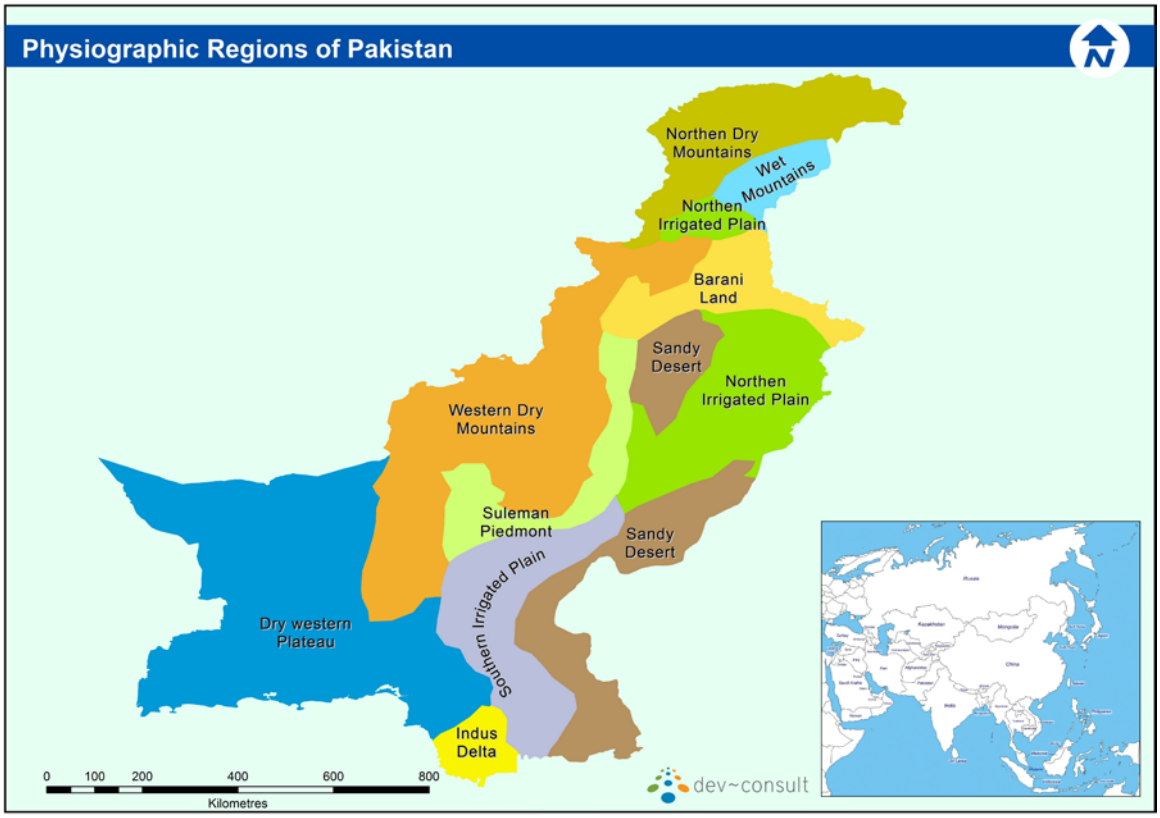
(1992). PARC (1980) categorised Pakistan in 12 physiographic regions (Figure 2) while according to Köppen climate classification, Pakistan is divided into the same number of climatic regions (Figure 3).

Figure 1: Topography of Pakistan

With this topographic, physiographic, and climatic diversity, Pakistan is blessed with all kind of flora and fauna, and food resources. However, with the uncertainties of climate change, Pakistan is challenged with increased frequency of occurrence and severity of extreme weather events. The balance of snow melt on more than 5000 glaciers in summer and nourishment in winters has got disturbed due to erratic temperature changes. The monsoon has facing the same challenge as on one hand the seasonal march of monsoon (onset, number of rainy days, offset etc.) is disturbed due to changing climate while on the other hand its inter-annual variability (repeated drought/flood events) has posed a serious challenge for the sustainable crop production. So now if north gets surplus water from heavy rainfall or snow/glacier melting, it immediately runs down to the low elevation plains of Sindh and Punjab flooding the cultivated

lands and destroying standing field crops. In case of less rainfall in the northern half, again the agricultural plains of south suffer a lot due to intense heat, higher water demands but less available water. The tropical cyclones of the north Arabian Sea are another emerging challenge faced by coastal areas of Pakistan.

Figure 2: Physiographic regions of Pakistan

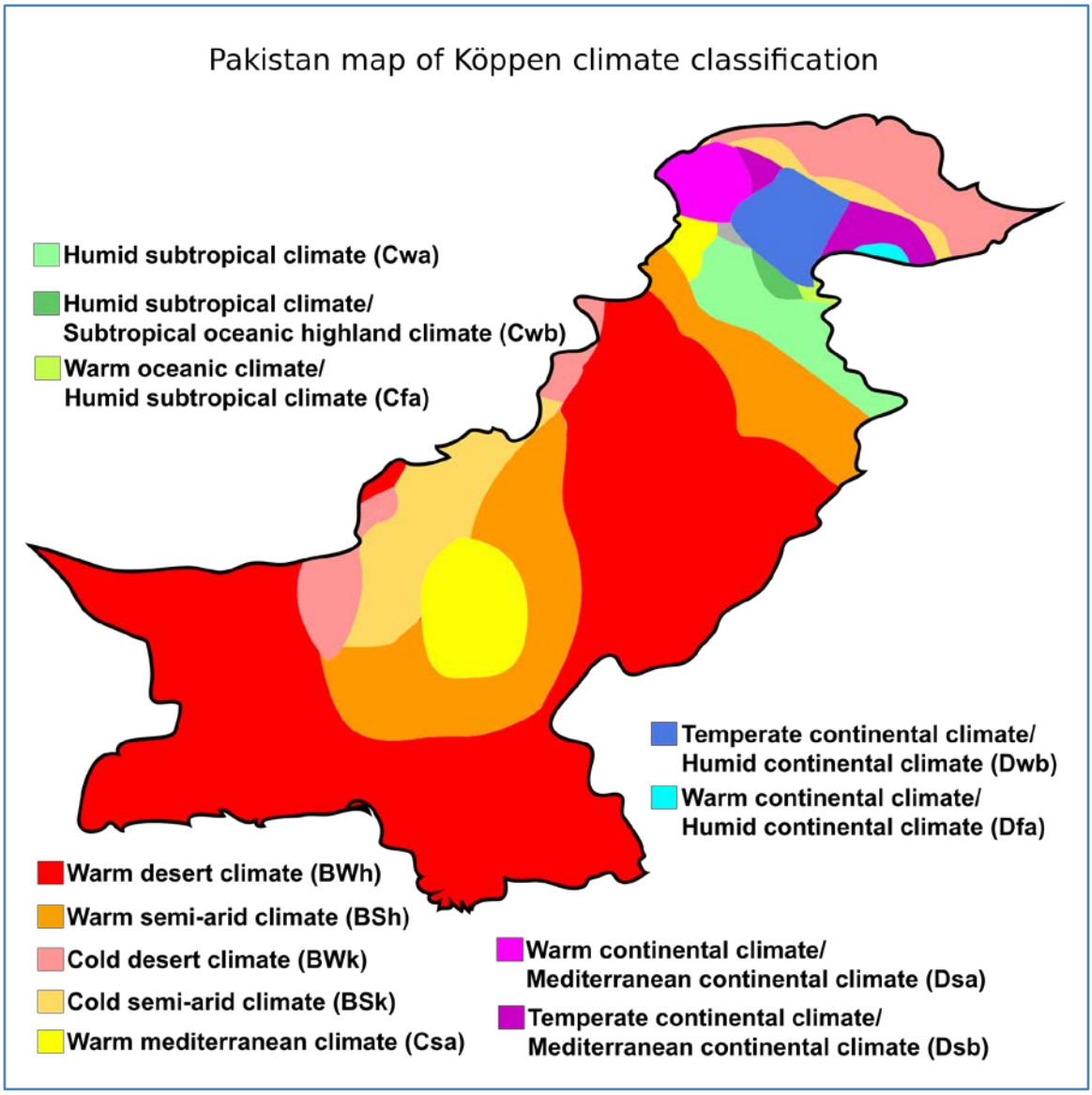


Data source: PARC, 1980.

The experts are of the opinion that climate change might take away or alter monsoon from the Indo-Pak sub-continent. Coupled with dry erratic and intensive rains, late monsoons, dry winters, and prolonged dry spells, Pakistan will witness severe weather conditions including disasters such as floods and droughts. The back to back floods of 2010, 2011, 2012, 2013 and 2014, worst drought during 1999-2003, two cyclones in one month in Karachi/Gwadar Coast in 2008 and increased incidences of landslides, GLOFs (Glacier Lake Outburst Floods) in the Gilgit-Baltistan are indicators of impacts of climate change. The major impacts of climate change in Pakistan are:

- Climatic variability in precipitation and river flows is extremely high even before the climate change, i.e. the annual highest historical river flows are twice of the lowest flows. In addition, there is an extreme seasonality in river flows where summers-season river flows are five-fold of the winter season flows.
- The increased variability of the Monsoon is a serious concern as the major river flows are received during the Monsoon season of three months (July to September).
- Uncertainty to timely availability of irrigation water caused by changes in river flows due to glacier melting and altered precipitation pattern; shortage of irrigation water due to inadequate storage capacity.
- Increased requirements of irrigation water due to higher evapotranspiration at elevated temperatures; while less water will be available.

Figure 3: Climatic regions of Pakistan



Source: Wikipedia: Climate of Pakistan (https://en.wikipedia.org/wiki/File:Pakistan_map_of_Köppen_climate_classification.svg)

- The extreme events (floods, droughts, cyclones, extreme high/low temperatures, etc.) are going to be severe and more frequent, resulting in heavy damages to both crops and livestock.
- Severe water and heat-stressed conditions in arid and semi-arid regions leading to reduced agricultural productivity, especially erratic and uncertain rainfall patterns affecting particularly the rain-fed agriculture.
- Increase in deforestation resulting in loss of biodiversity.
- Increased risks related to human and animal health.
- Reduced productivity of crops and livestock due to heat stress and other adverse impacts of change in climate parameters.
- Abundance of insects, pests and pathogens in warmer and more humid environment, particularly after heavy rains and floods.

- Degradation of rangeland and further deterioration of the already degraded cultivated land areas such as those suffering from water erosion, wind erosion, waterlogging, and salinity.
- Intrusion of seawater into deltaic region due to sea level rise affecting coastal agriculture, forestry, biodiversity, mangroves, and breeding grounds of fish.
- Low predictability in expected changes in climatic parameters such as temperature, precipitation, and extreme events.

Pakistan's economy and its food security are highly dependent on agriculture, which in turn relies on large-scale glacial reserves of water in the Karakorum, Pamir, and Himalaya regions. The growing population is putting pressure on water and other natural resources. Any additional pressure due to climate change will be difficult to sustain for the country as it has severe resource and capacity constraints. Inadequate physical and institutional infrastructure makes it impossible to cope with and timely respond to the impacts of climate change such as witnessed during natural disasters like floods and droughts in the last decade.

Pakistan Strategic Country Environmental Assessment Report of 2006 highlighted that the annual cost of environmental degradation in the country has been estimated at PKR 365 billion ($4.2 billion). Environmental experts believe the annual cost of environmental degradation has now reached around PKR 603 billion ($5.2 billion) in financial losses which is almost 2.35% of Pakistan's GDP (PKR 25,620 billion).

The country is now suffering from rapid deforestation with an annual rate of 4-6% while CO_2 emissions are increasing annually at the rate of 8-10%. Almost 250 million gallons of untreated water is dumped into the Arabian Sea every day by residents and industries located in Karachi, which is destroying the ecosystem. Similar situation exists in almost all the cities including Islamabad, Peshawar, Lahore, Quetta, and Hyderabad where raw sewage and industrial effluents are ultimately disposed in to waterways and pollute the groundwater. Recent data indicates that over one million acres of fertile arable land in the Indus Delta has become saline and unusable, largely due to reduced flows below Kotri largely because of enhanced allocations for the irrigated agriculture in the provinces including Sindh.

2.2. Policy and legal paradigm for climate change

2.2.1. Vision 2030

The main focus of Pakistan's Vision 2025 document is adaptation, in view of Pakistan's high vulnerability to the impacts of climate change including, inter alia, degraded ecosystems and high levels of rural poverty, illiteracy and marginalisation of women. Nonetheless, mitigation measures for the sectors of energy efficiency and conservation, transport, forestry, industry, agriculture, livestock, and town planning are also part of the Policy.

2.2.2. National Climate Change Policy, 2012

Policy identifies the vulnerabilities to climate change in the sectors of water resources, agriculture, forestry, coastal areas, biodiversity, and vulnerable ecosystems and spells out the appropriate adaptation measures to be adopted. It also puts forward appropriate measures concerning disaster preparedness, capacity building, institutional strengthening, technology transfer, and international cooperation.

2.2.3. National Forest Policy, 2010

This acknowledges the multiple functions of Pakistan's forests, such as carbon storage for climate change mitigation. However, there is a particularly strong focus on forests' role in mountains where they provide protection of soil from erosion and reduction of downstream siltation in wet mountainous environment; and crucially, watershed protection. It also notes the potential of forests to support local livelihoods in terms of provision of non-timber forest products (mushrooms, medicinal plants, etc.).

2.2.4. Renewable Energy Technologies Act, 2010

The law provides for institutional development by mandating the establishment of the Pakistan Council of Renewable Energy Technologies. The council will be responsible for promoting the development, acquisition, propagation, and dissemination of renewable energy technologies. Specifically named technologies are: solar/photovoltaic; thermal, hydrogen, biogas/biomass, mini and micro-hydro power; and wind technologies. Pakistan has a wide range of legislation relating to climate and energy, in addition to those mentioned above.

2.3. Key players in climate change adaptation[3]

2.3.1. Ministry of Climate Change

Pakistan is the only country, which has established an exclusive Ministry for Climate Change. This does not mean that Pakistan is addressing this issue more effectively; however, at least it has established the institutions at the highest level and provided policy and legal framework for future actions being a country expected to be most vulnerable to climate change. The Prime Minister of Pakistan approved launching of Green Pakistan Programme on 4 March 2016 in all the provinces to plant 100 million plants in next five years. The government of Khyber Pakhtunkhwa province has also initiated the Green Growth Initiative during 2015. The forest cover in Pakistan is one of the lowest in the world having similar environments. The climatic variability is extremely high even before the climate change and with the expected climate change the extreme events of floods and droughts are going to be more severe and more frequent, which the country has already observed in the last decade. Pakistan being an arid country will experience more persistent droughts in the future due to impacts on availability of water and increase in evapotranspiration requirement of natural vegetation and crops. The important point is how to mainstream climatic variability and climate change impacts in to the planning process in various sectors of development. This is one of the major challenges for the Ministry of Climate Change in Pakistan.

The Ministry of Environment, Government of Pakistan launched its first National Climate Change Policy in February 2012, to cope with the threats of climate change through adaptation and mitigation measures. The 18th Amendment to the Constitution of Pakistan, however, resulted in

[3] The section has benefited from papers and information available from the multiple web resources, and

- Ahmad, S. 2008. "Water Shortage and Future Agriculture in Pakistan – Challenges and Opportunities." Paper presented in the National Conference on "Water Shortage and Future Agriculture – Challenges and Opportunities", Agriculture Foundation of Pakistan. August 26-27, 2008, Islamabad, Pakistan;
- Ahmad, S. 2009. "Global Warming Impacts on Agriculture and Adaptations." Paper presented in Workshop on Climate Change Impacts and Adaptations in Agriculture of Pakistan. Agriculture Foundation of Pakistan and University of Arid Agriculture, Rawalpindi; and
- Information available on the websites of Ministry of Climate Change, COMSATS-CCRD, NUST-CAS-EN, LUMS-WIT and NARC-CCREWI.

devolution of environment as a subject to the provinces and the federal Ministry of Environment was abolished which slowed down the whole progress.

Owing to the magnitude and recurrence of climate change related disasters, such as consecutive floods of 2010, 2011 and 2012; Ministry of Climate Change was established on 18 April 2012. The Ministry of Climate Change has been vested with the mandate to comprehensively address disaster management along with spearheading national climate change initiatives both in adaptation and mitigation.

The establishment of the Ministry of Climate Change at the federal level has given higher priority to the subject of climate change and desired institutional arrangements have been developed to cope with the issues related to climatic variability and climate change. The Ministry of Climate Change has established five departments:

i. Global Change Impact Study Centre (GCISC);
ii. National Disaster Management Authority;
iii. Pakistan Environmental Protection Agency;
iv. Pakistan Environmental Planning & Architectural Consultants Ltd.;
v. Pakistan Environmental Protection Council; and
vi. Zoological Survey Department.

The Ministry of Climate Change has taken many initiatives and projects were formulated with the support of donors in the area of climate change adaptations and mitigation in accordance with the Climate Change Policy 2012 which includes: (a) legislative and policy interventions introduced and implemented; (b) framework for implementation of National Climate Change Policy (2014-2030); and (c) launched Framework for implementation of National Climate Change Policy (NCCP) for 2014-2030 in November 2013.

The framework for the implementation of the NCCP provides guidelines regarding the adaptation of changing impacts of climate and how to play an effective role in mitigation of the impacts. The framework is developed keeping in view the current and future anticipated climate change threats to various sectors of development. In view of Pakistan's high vulnerability to the adverse impacts of climate change, in particular extreme events of floods and droughts, the emphasis has been placed on the adaptation of climate change impacts, as laid down in the NCCP. The vulnerabilities of various development sectors to climate change have been highlighted and appropriate adaptation actions spelled out in the framework for implementation. These cover actions to address issues in various development sectors such as water, agriculture, forestry, coastal areas, biodiversity, health and other vulnerable ecosystems. Notwithstanding the fact that Pakistan's contribution to GHG emissions is very small, its role as a responsible member of the global community in combating climate change has been highlighted by giving due importance to mitigation efforts in sectors such as energy, forestry, transport, industries, urban planning, agriculture and livestock.

Furthermore, appropriate actions relating to disaster preparedness, capacity building, institutional strengthening; and awareness-raising in relevant sectors has also been part of this document. The Framework is now being used to prepare the detailed provincial and local adaptation action plans. The significant achievements of the Ministry are:

- National Report of Pakistan for HABITAT-III
- National Technology Needs Assessment (TNA) Committee
- Participation in international climate negotiations
- Preparations for COP-21

- Hosting of Second Pakistan Conference on Sanitation (PACOSAN-II) & Sanitation and Water for All (SWA) Regional Consultations
- Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5)
- Pakistan Elected as Member for Consultative Group of Experts (CGE)
- 13th Meeting of Governing Council of South Asia Co-operative Environment Programme (SACEP) and 5th Inter Ministerial Meeting of South Asian Seas Programme (SASP)
- SAARC Workshop on Climate Change Impacts on Coastal and Aquatic Resources
- SAARC Workshop on Bio-invasion and Ballast Water Management
- Pakistan is a member of regional initiative on Mangroves for the Future (MFF) programme along with other 11 countries since 2010.
- To ensure effective implementation of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) in Pakistan an exclusive law entitled "The Pakistan Trade Control of Wild Fauna and Flora Act, 2012" has been enacted.
- In October 2014, a CITES Management Authority of Pakistan under the Chairmanship of Federal Minister for Climate Change was notified to facilitate wildlife trade to strengthen the National economy and to facilitate local communities to conserve big game under trophy hunting of Markhor, Ibex and Urial.
- During 2013, Pakistan became member of World Bank's Forest Carbon Partnership Facility (FCPF).

Major projects initiated and completed by the Ministry of Climate Change are:

- Clean Development Mechanism (CDM) project
- Sustainable Land Management Project (SLMP) – Phase-I
- Global Environment Facility (GEF) funded projects
- Comprehensive Reduction and Elimination of Persistent Organic Pollutants in Pakistan (POPs)
- Climate Finance Unit (CFU) - Pakistan
- Glacial Lake Outburst Floods (GLOF) project
- Mangroves for the Future (MFF)

2.3.2. Global Change Impact Study Centre (GCISC)

The GCISC is the research arm of the Ministry of Climate Change, Government of Pakistan. The Centre is dedicated to national level R&D effort, capacity building, policy analysis, information dissemination and assistance to national planners and policymakers on issues related to past and projected future climatic changes in Pakistan, their likely impacts on the key socio-economic sectors of the country such as water, food, agriculture, energy, forestry, health, ecology, etc. and appropriate adaptation and mitigation measures.

Overwhelming evidence accumulated over the last three decades clearly shows that human activity has reached a level where it is significantly affecting the global environment. Furthermore, the global change due to anthropogenic perturbations is happening at a much shorter time scale compared to the natural events. It is feared that some of the resulting adverse impacts will have serious implications in areas such as climate, health, water, energy, food security, etc. in many parts of the world. Developing countries with weak scientific and technological base will be most vulnerable to such adverse impacts.

It is in this perspective that the GCISC was established in May 2002. The Centre started functioning with seed money provided by the Ministry of Science & Technology, and functioned as a public-sector development project for 11 years. In March 2013, GCISC was granted the

status of a regular national entity by passage of "GCISC Act 2013" through the Parliament. It is now functioning as a research arm of the Ministry of Climate Change, under the directions of a Board of Governors, which was duly approved in November 2013 by the Prime Minister of Pakistan (then Minister-in-charge of Climate Change Division, Cabinet Secretariat/Chairman of the BOG).

The main purpose of the Centre is to address climate change related issues in Pakistan on scientific basis and to assist the national planners and decision makers for strategic policy planning in consonance with the changing global environment in areas such as climate, water, energy, food, agriculture, health, ecology, new technologies, etc. The specific objectives of the Centre are to:

- Keep a track of the current and likely future trends of global change (climate change, technological change, etc.);
- Analyse and evaluate their likely impacts on the socio-economic development in Pakistan;
- Identify how science and technology may be called upon to cope with the adverse impacts, if any, and to advise national planners on the appropriate strategic approaches;
- Enhance national capacity for global change research;
- Raise public awareness of global change related issues; and
- Assist the concerned government agencies in formulation of national climate change policies and plans of action.

The main functions of the GCISC are:

- Research on climate change profiles of Pakistan, impact assessment in different socio-economic sectors and identification of appropriate adaptation and mitigation strategies;
- Capacity building of young scientists of GCISC and the relevant national research organizations in climate change research; and
- Dissemination of research findings to scientific community, planners, policymakers, and raising public awareness of climate change concerns.

The current research activities of the Centre are grouped under three Sections, namely Climatology and environment; (b) water resources and glaciology; and (c) agriculture, forestry and land use.

2.3.3. COMSAT Centre for Climate Research and Development (CCRD)

The COMSATS Institute of Information Technology (CIIT) has set up a Centre for Climate Research and Development (CCRD). The creation of CCRD is a manifestation of the realisation that there is an urgent need to develop Pakistan's capacity to:

i. Enhance understanding of climate change;
ii. Develop relevant technical research capacity;
iii. Establish knowledge networks and links in the region and internationally; and
iv. Promote the teaching of climate sciences.

Pakistan needs to increasingly look at its development work through a 'climate lens' to ensure adaptability and sustainability. Hence an important aspect of the work of CCRD would focus on mainstreaming climate change into development policy and community-based adaptation to climate change across the country. Major areas of work CCRD is mandated for include:

i. Study extreme weather conditions and associated environmental challenges by improving capabilities for scientific research;
ii. Assess climatic conditions and climatic variability in the region;
iii. Conduct research on the consequences of climate change, leading to formulation of mitigation and adaptation strategies; and
iv. Provide support to institutions in Pakistan for designing policies and programs in the framework of the national climate change policy.

CCRD's main office is located at CIIT Islamabad, with the technical resource centre located at the CIIT campus in Abbottabad. The main research expertise relevant to the climate change group at CIIT Abbottabad are (a) climate change and glaciers monitoring; (b) snow and glacier hydrology; (c) water resources management; (d) biodiversity and conservation; (e) nitrogen cycling (global warming); and (f) climate change and ecosystem functioning.

2.3.4. NUST – US Pakistan Centre for Advanced Studies in Energy

The National University of Science and Technology (NUST) entered into a USD 14.98 million Cooperative Agreement with USAID to establish Centre for Advance Studies in Energy (CAS-EN) to address some of the outstanding challenges faced by the energy sector in Pakistan and to facilitate applied research and education partnership between USA and Pakistan. Strategic goals behind CAS-EN are to evolve into a Centre of Excellence in Applied Research catering to the energy sector and economy of Pakistan with the aim to establish efficient governance structures – sustainability, value-added curriculum and capacity building; promote applied research to serve public/private sector and NUST-US students/faculty exchange programs. CAS-EN energy research agenda and research thrusts focus areas are research & policy development in renewable energy & emerging technologies, thermal engineering leading to energy security utilizing indigenous resources; promotion of technologies & practices that increase energy efficiency in all sectors and technology innovation and entrepreneurship in energy and supporting technologies, materials and services. The core mission of CAS-EN is to efficiently address and implement the E3 criteria (Energy, Environment and Economy) for sustainable societal development. The Centre is committed to create an ecosystem for addressing energy requirements by influencing policy makers, developing technologies, human resources and mobilizing communities for energy conservation. CAS-EN–NUST is determined to make it a world class Energy Centre, whereby pilot plants in the areas of accelerated biofuels, gas to liquid processes, solar modules and thin films, and indigenous development of windmills will be rigorously taken up. The core objective of this program at NUST is to raise the level of graduate training programs to international level and to encourage research and development; produce and groom effective managers and future leaders to formulate national economic development strategy. The Centre provides cost-effective and sustainable solutions to problems facing Pakistan through research and program design. CAS-EN is involved in forming public-private partnerships and interest-specific networks by bringing together the best minds in academia, government and the business community to produce research solutions to some of Pakistan's greatest challenges in energy security, water and agriculture. A separate USD 5.0 M green building is also contributed by USAID on NUST campus to house CAS-EN.

2.3.5. LUMS Centre for Water Informatics and Technology

In October 2015, the Centre for Water Informatics & Technology (WIT) was established at the Lahore University of Management Sciences (LUMS). The mission of WIT is to act as a hub for national and international research activities related to water resources, with a particular focus on ICT, decision support tools, and technologies, to facilitate the understanding of water as it operates in a complete system. In understanding water within an environment as an integrated

system, WIT activities will explore the social, political, economic, and technical aspects that shape water systems, with emphasis on the unique role of humans as agents of change.

WIT activities aim to stimulate competitive and innovative research that is developed within the broader context of water-development nexus to support the science-engineering-policy interface in Pakistan's water sector. Activities at WIT will not only be innovative, but will demonstrate how public and private institutions and organisations can best benefit from the use of hydro-informatics and systems analysis.

The research activities performed by the WIT staff will play a pivotal role in integrating awareness and understanding of water and its nexus with food, energy, agriculture and environment. Examples of past projects and those currently under implementation are: (a) smart water metering; (b) ICT and irrigation in Pakistan; (c) contamination spread monitoring in surface and groundwater; (d) Bayesian inversion, compressive sensing & data assimilation in hydro systems; (e) ICT solutions for efficient water resources management; (f) ICT and flood forecasting and management; (g) operational decision support system for flood management; (h) telematics; (i) data mining, knowledge discovery and data-driven modelling, with applications in civil engineering; (j) reservoir operations; (k) optimization methods; (l) pare-to-optimal solutions to multi-criteria decisions; (m) smart water grids; (n) control & identification of irrigation channels; and (o) water rights in smart water grids.

Looking at the agenda, it seems that the Centre does not have any priority in the selection of research agenda. There is a need to focus the research agenda by developing 3-4 programmes.

2.3.6. Climate Change, Alternate Energy and Water Resources Institute, NARC

The Water Resources Research Institute (WRRI) has been renamed as Climate Change, Alternate Energy and Water Resources Institute (CAEWRI). WRRI was established in 1991-92 as a result of reorganization of the water related research programmes being executed at the National Agricultural Research Centre (NARC), Islamabad. Presently, the Institute is involved in problem-oriented, strategic, operational, and inter-disciplinary research in areas of national importance.

The Institute has trained multi-disciplinary team of about 24 qualified scientists/engineers supported by skilled staff of over 40 persons with well-equipped laboratories and weather stations. The scientists and engineers are engaged in research activities aimed at devising solutions and management strategies for climate change, water resources and alternate energy which are economically viable, technically feasible and socially acceptable.

The goal of the Institute is to develop technologies; knowledge base and management strategies for farming systems to enhance the productivity of per unit of water. The objectives of the Institute are to:

- Optimize the productivity of water use under rain-fed and irrigated environments;
- Develop sustainable balance between resource utilization and its replenishment;
- Climate change impact assessment on water resources and agriculture, its adaptation and mitigation; and
- Alternate energy resources production/harvesting and management.

The major issues related to climate, energy and water as outline by the Institute are:

- Aridity causing shortage of water;
- Erratic rainfall;
- Climate change extremes impacting water resources and agriculture;

- High energy cost for water pumping; (e) excessive mining of groundwater in fragile environments like Balochistan;
- Water erosion causing degradation of watersheds and rangelands and sedimentation of water reservoirs;
- Significant losses in water conveyance and application causing waterlogging and salinity; and
- Loss of rainwater as surface run-off.

The major research programmes of the Institute are:

- Water resources planning;
- Agriculture water management;
- Integrated watershed management;
- Climate change and geo-informatics; and
- Alternate energy in agriculture.

The Institute has been engaged in innovative and applied research with the following national and international organizations:

- International Centre for Integrated Mountain Development (ICIMOD), Nepal.
- The Norwegian Institute for Agricultural and Environmental - Bioforsk, Norway
- SAARC agriculture Centre, Dhaka, Bangladesh
- University of Tokyo, Japan
- Japan International Cooperation Agency (JICA), Japan.
- Australian Centre for International Agricultural Research (ACIAR), Australia.
- Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia.
- International Centre for Bio-Saline Agriculture (ICBA), Dubai.
- Water and Power Development Authority (WAPDA)
- Ministry of Climate Change, Government of Pakistan.
- Pakistan Meteorological Department, Islamabad
- National Centre of Rural Development (NCRD), Islamabad
- Global Climate Change Impact Study Centre (GCISC), Islamabad

2.3.7. Institutional setup for disaster management

2.3.7.1. National Disaster Management Commission (NDMC)

The NDMC was established through an ordinance in December 2006 after the earthquake of 2005. It is a body to ensure DRR at policy, planning, and implementation stages across the country. The NDMC shall have the responsibility for laying down the policies, plans, and guidelines for disaster management. Without prejudice to generality of the provisions in sub-section (1), the National Commission may:

- Lay down policies on disaster management;
- Approve the national plan;
- Approve plans prepared by the ministries or divisions of the federal government in accordance with the national plan;
- Lay down guidelines to be followed by federal government and provincial authorities;
- Arrange for, and oversee, the provision of funds for the purpose of mitigation measures, preparedness and response;

- Provide such support to other countries affected by major disasters as federal government may determine; and
- Take such other measures for the prevention of disaster, or the mitigation, or for preparedness and capacity building for dealing with disaster situation as it may consider necessary.

The composition of NDMC is illustrated as under:

- The Prime Minister of Pakistan, Chairperson
- Leader of the Opposition in the Senate, Member
- Leader of the Opposition in the National Assembly, Member
- Minister for Defence, Member
- Minister for Health, Member
- Minister for Foreign Affairs, Member
- Minister for Social Welfare and Special Education, Member
- Minister for Communication, Member
- Minister for Finance, Member
- Minister for Interior, Member
- Governor Khyber Pakhtunkhwa (for Federally Administered Tribal Areas), Member
- Chief Ministers of all the Provinces, Member
- Prime Minister, Government of AJK, Member
- Chief Executive (Chief Minister), Gilgit-Baltistan, Member
- Chairman, JCSC or his nominee, Member
- Representatives of Civil Society or any other person appointed by the Prime Minister, Member

2.3.7.2. National Disaster Management Authority (NDMA)

The NDMA is the lead agency at the Federal level to deal with whole spectrum of disaster management activities. It is the executive arm of the NDMC, which has been established under the Chairmanship of the Prime Minister, as the apex policymaking body in the field of disaster. In the event of a disaster all stakeholders, including Government Ministries, Departments, Organizations, Armed Forces, INGOs, NGOs, UN Agencies work through and from part of the NDMA to conduct one window operation. NDMA aims to develop sustainable operational capacity and professional competence to undertake the following task:

- Complete spectrum of DRM at the national level.
- Act as secretariat of the NDMC to facilitate implementation of DRM strategies.
- Map all hazards in the country and conduct risk analysis on a regular basis.
- Develop guidelines and standards for national and provincial stakeholders regarding their role in DRM.
- Ensure establishment of DM Authorities and Emergency Operations Centres at provincial, district and municipal levels in hazard-prone areas.
- Provide technical assistance to federal ministries, departments, and provincial DM authorities for DRM initiatives.
- Organize training and awareness raising activities for capacity development of stakeholders, particularly in hazard-prone areas.
- Collect, analyse, process, and disseminate inter-sectoral information required in and all hazards management approach.
- Ensure appropriate regulations are framed to develop disaster response volunteer teams.

- Create requisite environment for participation of media in DRM activities.
- Serve as the lead agency for NGOs to ensure their performance matches accepted international standards, e.g. the SPHERE standards.
- Serve as the lead agency for international cooperation in DRM. This will particularly include, information sharing, early warning, surveillance, joint training, and common standards and protocols required for regional and international cooperation.
- Coordinate emergency response of federal government in the event of a national level disaster through the National Emergency Operations Centre (NEOC).
- Require any government department or agency to make available such men or resources as are available for the purpose of emergency response, rescue and relief.

2.3.7.3. Technical committees

The NDMA, PDMA and DDMAs may establish Technical Committees in order to facilitate coordination and enable optimum use of available skills and resources. Technical Committees will focus on specific disaster threats and issues, which may not have been covered as part of the stakeholders' responsibilities in the Framework. Technical Committees could assist local, provincial or national authorities in identifying issues and problems and devising solutions. The specific areas that could be covered through the establishment of TCs are:

- Cyclones, storms, winds
- Disaster risk communication
- Drought
- Early warning systems
- Earthquakes
- Epidemics
- Floods
- Industrial and mines accidents
- Landslides, earth slides and avalanches laws, procedures and standards
- Locust/pest infestation
- Major transportation accidents
- Marine disasters, including oil spills
- Refugees/displaced persons
- Tsunamis
- Urban and forest fires
- Any other future calamity

2.3.7.4. Provincial Disaster Management Commissions (PDMCs)

The DRM is a provincial subject, the provincial governments will have crucial role in implementation of DRM policies, strategies and programmes. Each provincial government will form a Provincial PDMC, which will be chaired by the Chief Minister. Leader of the opposition and a member to be nominated by him will also form part of the PDMC. Other members will be appointed by the Chief Minister. They may include stakeholders from provincial departments, civil defence, Red Crescent, police, fire services, university faculty, research institutions, civil society organizations, representatives from commerce, industry and insurance sectors, and other technical experts in the province. Provincial Commission will facilitate links between national objectives and provincial/regional priorities. The Director General, PDMA will serve as the Member/Secretary of the PDMC with focal point responsibilities for disaster policy, planning and implementation.

The PDMCs shall:

- Lay down the provincial DRM policy
- Develop provincial DRMPs in accordance with guidelines laid down by the National Commission
- Ensure that DRMPs are formulated by all departments, and district/municipal authorities;
- Review the sectoral development plans of provincial departments and ensure that risk reduction measures are integrated therein
- Approve DRMP prepared by the provincial departments
- Review implementation of the plans, and
- Oversee the provision of funds for risk reduction and preparedness measures.

2.3.7.5. Provincial Disaster Management Authorities (PDMAs)

The PDMAs are headed by a Provincial Director General with the status and powers of a Secretary. The DG will be appointed by the Provincial government. The Authority will serve as secretariat of the Provincial Commission. It will work upon development, implementation and monitoring and evaluation of DRM activities in vulnerable areas and sectors in the province. The provincial authority will have the following responsibilities:

- Coordinate complete spectrum of disasters in the province and formulate provincial DRMPs
- Continuously monitor hazards, risks and vulnerable conditions within the province
- Develop guidelines and standards for provincial and local stakeholders regarding their role in DRM
- Ensure preparation of DRMPs by all district authorities
- Coordinate implementation of provincial DRMPs in accordance with the National Framework,
- Promote education, awareness and training on DRR and response
- Provide necessary technical assistance and advice to local authorities for carrying out their functions effectively
- Coordinate emergency response in the event of a disaster, through the Provincial Emergency Operations Centre (PEOC)
- Develop specific capabilities to manage threats that exist in the province
- Perform such other functions as may be assigned by the Provincial Commission.

2.3.7.6. District Disaster Management Authorities (DDMAs)

The DDMAs shall be established by the provincial government in hazard prone areas on a priority basis. The District Authority will comprise of the Nazim, District Coordination Officer (DCO), Police Officer, ex-officio, EDO health and Tehsil Nazims. The local government can nominate other officers as members of the DDMA. They may include EDOs for education and agriculture, Red Crescent, NGOs, media, private sector, fire services, or any other local stakeholders. Municipal Disaster Management Authorities (MDMA) will be established in urban areas and cities on similar lines. The DDMA and MDMA will:

- Formulate district disaster risk management plan (DDRMP), based upon local risk assessment, and coordinate its implementation
- Review development plans of government departments and provide guidance on mainstreaming DRR measures in these plans,

- Continuously monitor hazards, risks and vulnerable conditions within the district, municipality, or cantonment areas,
- Prepare guidelines and standards for local stakeholders on DRR
- Conduct education, training and public awareness programmes for local officials, stakeholders and communities
- Encourage involvement of community groups in DRR and response by providing them necessary financial and technical assistance for implementing community level initiatives
- Examine construction in the area and if hazard safety standards have not been followed, direct the relevant entities to secure compliance of such standards
- Invest in specific capabilities according to the requirement to manage all types of threats peculiar to local area
- Undertake appropriate preparedness measures at district level; e.g. maintain an early warning system, identify buildings to be used as evacuation sites, stockpile relief and rescue materials and identify alternative means for emergency communications
- In the event of a disaster, organize emergency response through the District Emergency Operations Centre (DEOC),
- Maintain linkages with the PDMA and the Relief Department, and
- Perform such other functions as the Provincial Authority may assign to it.

2.3.7.7. Tehsil and Town Authorities

Institutions at this level are the frontline of DRR and response. For many departments this is the lowest level of administration where they interface directly with communities; agriculture, education, health, police, revenue and others. Extension workers of above departments could play a significant role in promoting risk reduction. For example, agriculture extension workers could promote awareness of drought, flood or cyclone resistant crops. Health workers could raise people's awareness about potential diseases that may occur after a flood or drought and how to prepare for them. Education officials could work on school disaster preparedness. Similarly, Tehsil Authorities have an important role in organizing emergency response and relief; e.g. damage and loss assessment, and recovery needs assessment. Tehsil and town Nazims will lead the risk reduction and response operations with the help of Tehsil or Town Municipal Officer in consultation with the DDMA. Other key players include; extension workers, police, fire services, community organizations (COs), traditional leaders and NGOs. Appropriate local structures would be established for risk reduction and preparedness.

2.3.7.8. Union councils (UCs)

The UC is the lowest tier in the governance structure. Elected representatives from village and ward levels form these bodies. These bodies have an important role in allocation of resources for local development works. UCs can play an important role in advocating demands of communities to the District Councils and DM Authorities. Community demands may include requests for allocation of resources from local budgets for hazard mitigation and vulnerability reduction activities; e.g. spurs for flood control, rainwater harvesting structures for drought mitigation, vocational training for livelihoods to reduce vulnerability, etc. Therefore, it will be important to develop orientation and knowledge of local political leadership at this level. More capable UCs may develop local policies and guidelines for vulnerability reduction.

2.3.7.9. Community based organizations (CBOs)

In order to promote community level DRM activities, the capacity of existing community organizations will be developed and enhanced by district and tehsil authorities. In the absence

of community organizations, new groups would be established to work on DRM. The CBOs will be trained about local early warning system, evacuation, first aid, search and rescue, fire-fighting, etc. Linkages would be developed between CBOs and relevant local agencies; e.g. agriculture, banks, health and veterinary services to promote disaster preparedness. Skills and knowledge of CBO leadership will also be developed in financial management, people management, resource mobilization, interpersonal communication, and presentation and negotiation skills. The provision of Citizen Community Boards (CCBs) in Local Government Ordinance (LGO 2001 and amendments thereafter) provides a good opportunity to organize communities and mobilize resources for local level DRM.

2.4. Gender and climate change adaptation[4]

While the climate change adaptation itself has not been adequately addressed at the policy and institutional level, and the communities are experimenting to respond to the climate challenge based on their indigenous practices, the role of women in climate change adaptation is understandably under-recognised. Despite the guiding principles within the UN system to incorporate gender considerations, the UN Framework Convention on Climate Change, UNFCCC has failed to adopt a gender-sensitive approach, which leads to shortcomings in the efficiency and efficacy of climate-related adaptation and mitigation measures and instruments.

Women are affected differently, and often more severely, by climate change and associated natural disasters such as floods, droughts, cyclones and storms largely because men and women are bound by distinct socio-economic roles and responsibilities that give rise to differences in vulnerability and ability to cope with these climate change consequences. Consequently, vulnerable groups – especially poor women – are likely to be faced with problems such as food insecurity, loss of livelihood, hardships due to environmental degradation that lead to displacement and a host of other potentially devastating economic and social consequences.

The National Climate Change Policy (2012) emphasises the need to address gender aspect in climate change debate through its policy objective "To focus on pro-poor gender sensitive adaptation while also promoting mitigation to the extent possible in a cost-effective manner." It recognises that climate change will affect women and underprivileged people disproportionately as they are weak and more vulnerable and have the least resources to adapt. The majority of rural women being engaged in agriculture are likely to be strongly affected by climate change as it would increase their work in agriculture production and other subsistence activities such as collecting fuel wood and water, putting extra pressure on women. Further, women are found to be more vulnerable during extreme climate events and disasters.

However, women are also very powerful agents of change necessitating to ensure their participation in all policies, initiatives, and decisions relating to climate change. In this regard, the Policy has identified the following policy measures:

a. Mainstream gender perspectives into climate change efforts at national and regional levels;

[4] This section has benefitted from:

- Government of Pakistan. 2012. *National Climate Change Policy*. Islamabad: Ministry of Climate Change, GoP.
- Government of Pakistan. 2013. *Framework for Implementation of Climate Change Policy (2014-2030)*. Islamabad: Climate Change Division, GoP.
- UNDP. 2009. *Gender and Climate Change: Impact and Adaptation*. Bangkok: UNDP.

b. Take steps to reduce the vulnerability of women from climate change impacts, particularly in relation to their critical roles in rural areas in providing water, food and energy;
c. Recognize women's contribution in the usage and management of natural resources and other activities impacted by climate change;
d. Undertake a comprehensive study of the gender-differentiated impacts of climate change with particular focus on gender difference in capabilities to cope with climate change adaptation and mitigation strategies in Pakistan;
e. Develop gender-sensitive criteria and indicators related to adaptation and vulnerability, as gender differences in this area are most crucial and most visible;
f. Develop and implement climate change vulnerability-reduction measures that focus particularly on women's needs;
g. Incorporate an appropriate role for women into the decision-making process on climate change mitigation and adaptation initiatives;
h. Develop climate change adaptation measures on local and indigenous knowledge particularly held by women.

The Framework for Implementation of Climate Change Policy underlines the need for considering gender differentials for success of any adaptation programme. It recognises that while a large number of women in rural areas depend on climate-sensitive resources for survival and their livelihoods, they do not enjoy equal authority, decision-making power and resources needed to adapt to climate change. Pakistan's experiences in recent climate disasters clearly suggest that climate change is amplifying and exacerbating existing patterns of gender disadvantage. Thus, women's historic disadvantage, their limited access and control over decision-making and economic resources, and their restricted rights, make them more vulnerable to climate change.

Therefore, recognising that women's vulnerability to climate change differs from men and climate change interventions that are not gender-responsive often result in deepening the existing gender divide, the Government of Pakistan has shown its determination to support gender integration into various efforts to address climate change. This would be achieved by countering the disproportionate burden of climate change on women by ensuring their empowerment and recognition of their critical role in the management of climate change plans and strategies.

3. HYDROPOWER GENERATION AND SMART VILLAGES – CASES FROM GILGIT-BALTISTAN AND CHITRAL VALLEY, PAKISTAN[5]

In the Gilgit-Baltistan and Khyber Pakhtunkhwa (particularly Chitral), the potential of hydropower is enormous. Traditionally, water mills have been used as the flourmills, where wheat and corn grains are milled for household consumption. The water mills provide flour at very slow speed and local population is of the opinion that it provides delicious bread. The people in rural Pakistan still prefer flour from the water mills. But with the large-scale production of hydropower, the electric operated flourmills are now replacing the water mills. The climatic variability and climate change is going to worsen the problems of seasonality due to variations in water flows where hydropower units perform well at full capacity during the high flows and capacity reduced considerably in the winter season due to extremely reduced flows. The floods are now more common due to global warming resulting in higher snow- and glacier melts during the summer season. The floods are also increasing due to the Glacier Lake Outburst Floods (GLOF) phenomena, which has affected the community based hydropower plants. The generation and use of hydropower also helps to reduce the GHG emissions due to reduced use of fuel wood and fossil fuels. They also have positive impacts on the environment, in terms of reduce dependence on forest plantations for harvesting the fuel wood. Therefore, contribute in claiming the carbon credits due to avoidance of GHG emissions.

3.1. The context

The Gilgit-Baltistan is the water bank for Pakistan due to large area of glaciers and snow deposits in its mountains. The catchment area is 72496 km^2, which includes about 27% glaciers, the biggest in the world outside polar region. There are six main tributaries of Indus River - Olding, Shyoke, Shigar, Gilgit, Hunza and Astore. Drop of Indus River up to Diamar-Basha Dam site is 1.37 km. The average annual runoff near Basha is 50 MAF. The hydropower potential on main tributaries and Indus River is 40000 MW. The hydropower potential on the sub-tributaries is 1200 MW. The current generation of hydropower is 90 MW from 92 power stations. These are

[5] This section is based on the selected papers and web resources:

- Ahmad, S. 2008. *Water Resources of Gilgit-Baltistan*. Water Background Paper for the Gilgit-Baltistan Economic Report. World Bank, ADB and Government of Gilgit-Baltistan.
- Abidi-Habib, M. 2015. "Pakistan's first community power company lights up Hunza valley." (www.thethirdpole.net/2015/02/18/pakistans-first-community-power-company-lights-up-hunza-valley/). The authors of this paper are the founding member of the Karakoram Research Institute for understanding social and ecological change in the Gilgit-Baltistan region of Pakistan.
- Thirdpole (www.thethirdpole.net).
- Dr. Abdur Rehman Cheema is a development studies academic and practitioner based in Islamabad. He is Team Leader for Research at RSPN, Islamabad.
- Chitral Pioneer Community Hydropower Schemes
- How Clean Energy could Transform Pakistan
- Shaikh, Saleem and Sughra Tunio. 2016. "Mountain Pakistan Cuts Forest Loss Disaster Risk with River Power." Reuters (http://www.reuters.com/article/us-pakistan-hydropower-forest-idUSKCN0WG0I6), 14 Mar 2016.
- Potential of Small Hydropower Stations in Pakistan (https://www.linkedin.com/pulse/20141003215435-190310188-potential-of-small-hydropower-stations-in-pakistan).

large power stations and smaller are not included in it, which is the focus of the case study. The population of Gilgit-Baltistan connected with suppressed load is 75%. The present demand under conservative estimates is 200 MW and the optimistic projections shows that it is 410 MW. This would increase to 506 MW in 2015 and 863 MW in 2030. The under-construction power plants are of the capacity of 40 MW comprising of 29 plants.

The GoP Policy for power generation projects indicates that all types of power projects exceeding 50 MW capacity under public sector, private sector (IPPs) and public-private partnership are covered. The GoP Renewable Energy Policy 2006 indicates that solar, wind and small hydropower projects up to 50 MW are covered. The policy also provides private investment incentives. The GB Hydel and Renewable Energy Policy 2007 indicated that projects up to 50 MW capacity under public-sector program are covered.

Under the Renewable Energy Policy of Pakistan (2006), which is also applicable to Gilgit-Baltistan, the following incentives for the private-sector investment in developing hydropower projects having capacity of 50 MW or below are offered:

- Investment opportunity for private sector for following categories:
    - IPPs for sale of power to the grid only (solicited and unsolicited proposals)
    - Captive power cum grid spill over projects for self-use and sale to utility
    - Captive power projects for self or dedicated use
    - Isolated grid power project for 5 MW and below
- Except for IPPs, the projects will not require any Letter of Invitation, Letter of Support or Implementation Agreement.
- It permits investment to generate electricity from hydropower project at one location and receive an equivalent amount of energy for own use elsewhere the grid at investment or own cost of generation plus transmission charges (wheeling concept/energy banking).
- It permits “Net Metering and Billing.” A power producer can sell surplus energy at one time and receive electricity from the grid at another time and settle accounts on net basis.
- Simplified principles of tariff determination.
- Insulates the investment from hydrological variability risk. It facilitates projects to obtain carbon credits for avoiding GHG emissions; helping financial returns and reducing energy cost for the purchaser and in turn the consumers.
- Off grid hydropower projects can be developed for supply to a local community by corporate entities, NGOs or individuals at any location with the approval of the Provincial Government. For such projects, simplified procedural arrangements can be developed by the provincial government.
- No custom duty or sales tax for machinery and equipment with spares requiring import and not manufactured in the country for initial installation for renewable energy projects.
- Many other fiscal and financial incentives. Details can be seen from the Renewable Energy Policy of 2006.

3.2. Case study on integrated irrigation and hydropower generation

The shortfall in supply and demand of water under surface irrigation systems on undulating steep terrains can be met more effectively if power supply is available to the water users to pump water and for initiating ‘plasticulture’ for the production of high value vegetables and fruits in winter and summer seasons. The water lifting from the Indus River or other adjacent

streams is limited due to higher delivery head and the lack of availability of electric power. It will be difficult to use the diesel engines, as the initial capital cost is many-fold higher than the electric motors. In addition, the recent rise in prices of diesel-fuel made this option completely un-economical. Thus, development of hydropower and availability to the water users on reasonable tariff is necessary to meet the shortfall in water availability during the peak demand periods. This would also avoid the need for developing grid system for isolated irrigation schemes in extremely rugged terrain. There is hardly any existing option of integrated irrigation and mini hydel-power systems. But the similar concept was integrated for developing water scheme for raising trout fish and the generation of hydel-power at Mountain Agriculture Research Centre (MARC), Trout Farming Station, Juglote (Figure 4).

Figure 4: Trout farming, MARC, Juglote

The complete power requirement of the station, hatchery, and laboratory equipment is met from hydropower. The system is so simple that it can be easily managed by the communities in Gilgit-Baltistan if the concept is extended to irrigation and mini hydropower.

Private sector may be encouraged to provide services to the Water User Organizations (WUOs) and Female Water User Organizations (FWUOs) to develop integrated irrigation and mini hydropower systems on turnkey basis. Cost effectivity and technical feasibility are the two essential requirements for the integrated irrigation and hydel-power generation. In these systems, the existing open channels can be replaced with the pipe-flow water delivery systems for integrated hydel-power generation and irrigation. The hydraulic head available can be used for the installation of drip/sprinkler irrigation systems and hydropower for initiating 'plasticulture' for production of off-season vegetables (strawberry, cucumber, tomatoes, etc.).

The strategic elements to be considered for developing integrated irrigation and hydropower generation systems are:

- Indigenisation and commercialisation of mini hydropower generators in Gilgit-Baltistan so that low-cost equipment and machinery is available locally;
- Encourage private sector companies for integrated irrigation and hydropower generation for development of high-tech and high-efficiency farming systems (drip/sprinkler irrigation systems and plasticulture). The local pump industry and micro-irrigation systems companies in Pakistan are having full capacity to indigenize the mini hydropower generators. Even the private sector is interested to provide services for the design and installation of integrated systems;
- Introduce mini hydropower units at locations where water can be lifted for multiple uses: Such locations are available especially the abandoned water mills for wheat flour, locally named as Grats, can be used for the installation of small scale hydropower stations. The power generated can also be used for the operation of flour mills;
- Introduce water lifting turbines on the perennial streams to lift water. These turbines work under water head and lift water based on available head. Low-head Chinese water lifting turbines have been used successfully in the Barani areas, whereas high head turbines would be required for the Gilgit-Baltistan. These turbines can be manufactured locally by the pump industry with active involvement of research institutions and NGOs.

3.3. Case study on Pakistan's first community power company established in Hunza

The mountainous region of Gilgit-Baltistan has steep gradients in the waterways, where glacier melt flows on steep waterways and cuts through valleys and human settlements, providing sustenance for agriculture. But more recently, the water is now being used as a source for hydropower generation.

Pakistan's first hydropower company fully owned and operated by the community is selling hydropower to neighbouring villages and businesses in the Hunza valley using funds from the UN Clean Development Mechanism (CDM). Ahmedabad village in the remote Hunza valley of northern Pakistan generates more electricity than its households can consume, which is a rare situation in Gilgit-Baltistan due to acute shortage of energy.

Over the past thirty years, the AKRSP has worked with the mountain communities to build 23 micro hydropower plants in Gilgit-Baltistan – all owned and operated by local community organisations. The hydropower technology has been developed in many countries including Germany and Switzerland and the technology has been developed for the mountainous regions. The AKRSP has used this technology in Gilgit-Baltistan's mountainous landscape and for the local manufacturers and community-based operation.

The Government of Pakistan ratified the Kyoto Protocol in 2005, which established GHG emissions reduction targets, this led the AKRSP to access money under the UN Clean Development Mechanism (CDM), to scale up the Gilgit-Baltistan hydropower capacity. The CDM allows the developed countries to offset emissions by funding sustainable development initiatives in developing countries.

AKRSP prepared a plan to generate up to 15 MW of power from numerous small hydropower plants and set up private utility companies which could sell excess power elsewhere. However, the CDM stipulates that it will provide 50% of project costs if the beneficiary community contributes 20%. Hunza's Ahmedabad community was the first to rise to this challenge. They felt that every household in the village could afford to sell one cow or six poplar trees which would

raise USD 3000 to match 30% of the total project cost (stated by Habibullah, President of the Community Organisation).

AKRSP mobilised the remaining 30% from the Acumen fund and a national poverty alleviation facility grant. The project was registered in 2009 with the UNFCCC and the German government provided technical assistance.

A 200 kW hydropower plant is now being successfully operated in Ahmedabad. The Ahmedabad Power Utility Company sells electricity to its own village, neighbouring settlements, commercial businesses and hotels in Karimabad, the tourist centre of Hunza, as well as the Chinese road construction company repairing the Karakoram Highway. Local women's carpentry enterprise and restaurant also use power from Ahmedabad's community hydropower company.

This is Pakistan's first community owned and operated private power company. Its shareholders are all local villagers who have drawn up their own company rules and regulations. No member can own less than two shares or more than four shares: this allows even the poorest widow in the village a stake in this profitable enterprise. The collective has also decided to reinvest profits back into the company for three years in order to enable company development and sustainability.

Hydropower has brought a number of benefits to the village: reduced deforestation and emissions from diminished use of petrol fuels and an improvement in biodiversity. People also say night-time illumination in homes has allowed children to study longer; families in this part of Pakistan see education as the best investment for the future. Women appreciate time spent on household chores have been freed up by electric devices such as washing machines.

At night, surplus electricity is used to pump water from the villages up the mountainside to irrigate plantations of popular, mulberry, and olive trees, intercropped with alfalfa used for fodder. The community stated that they carried out research in 2013 in the Hunza valley, with field visits to the Ahmedabad Power Utility Company, interviews with senior management of key institutions including Aga Khan, officials from the Ministry of Climate Change and other experts.

3.3.1. Recipe for success

The analysis conducted by the Study Team the success of the community owned power-company is based on three factors. Firstly, the leadership shown by AKRSP made excellent strategic use of CDM. The leadership pushed the limits of governance boundaries although in the process it encountered many obstacles, for example, difficulties in securing loans. The government was also slow to respond to the needs to provide private power distribution services. Secondly, technological innovation was used for the adaptation of the German turbine technology to the mountainous environment of Hunza and installed stabilising devices to suit the local conditions. Thirdly, financial innovation met UNFCCC requirements and combined community investment with international grants and loans.

Over ten years, the Ahmedabad project has evolved tremendously and the community now operates a successful hydropower plant and sells electricity to neighbouring areas. In this way, an international carbon finance mechanism has been able to reduce GHG emissions and improve the quality of life for rural families.

3.4. Case study on Chitral as pioneer of community hydropower schemes

The rural communities in the Chitral Valley have demonstrated a success model for the development and operation of community owned small hydropower plants and now they are helping other communities to execute new plants to meet their electricity needs (Figure 5).

Figure 5: Community hydropower plant in Chitral valley

The Chitral valley is not connected to the national grid and also ignored by major investors. The local community in the valley has been involved over decades in the generation of hydropower, primarily with the support of the AKRSP. This success story has been endorsed by the Government of Khyber Pakhtunkhwa, which has entrusted the task to the community for the execution of over 50 mini hydropower plants in the valley.

The remarkable participation and involvement of local communities, electricity from small hydropower plants is not only supplied to households, but also to educational institutions, commercial areas and in some areas to government offices, including police stations and cantonments of the paramilitary Chitral force.

The journey to self-sufficiency of people of Chitral valley started in 1983 with the inception of AKRSP in launching its rural development programme through active participation of community. Over the years, small local community organizations helped build social infrastructure for the smooth implementation of development schemes, that's why the provincial government entrusted construction of 55 mini hydel-power schemes in the valley to AKRSP to build and operate these schemes through the local community. The success of the Chitral model has resulted in the adoption of the model by the government for extension to rest of the 11 districts of Khyber Pakhtunkhwa.

Mr. Saqeb Mushtaq, Resident Engineer, Pakhtunkhwa Energy Development Organisation stated that we have first observed the mini hydropower plants in Garam Chashma, Bumburat and Laspur areas of Chitral, which have been operated by the community for decades, and based on the success then the government has awarded the construction of 55 projects to AKRSP through

competitive bidding. More than 12000 people are now benefiting in the Chitral Valley. The other districts of Khyber Pakhtunkhwa have potential for the involvement of community in building and operating the hydropower plants. The largest number of community managed hydropower systems is located in Chitral valley followed by Hunza and Dir. He further stated that some community based mini hydropower plants were being constructed in areas where electricity is available from the government grid. The government will review that how the community runs these plants in a competitive environment. This will be a challenge for the community and the government will finance additional mini hydropower plants, if there is large-scale success in different political and ethnic settings.

3.4.1. Chitral valley

The total energy requirement of Chitral is 40 MW and 6.2 MW will be added after the completion of 55 new mini hydropower plants, funded by the provincial government. After the completion of these schemes within 18 months of starting the project, the electricity shortage in Chitral valley could be taken care within three years if funding is available for additional plants. The Group has set up 176 mini hydropower plants in various villages of the Chitral valley since 1990. The total installed capacity of these plants is around 7 MW and these currently produce 4.5 MW.

With a population of 500000, Chitral is the largest district of the province, covering 40% of the area. Its scattered population is one of the reasons why small hydropower projects are considered the most viable solution to meet the power needs. The valley, which is in the heart of the Hindu Kush mountain range and has many glaciers and streams, has the potential to produce 5000 MW of electricity.

In the past, this potential was not tapped due to lack of resources and lack of priority of the provincial government. But things have changed over the years. The local community was engaged right from the beginning to build and then to operate mini hydropower plants. This model was successful for the construction of mini hydropower plants within short time and with limited resources. In his view, the decades of engagement in the development process has started paying off with people now trained enough to handle small projects and provide electricity for not just their own homes but for surrounding areas too. He further stated that Chitral is also prone to natural disasters. The community is so active that if there is any disaster and damage to these power plants, local community organisations take the lead in repairing and restoring electricity.

3.4.2. Success stories

AKRSP had established a 50 kW hydropower plant in early 1992 in the village of Birrir. It was the first ever community mini hydropower plant in their small village of 150 households. The community had been operating the plant since the AKRSP handed over it about 20 years ago. He further stated that we are not only using the electricity for cooking and lighting, but women also use electric appliances for various uses. Now, another 75 kW plant is under construction. This would meet the entire demand of electricity for the village. Some community members have set up personal power plants on commercial basis. For example, Muhammad Khan, has set up a 1 MW plant in his village Ayun and sells electricity to thousands of households, factories, educational institutions and telecommunication companies. He first established a small hydropower plant in 1997, which was a success and the plant gradually upgraded to the capacity of 1 MW. He sells electricity to households at PKR 6 per unit (kWhr) as compared to over PKR 10 per unit provided by the government in other areas because there is no tax component.

There are damages too, particularly during the monsoons, leading to huge losses every year. But Khan says he's not in it for the money. There is a small profit margin but he looks on the plant as community service that not only provides electricity but also employment to over 200 people. According to the government policy, a local community organisation or individual can only produce electricity up to 1 MW. Beyond that, they have to get a no objection certificate from the government and add it to the national grid.

3.4.3. Future plans and lessons learnt

Mini hydropower plant is a successful model for other mountainous areas. The future plan of AKPRSP is to go beyond mini hydropower plants. AKRSP will support installation of large plants to meet the growing demands of the local population. Since 2010, AKRSP have started installing plants in the range of 500-800 kW. There are also plans to establish small grids in different valleys and 32 sites have been identified and feasibility studies conducted. Such a system will help provide stable supply of electricity to all the villages through local grids. At present, if a small power plant is not working for some reason, there is a blackout till repairs are completed.

Community based utility companies are also being formed to maintain and regulate projects greater than 500 kW. Such an initiative will convert community contribution for power generation into community investment; people will get shares of these companies.

The Provincial Government is responsible to maintain a check on the construction of 55 mini hydropower plants in Chitral. The government officials visit sites of these schemes to monitor the quality as per design specifications and also ensure active participation of the local community. They prepare the monitoring report on weekly basis and ensure that the schemes are being completed with full accountability and transparency.

There are many challenges still ahead. The major one is the flash floods in the Chitral River in July left about 250000 people stranded and saw major roads irrigation and water systems and power stations damaged. Of the six power stations damaged, four were community run powers houses — in Ayun, Rumbur and Shugram and Broz – and two were government run power stations.

The government-operated power station at Rashun was completely washed away, leaving most of upper Chitral in darkness. Three-kilometre link road to the powerhouse has been washed away and there is no alternate road.

3.5. Case study on Smart Villages in Chitral Valley

Expansion of small hydropower and micro-grids could tackle poverty in remote mountainous villages in the Hindu Kush Himalayas, stated by Mr. Abdur Rehman Cheema, Team Leader of RSPN, Islamabad on March 10, 2016. Life is tough in the remote villages of the Hindu Kush Himalayas of northern Pakistan, far from the reach of power grids and at the mercy of floods and extreme weather. But by harnessing the glacier fed rivers that flows down the steep mountains, communities are transforming their lives and future prospects. The community stated that before the hydropower plants, when clothes needed washing we had to go to the river and spend whole day in washing of clothes. Now it just takes two hours with the use of washing machine. Furthermore, electricity has improved the life of children, who now have enough time to play and to assist at the farm during the day because they can do school homework with electric lights at night and many household chores (Figures 6 and 7). Electricity is also being used for drying of apricots (Figure 8).

Figure 6: Electricity from micro hydropower projects power computers in Chitral

Photo Credit: Sarhad Rural Support Programme

Figure 7: Micro hydropower plants have made use of washing machines possible

Photo Credit: Sarhad Rural Support Programme

Pakistan has four decades of experience in building micro hydropower plants with the cooperation of local communities to bring electricity to these isolated regions. Since 2014, Pakistan's RSPN has worked with the "Smart Village Initiative" started by a team based at Cambridge and Oxford universities in the United Kingdom, to further expand energy.

About 70 million people in Pakistan have no access to electricity and majority of them live in rural areas. There are about 3 million households where grid connectivity is not feasible, according to the AEDB, Pakistan. Small hydropower schemes and micro-grids that generate their

own electricity can plug this gap. Yet Pakistan is only producing 128 out of a potential of 3,100 MW of electricity from small hydropower projects.

Figure 8: Farmer unloading dried persimmons from an electric dryer in Peochar, Swat

Photo Credit: The Third Pole

Figure 9: Locals contribute the effort to build and maintain the hydropower projects

Photo Credit: The Third Pole

In Pakistan, the growth of micro hydropower schemes has been led by the AKRSP and SRSP, who have both received the prestigious Ashden International Award for their work. They worked with rural support programmes and local village organisations to help communities build micro-hydropower schemes across Khyber Pakhtunkhwa, Gilgit-Baltistan, FATA, and AJK. Communities contribute time and labour (known as "sweat equity") which creates a sense of ownership and helps sustain these schemes. These schemes typically generate between 5-100 kW of hydropower.

The "Smart Village Initiative" covers six regions in Africa, South and Southeast Asia, and Central and South America and aims to provide energy access for remote off-grid villages, where local solutions are both more realistic and cheaper than national grid extension. It brings together scientists and engineers, entrepreneurs, villagers and civil society organisations, policy makers and regulators through country level workshops.

Just like a smart city, a smart village means providing access to affordable, reliable and clean energy for households and businesses. This energy access particularly benefits women who suffer from the drudgery of collecting fuel wood and the health consequences of breathing in cooking smoke from traditional biofuels, such as animal waste.

By 2015, the SRSP had constructed 166 micro-hydropower projects and brought power to around 275,000 people. Similarly, the AKRSP has supported 191 micro-hydro schemes producing 14.35 MW of power. The government and NGOs provide initial financial and technical support but the hydropower plants are maintained by the communities in the long run for the benefit of future generations. Over 90% of these micro-hydro systems are well maintained at affordable

cost, according to follow up surveys, and these schemes have transformed the education, health and lifestyle of communities.

3.6. Case study on hydroelectricity transforming life in Hunza

In Ahmedabad, in her home in the remote Hunza valley, Ms. Gul Mehreen smiles as she places a tea kettle on the electric stove in her immaculate kitchen. As she makes tea for guests, the former jokes about "how amazingly enjoyable" cooking has become since a small-scale hydropower generator was installed nearby.

In this picturesque village, perched above the gushing turquoise waters of river Hunza, and with a view of the 8000-metre mountain Rakaposhi, in the Karakoram Range, women once had to walk for miles to collect fuel wood each day. For the last eight years, however, hydropower has supplied the village's energy needs, and life has gotten much easier, said Mehreen, who has an electric stove, oven and lights, fitted with energy-saving bulbs. With the availability of electricity, we have been relieved of such burdensome work, she told Reuters. The initiative holds great meaning in our lives. The village's community-run micro hydropower station — built in 2008 by the AKRSP with backing from the USDA and PPAF — produces about 190 kW of electricity an hour. That's enough to supply power to 144 homes in Ahmedabad and nearly 110 in the nearby villages of Sultanabad and Faizabad.

Such small-scale hydropower plants are proving a key way to provide power in remote, off-grid areas, while at the same time helping protect the environment.

3.6.1. More trees, less risk

Besides making life easier for people in the villages of Gilgit-Baltistan, hydropower has slowed deforestation, rampant in many mountain areas, and cut landslide risks as more trees are left standing to hold the soil, local people say. Now no one chops down trees to harvest fuel wood, said Ghulam Raza, an environmentalist who works in the area with a range of non-governmental organisations. As a result, natural forests in the mountains nearby are coming back to life, he said. Social development activist Mr. Ghulam Sarwar, who works for the AKRSP, said hydropower had changed Ahmedabad from a village that "lived in darkness" to one where children could now study using electricity at night, and no longer miss school to help their families collect fuel wood. Now our children don't skip school. They find enough time at home to study and finish their schoolwork even after sunset, said Ali Gohar, a member of the community committee that maintains hydropower plant.

Community leaders say if they can find the funding, they intend to expand the project and provide electricity to an additional 1,400 households in nearby Karimabad and Altit villages. Shahana Khan, a development projects Manager for the AKRSP, said small-scale hydropower was a natural for mountain villages with access to rivers, and a good way of ensuring access to clean energy. A key, she said, was that such facilities "are owned, run, and maintained by the communities."

3.6.2. Potential for more

The country could generate around 100000 MW of hydropower, through both large and small schemes, according to a 2006 report by the AEDB. Sixty per cent of that could come at spots identified in the river-rich, mountainous region in the northwest. Jamiluddin, who manages development projects in Gilgit-Baltistan for the AKRSP, said his organisation, in collaboration with the AEDB and the PPAF, plans to install more than 100 small hydropower plants in Chitral district and Gilgit-Baltistan in the next few years. Much of the funding, from international and

national NGOs, is already in place, he said. Jamiluddin said the plants would cut deforestation, reduce the carbon footprint and provide off-grid mountain communities with affordable, clean and reliable electricity. Ahmedabad's women, including Nasreen Gul, a 27-year-old vegetable farmer, say the benefits are clear. When we burned wood for fuel, the smoke from the stove would spread throughout our home and we would cough and feel pain in our eyes. Now cooking food and other chores in the kitchen have become considerably easier and stress-free. We use an electric stove as electricity is much cheaper and readily available," said Gul who now has an electric iron and a washing machine as well.

3.7. Difficulties in developing small hydropower plants

The main difficulties, which are being faced by Pakistan in developing small hydro power plants, are:

- Lack of local manufacturing of equipment and machinery related to hydropower plants
- Difficulty in getting access to financial resources
- Unavailability of cost-effective equipment
- Higher dependence of agriculture resources on hydropower schemes

The remedial and revolutionary steps are required to be taken at the government level. The Government should simplify the process of establishing micro, mini and small hydropower plants. Locally manufactured cost-effective power turbines can make investment affordable. Local manufacturers of power turbines need encouragement and technical support from the Government as well as from the private sector.

There are a number of obstacles to expanding access to energy. First, the lack of government policy support hinders expansion in remote rural areas. Pakistan's state regulator, the AEDB, needs to establish a framework to support off-grid energy solutions. The 2013 National Power Policy does not provide details of how the government will do this. The second big obstacle is the lack of access to finance and capital – and failure to engage the private sector. There is a need to strategize the policy in this regard.

While hydropower has taken off, other technologies like solar energy still in the process of taking off. In this case, the lack of cheap energy storage remains one of the main hurdles. In Balochistan, where solar power has brought electricity to remote rural communities, consistent supply can only be ensured by better storage. Further R&D is needed for manufacturing a low cost long life battery for energy storage. The federal government and research institutions must develop partnerships with international research groups engaged in such schemes. For example, researchers at Cambridge University are designing more efficient lithium-oxygen batteries to replace the typical lithium-ion batteries. It is such breakthrough that will transform the villages of the region, and allow their residents to fully access to the opportunities of modernity.

4. MOUNTAIN IRRIGATION – CASE OF GILGIT-BALTISTAN, PAKISTAN[6]

Mountain irrigation in Gilgit-Baltistan is a puzzle in harnessing snow- and glacier-melt originated at higher elevation and challenge is to bring it to the valley for irrigated farming. The water channels (locally named as Kuhls) have been constructed in Gilgit-Baltistan and Chitral centuries ago. These water channels have been rehabilitated and upgraded in the last three decades by the communities with the support of AKRSP. In the National Watercourse Improvement Programme (2003-08), Water Management Directorate of Gilgit-Baltistan contributed significantly in the improvement of these watercourses through lining and earthen improvements. Best practices have been developed by the Water Management Directorate of Agriculture. In addition, the mountain irrigation areas are prone to extreme climatic variability and climate change as they experience the extreme event of floods and this event is going to be more severe and frequent in the future due to the phenomena of Glacier Lake Outburst Floods (GLOF) and global warming in summer. In addition to the flood hazards, there is extreme seasonality in snow- and glacier-melt, as the Rabi season flows are almost one-fifth to one-tenth of the Kharif season flows. The population of the area is vulnerable to flood hazards and reduced flows in winter and thus face problems due to these hazards.

4.1. The context

The development of open channels in the Gilgit-Baltistan was historically a localized and traditional activity for dividing water for multiple purposes (agriculture, domestic and stock water). It was concentrated in locations where stream flows from glacier- and snow-melt were easily diverted by water users using indigenous technology and local resources. Later on, Mirs of Hunza, contributed to mobilize larger segments of rural population for the development of new open channels in more rugged terrains, remodelling of older channels, and development of new command areas with an objective to ensure food security in the Gilgit-Baltistan. Although, a portion of increased production resulting from enhanced and more reliable water supplies was recovered by imposing a land tax, the Mirs did initiated successfully the development of mountain irrigation systems and modest expansion of settlements, where smaller and resource-poor groups could not materialize such efforts. Following the establishment of British supported Dogra Administration in Gilgit in 1880s; a gradual decline in feudal authority began, accompanied by a reduction in the development of open channel systems. This trend continued after the independence of Pakistan until 1974 when authority of Mirs and Chiefs of Gilgit-Baltistan was formally abolished.

After the establishment of Gilgit-Baltistan PWD during mid-70s, the government of Pakistan provided the support for the construction of open channels in the Gilgit-Baltistan. These channels were constructed through contractors, which were relatively large in size. The community participation was low because water users were not organized using a process of social mobilization. Therefore, failures of open channels were common as community was not taking interest for the O&M of these channels. They were of the opinion that channels are constructed by the public-sector; therefore, they are responsible for its maintenance. Similarly, the LG&RDD was entrusted to undertake construction of new and rehabilitation of older

[6] This section is based on the web resources and the Background Paper:

- Ahmad, S. 2008. *Water Resources of Gilgit-Baltistan*. Water Background Paper for the Gilgit-Baltistan Economic Report. World Bank, ADB, and Government of Gilgit-Baltistan.

channels, which are relatively small in size and community, can undertake such works. Most of these schemes were identified by the notables, political leadership, technical experts, administrators or community. Therefore, mix response was observed in terms of success of these smaller works.

The Aga Khan Foundation during 1982 initiated the AKRSP for social organization of rural communities (men and women) and physical infrastructure development with active participation of water users. In the Gilgit District, hundreds of open channel development and rehabilitation projects were completed by the Villages Organizations (VOs) through AKRSP supported infrastructure development interventions. AKRSP in fact reinvigorated the traditional participatory approaches for channel development through grafting of local knowledge with engineering principles.

WAPDA conducted a survey in Gilgit and Hunza-Hispar River sub-basins, which identified over 220 open channels supplying irrigation to the respective command areas. Most of the surveyed channels have perennial flows, but extreme seasonal variations between low- and high-flows as high as 20 times were reported. The survey also reflected that in more than 85 % of the surveyed channels, the water source was a combination of snow-, glacial-melt and/or springs. The surveyed channels varied widely in length between source of water supply and the command area, from 2 km to as much as 18 km in the case of Parri Open Channel on the Gilgit-Juglote road. They also varied substantially in capacity. The discharge of smallest and largest channel was in the range of 7-425 lps (0.25-15 cusecs).

Water availability per unit of command area was computed based on the findings of the survey of 44 villages in the Gilgit-Baltistan. In almost one-third of the surveyed villages, the channels delivered <0.75 lps/ha (<6.5 ha-mm/day), ranging as low as 0.13 lps/ha (1.1 ha-mm/day). For these channels, water is apparently scarce per unit of land, representing the level of inefficient management of channels and in-efficient irrigation practices at the farm level. In seven villages, the open channel systems supplied discharge from 0.75 to 1.25 lps/ha (10.8 ha/mm/day), which is adequate amount of water availability for agriculture. In general, the channels in the Hunza-Hispar villages varied more widely in the Gilgit River sub-basin. In summary, roughly in one-third of the villages, the channels apparently supplied water in relatively adequate or abundant amounts. This revealed that in these locations, land suitable for agriculture is scarcer than water.

In 2003-04, the President of Pakistan initiated the “National Programme of Improving Watercourses” in all the four provinces including Gilgit-Baltistan. In Gilgit-Baltistan, around 600 watercourses were improved through partial lining and earthen improvement. The Water Management Directorate of the Agriculture Department has completed 262 channels using stone masonry. The construction of lined channels in steep slopes is a unique experience in the Gilgit-Baltistan and further improvements are needed to make these lining works more cost-effective. Farmers in the Gilgit district are of the opinion that travel time of water to their farms has reduced to at least one-fourth through lining of the open channels.

In conclusion, both land and water are limiting resources in the Gilgit-Baltistan. At certain locations water is scarce, whereas at other locations land is scarce and at others both resources are limited to have sustainable livelihood. In reality, the mountain irrigation systems are being designed using surface irrigation concept, which is not the appropriate method of developing mountain irrigation systems in Gilgit-Baltistan. Furthermore, land is of steep slope and unlevelled, whereas soil is of extremely gravely and coarse texture and it has to be modified through removal of stones and adding organic materials to improve its structure. Developing

command area for surface irrigation is not economical for crops and vegetables and it takes 5-10 years for making use of the full command area. Thus, the issue is how to design and develop mountain irrigation systems, which are appropriate to the environment of fragile ecosystems of Gilgit-Baltistan and to modernize irrigated agriculture. One of the Case Studies illustrates the sustainable way of managing water in the mountains using pipe-flow irrigation system – a system that is environment friendly and can have adaptations with the impacts of climate change on water.

4.2. Case study on increasing storage and aquaculture at the channel command level

The storage of water is essential for addressing the requirement of domestic, stock water, irrigation and ecosystems. The water users are facing difficulty in the winter season when water supplies are in short due to reduced snow- and glacier-melt. Thus, there is a need to introduce small-scale storage of water (at places where it is feasible) to meet the needs of various sub-sectors. The strategic elements for increased storage of surface water to augment the existing supplies are:

- Introduce small-scale storages (ponds/tanks) at the farm or command level and lining of these tanks using the geo-synthetic liners, where it is cost-effective;
- Introduce sand filters to provide clean water for drinking and stock water purposes especially during the winter months;
- Introduce earthen reservoirs and lining at the tail-end of the channel command system to store excess water especially at the night time for utilization in the adjacent commands and reduce the hazard of soil erosion at the tail commands. The stored water can be used with high efficiency irrigation systems to grow orchards and creeper-type vegetables; and.
- Introduce fish production at tail-end storages to recover cost of storage as a community enterprise. The production of fish will also help to seal the pond because the organic manures added as feed for fish will provide fertile water for raising high value crops.

The Water Management Directorate of Agriculture Department provides the technical backstop support to the WUOs for the development and lining of water storage tanks, development of tail-end reservoirs and introducing freshwater aquaculture (Figure 10). The extra water stored at the tail end command would help to (a) avoid water induced erosion at the tail-end due to excessive availability of water or inefficient use of water; or (b) fallow area at the tail-end command due to extreme scarcity of water (Figure 11) can be made productive with the use of stored water.

Figure 10: Storage of water in lined tank

Figure 11: Reduced cropped area due to shortage of water at tail end

4.3. Case study on Gail Bala cluster and open channel irrigation system

The Gali Bala Cluster has 1200 households and population of around 12000. The Gali Bala Cluster has 5 Community Organizations (COs). The number of beneficiaries of the Gali Bala Open Channel is 500. The resolution from the community was received by the Northern Areas Development Programme (NADP) during November 2002. The survey of the channel was started during April 2003. This was a cluster scheme and the length of the channel was 3.13 km. The total designed command area was 400 ha, out of which 350 ha were under the existing command and 50 ha were added by extending the channel and the command area.

The cost sharing was among the community and the NADP. Community contributed PKR 0.499 million, whereas project contributed 1.996 million. Thus, the total cost of the scheme was PKR 2.495 million. The cost estimates were submitted during June 2003 and work was started during July 2003. The scheme has been completed and payment of PKR 1.996 million has been made to the CO. In fact, after the registration of WUA, the Committee of the WUA open a bank account, where NADP transfers the money as per agreed schedule of deliverables. It is a joint account with the WMD-AD.

Figure 12: Tangir Valley and Gali Bala channel in the background

Figure 13: Gated intake of water at the head of the channel

The scheme was initially constructed by the NA-PWD at a cost of PKR 10.0 million and the flow was seasonal. The command area was practicing single cropping largely due to water shortage or lack of awareness. The operational losses (leakage, over-spills and seepage) in the channel were very high and scheme was practically semi-functional to non-functional. There were crises of water and 5 casualties occurred due to conflicts on water.

Initially Mr. Haji Mohammad Hussain provided the lead and 400 persons worked for two months and make the channel functional by controlling the leaks and spills. No support was provided by the public sector. One of the visitor provided PKR 4000 for the explosives. But the job was not over rather it was the beginning for the new light.

Later on with the inception of the NADP, Mr. Saad Mohammad and Dr. Khazan, provided the lead, and NADP indicated their interest to support the rehabilitation and extension of the channel. The two branches were assigned to the two clusters. The increased water supply and demonstrations conducted by the staff of NADP converted the single cropping command area to double cropping command area along with increase in command area of 15%. The new crops introduced in the area are peas and potatoes. The contribution of 20% by the community in terms of materials is an indicator of their effective participation in rehabilitation and extension of the scheme.

The Tangir is considered most rugged in natural topography and a difficult area. Population of the Tangir is also conservative and they think that any involvement of international NGOs might end up with changing their culture of separate role for men and women. The traditional and

prescriptive approaches of Gender in Development would not work. Therefore, a visionary and phase-wise approach is needed.

4.4. Case study of community of Jutal Bala channel, Gilgit District for record accomplishment

The construction of Jutal Bala watercourse was started on 14 February 2008 and completed on 6 March 2008. This was unbelievable because such a large operation was hard to complete in 20 days. The total cost of improvement was PKR 392130, out of which 22% was the farmers' share.

There are 200 households in Jutal Bala and the command area is 100 ha. There is 7 days rotation on water. There was extreme scarcity of water due to huge operational losses in the channel and it took one hour for water to reach the beginning of the command area from the head. The shortage of water was the real issue on which everyone participated on war footing. The community hired 12 masons and 20 skilled labourers and work was performed in two shifts by making arrangement for the light at night time. Work was performed during day and night and that's why it was completed in 20 days. The length of the channel to be constructed and lined was 1600 ft. This means that on an average 80 ft length of the channel was constructed and lined daily. In addition 100 water users from the community were available all the time to support the construction process and to provide unskilled labour for earthwork and other related works. The community has selected 12 members to constitute the committee. If anyone of the water user did not provided labour a penalty of PKR 500 per day was imposed on the defaulters during the construction period. Everyone provided labour for the construction work. There was not a single happening that anyone defaults to the agreed decisions (Figure 14).

Figure 14: Jutal Bala channel lined under participatory process of Water Management Directorate, Department of Agriculture

The reason illustrated by the community to arrange a Crash Programme for the construction and lining of channel was that the community do not want to lose the season or affect the crop productivity adversely for the crops planted in the field. In their opinion, the contractor does not have any feel of losing the season and that's why most of the channels constructed by contractors by the PWD failed. The level of awareness of community was remarkable as most of their livelihood is based on agriculture and livestock.

Six families contributed as catalyst and motivated the whole community to apply for the support of Water Management Programme primarily due to the acute shortage of water, which adversely affected their livelihood. Whole of the community contributed both in kind and cash.

The impact of the lining was that the travel time of water was reduced from 60 minutes to 7 minutes, which is a major achievement and accordingly the delivery losses were reduced many-fold. In their opinion, the irrigated cropped area was increased by five-fold, which was due to increase in water availability. This can also be viewed from the fact that potatoes were grown first time in the command area after the improvement of the channel. It is important to note that reliable water supply is essential for potatoes and other vegetables.

Figure 15: Interactive group dialogue with Jutal Bala Water Users Association

The community in an interactive group dialogue also shared that water is not linked with land (Figure 16). The owner can sell land and may not sell water or sell the both. The community also identified that there are around 500 ha of land available, which can be brought under cultivation if water is brought from Naltar nullah. The community is ready to contribute up to PKR 5.0 million as in their opinion the cost of the construction of new channel will be more than PKR 15 million. This is a remarkable commitment of the water users because they are aware that by the next generation the land holdings will just be sufficient for the construction of houses and not for farming. Mr. Shamshair Ali stated that they are 7 brothers and after division of land everyone has 2.5 kanal of land. But he has purchased 45 kanal of culturable wasteland, which can be cultivated if water is made available.

The WUA of Jutal Bala had long dialogue with the community of Naltar nullah and already had agreement that the unutilised water at the downstream of Naltar nullah can be diverted for

Jutal Bala new scheme. In addition to this the WUA has already started dialogue with the two communities falling in the transit – Rahimabad and Juglote. They stated as water rights are separate from the land, they can negotiate with the communities of Rahimabad and Juglote to have their stake in the new scheme even to the extent of providing some land to those communities or water during transit. This shows that water users and farmers in Gilgit-Baltistan are under-utilized as their capacities and potential for improvement is immense. The real trick is how to make an entry for having successful planning, design and implementation of the scheme and what is the right exit for sustainability. We should not be victim of circumstances rather one has to be visionary in the process of participatory development which has to be innovative and forward looking. The prescriptive template now a days used by some of the institutions is not sustainable in the longer run. Participation is a mean to accomplish the end (stipulated goals). The goal should be very clear in the mind of all partners and actors. This case study provided a Best Practice for how to improve the water channel in shortest possible time so that crops in the command area are not affected.

4.5. Case study of innovative pipe-flow water conveyance system by the WUA of Turmai channel at Nomal, Gilgit District

After visiting the Sakwar water channel, the Consultant had a meeting with the Director, Water Management Directorate to arrange field visits to see some of the success stories where pipe-flow irrigation systems have been installed especially for the spring water, which is affected by the surface water. The Water Management Directorate organized the trip to Turmai Channel and command area on June 3rd 2008. This was a unique experience in the Gilgit-Baltistan, where public-sector institution (Water Management Directorate), WUA (community organization) and private sector (Dadex Eternit Pvt. Ltd) worked in partnership. This is the most logical way of introducing innovative irrigation systems in the Gilgit-Baltistan. The success story is also important from the standpoint that communities are very much clear for the need to introduce pipe-flow irrigation systems from that of open channels, whereas some of the public-sector institutions and NGOs are sceptical.

The story started when Mr. Mohammad Ayub and Mr. Shamshad, the two farmers activists, motivated the community to address the issue of water scarcity in general and especially in the winter season. One of the farmers, Mr. Malik Shah, was asked to visit Chitral. By chance he got an opportunity to participate in a visit arranged by the AKRSP, where Mr. Shah visited the Bonie Siphon Scheme of transferring water across the river. On his return he shared the experiences with the fellow water users. The motivating force illustrated by Mr. Shah was that Warabandi schedule of 65-67 days in the Turmai scheme, which was extremely long to support profitable farming. During 2002-03, the community decided to pipe the water channel and contribution of PKR 250 per Kanal of landholding was imposed and this way the community collected a total of PKR 200000 in addition to provision of labour. With this amount the community purchased pipe of around 2000 feet length and 6-inch in diameter. The money was not collected in one go. Whatever collected was used to purchase the pipe. The step-wise installations of pipeline resulted in demonstration to the defaulters and then everyone contributed. The water users are of the opinion that no one came to their support even the technical support was not provided by the public-sector or NGO including AKRSP. They were also cheated by the local market dealers and low quality and low pressure plastic pipe was provided, even then the benefit was tremendous.

Mr. Ayub, the local change agent, works with the Agriculture Department of the Gilgit-Baltistan. One year later and with the inception of the Water Management Directorate during 2003-04, he discussed with the community and an application was filed. The Water Management Engineer

visited the channel and command area and explained the procedure of sharing the cost and formation of WUA including the involvement of majority of water users in the scheme. As there was existing committee of the water users, which after agreement of all the water users became the WUA and registered with the Water Management Directorate. The management committee of WUA was formed having three members – President, General Secretary and Treasurer. In addition, three more members were included. After the approval of the scheme (formation of WUA, survey and design), the WUA opened a joint account. The design verification and supervision of construction of scheme is done by NESPAK as a third party. The money is provided to the WUA in three instalments: (a) first instalment of 30% as mobilization after the approval of the scheme and opening of the joint account by the WUA; (b) second instalment is based on the actual work completed; and (c) the third is the balance based on the actual works performed. There was 30% cost sharing by the community. The water users who are employed and could not provide labour they provide either cash or hired person on their behalf.

The community has also documented the impacts of the pipeline system and are listed as under (Figures 17 and 18):

- The Warabandi schedule was reduced from 65-67 days to 20-25 days, which is a direct indicator of increase in water supply at least 3 fold;
- The water travel time was reduced from 16 hours to 5 minutes at the head of the open channel;
- Water tank constructed at the head of the command area helped to store water during night time and use it during day time with larger stream size especially it helped to have better water use during winter when water is short from snow-melt
- The pipeline behaved satisfactorily both in terms of pressure and discharge and community is fully satisfied with the quality of work done by Water Management Directorate and the Dadex Eternit Pvt Ltd.;
- Four time increase in water supply was observed;
- The increased water supply resulted in increased command area by 25%, in addition, farmers moved from forestry and grasses to crops and vegetables. Number of fruit plants planted at boundaries was increased.
- Increase in cropping intensity was around 50%, which is also due to increased water supplies.
- Potatoes and cherry area has increased tremendously. The Nomal Community has also established local marketing system for cherry and now the local contractors are purchasing the cherry fruit plants for marketing in downstream areas of Pakistan.
- The production of fodders, forages and grasses was increased for feeding to livestock.

Figure 16: WUA members involved in earthwork at High Pressure PE Pipe Irrigation System at Nomal, Gilgit

Figure 17: WUA involved in laying of PE High Pressure Pipe under the supervision of Dadex Eternit Pvt Ltd., WMD-AD and NESPAK Engineers at Turmai High Pressure PE Pipe Irrigation System at Nomal, Gilgit

Figure 18: Heat welding of pipe by the Dadex Eternit Pvt. Ltd. Pakistan

Figure 19: Water users, staff of WMD-AD and NESPAK at the downstream of pipe system

One Ditch Rider is provided by the Government of GB and other by the WUA, where PKR 5000 per month is paid to the Ditch Rider (Chowkidar) by the community. In fact, the Ditch Rider also performs the duty of irrigation specialist, where he controls the Warabandi schedule and gives his opinion for completion of irrigation to a particular field. One matured tree of cherry provides income up to PKR 10000 per annum, whereas a young tree provides an income to the extent of PKR 1500 per annum. The pressure of the pipe is huge and it can be used to generate hydropower and to operate pressurized irrigation systems. This site also confirmed the viewpoint of the Background Paper of integrating the irrigation and mini-hydropower systems.

5. VALLEY SPATE IRRIGATION – CASE OF BALOCHISTAN AND KHYBER PAKHTUNKHWA PROVINCES OF PAKISTAN[7]

Pakistan has utilized most of its surface water in the Indus basin canal irrigation system. The only potential for further development is under Spate irrigation of 6.935 mha[8] having floodwater of 23 billion m^3 per annum in an average year against current command area of 0.64 to 1.28 mha during dry and wet years, respectively. Large temporal variability in floodwater availability of 1:2 during dry and wet years provides potential command area of 4.0 mha on sustainable basis. The Spate irrigation areas are prone to extreme climatic variability and climate change as they experience the extreme events of droughts and floods and these events are going to be more severe and frequent in the future. The population of the area is vulnerable to both the extreme events and face problems due to drought and flood hazards. The floods are getting so severe in the last decade that the Spate irrigation infrastructure has been damaged significantly during the last decade and local population has to migrate to safer areas during these events.

5.1. The context

Spate irrigation in Pakistan is characterized in four categories: (a) non-perennial Spate irrigation systems based on floodwater generated from hill-torrents and diverted through natural, earthen or weir regulated structures; (b) non-perennial Spate irrigation systems with headworks for diversion of floodwater into a canal network and tanks for storage and regulation; (c) perennial Spate irrigation systems based on groundwater which oasis out in the form of springs; and (d) integrated Spate irrigation systems having both non-perennial and perennial flows. This categorization is based on the concept of managing surface waters because spring water is also treated as stream flow. The abstraction of groundwater using tubewells, dugwells and Karezes is not considered, while characterizing the Spate irrigation systems; because they are widely spread and vary in space and time.

5.1.1. Non-perennial spate irrigation system

Non-perennial Spate irrigation system is defined as "diversion of floodwater through natural, earthen or weir regulated structures and channelized into a water conveyance network for delivery to the command area as per agreed water rights and allocation rules". The fields are normally of large size and vary from 2 to 10 ha. The depth of water ponded in the field is a function of bund size. Farmers normally try to irrigate maximum amount of water because they are not sure when they will receive the next Spate flows. A deep irrigation of 1-2 m depth is sufficient to grow winter wheat in temperate environments, if the incident rainfall is >100 mm during the later-part of the growing season. This system is locally named as 'Rod-Kohi' in Khyber Pakhtunkhwa and Punjab, 'Sailaba' in Balochistan and "Gabar Bund' in Sindh. Around one-third of country's Spate irrigation area falls in this category (Figure 20).

5.1.2. Non-perennial spate irrigation with storage facility

Non-perennial Spate irrigation with storage facility is defined as "diversion of floodwater and channelized into a canal network through Headworks for delivery of water to the storage Tanks.

[7] This section is based on web resources and the paper:

- Ahmad, S. and Steenburgen, F. 2010. *The potential for the development of Spate irrigation in Pakistan. Practical Notes for Spate irrigation*. Practical Note 1. MetaMeta, PARC, SPO, and Spate Irrigation Network.

[8] Estimated by NESPAK 1998 – mha is million hectares.

Tanks are designed to store floodwater to provide reliable and sustainable supply of Spate water during crop growing season." The delivery of water from the storage Tanks is provided to the command area as per agreed water entitlements. Some of these systems are sustainable in Balochistan over the last 128 years, which were constructed in 1880s by the British rulers. This system is locally named as 'Tank Bandat' in Balochistan and different names in other provinces, but in the Agriculture Census of Pakistan it is named as 'Tank Bandat'. Around 21% area under Spate irrigation is having 'Tank Bandat'. This is the most effective system of managing floodwater, sediments and allocation of water to the water users and regarded as the most enlightened concept of managing non-perennial Spate irrigation in Pakistan (Figure 22).

Figure 20: Weir, upstream view of head regulator of the Chandia Spate irrigation scheme, Sibi district, Balochistan, Pakistan

Figure 21: Weir, upstream view of sediment sluice of the Chandia Spate irrigation scheme, Sibi district, Balochistan, Pakistan

Figure 22: Weir structure and head regulator at Shabo Headworks, Pishin district, Balochistan, Pakistan

Figure 23: Weir canal at Shabo Headworks, Pishin district, Balochistan, Pakistan

5.1.3. Perennial Spate irrigation systems

Perennial Spate irrigation systems are defined as "diversion of groundwater that is normally oasis out in the form of springs and is relatively clear water with little or no sediments. The water entitlements of these systems are sharply defined and normally codified." The water users and their institutions adhere to water entitlements. Both the prior appropriation and head-to-tail system of water rights are followed. The perennial Spate irrigation systems in D. G. Khan District of Punjab, D. I. Khan District of Khyber Pakhtunkhwa and areas to the border of Balochistan province are named as "Kalapani" meaning water without sediments. Around 46% of country's Spate irrigation area falls in this category.

5.1.4. Integrated Spate irrigation systems

Integrated Spate irrigation systems are defined as "diversion of both non-perennial and perennial Spate flows is made through structures and delivery to the channel network normally to the same command area." Most of the time, perennial flows are transported in the same channel providing non-perennial floodwater, which damage the perennial system during Spate flows and farmers have to continuously manage both the flows. The system is named as "Kalapani" meaning water without sediments, whereas the non-perennial floodwater is locally named as "Sufaidpani." These systems are found all over the country but are not classified separately (Figures 24 and 25).

Potential area under Spate irrigation as estimated by NESPAK (1998) is 6.935 mha (Table 1). Out of this, 4.68 mha are in Balochistan and thus having largest potential for future development of Spate irrigation followed by Khyber Pakhtunkhwa, Punjab and Sindh. The important point to note is that federally administered Northern and Tribal Areas also have potential of 0.271 mha for development of Spate irrigation. Availability of floodwater in wet years will increase by 2-3 folds.

Figure 24: Integrated system of Mithanwan watershed, D. G. Khan

Figure 25: Non-perennial spate irrigation weir of Mithanwan integrated system

Table 1: Potential area of Spate irrigation in Pakistan

Province	Major Torrents or River Basins	Potential Area (mha)	Actual Spate Area Cultivated in 1999-2000 (mha)
Federal	-	0.271	-
KP	25	0.862	0.226
Punjab	17	0.571	0.084
Sindh	-	0.551	0.056
Balochistan	17	4.680	0.274
Pakistan	-	6.935	0.64

Source: NESPAK. 1998. Master Feasibility Studies for Management of Hill Torrents of Pakistan - Balochistan Province.

In wet years, there is a chance to develop all the potential area. What is the sustainable level of development of Spate irrigation to support livelihood in these fragile ecosystems? This is a logical question to be addressed, while developing new Spate irrigation systems. The availability of floodwater is 23 km^3, which is not adequate to develop all the potential area. The minimum area, which can be commanded in an average year, is 2.0 mha.

Area cultivated in Spate irrigation was 0.64 mha in 1999-00. The highest Spate cultivated area lies in Balochistan province followed by Khyber Pakhtunkhwa, Punjab and Sindh. It was relatively a dry year due to the persistent drought. The Spate cultivated area in the wet year would be almost double of the reported Spate cultivated area in 1999-00 because the floodwater

doubled. In one-out-of-four years, the cultivated area can be increased to 1.28 mha, if the Spate flows are well distributed in the crop growing season. The perennial Spate irrigation area is around 46% of the total Spate irrigated area in a dry year. The crop cultivated area in this category is relatively less affected from that of the non-perennial areas during the drought years (Table 2).

Table 2: Spate cultivated area in Pakistan in 1999-2000

Province	Area under Spate Irrigation Systems (mha)			Total
	Non-perennial Spate Irrigation with Tank (Tank Bandat)	Perennial Spate Irrigation (Spring Rod-Kohi)	Non-Perennial Spate Irrigation (Sailaba/Rod-Kohi)	
KP	0.101	0.117	0.008	0.226
Punjab	0.014	0.046	0.024	0.084
Sindh	0.008	0.045	0.003	0.056
Balochistan	0.012	0.089	0.173	0.274
Pakistan	0.135	0.297	0.208	0.64

Source: Agriculture Census of Pakistan, Census Organization of Pakistan, 2000.[9]

Cost of development of Spate irrigation is difficult to assess. However, some estimates are made from the selected multi-purpose projects by isolating the non-perennial and perennial Spate irrigation systems.

Gomal Zam is one of the five major *Zams* located in D. I. Khan. *Zam* is a flow of hill-torrents like a flood river. It is very important and largest *Zam* in Spate irrigation of D. I. Khan. The water of the *Zam*, at Kot Azam is distributed in a 2:1 ratio into '*Nulla Looni*' and '*Nulla Kot Azam*'. The floodwaters of Gomal Zam are going waste and causing heavy land erosion and ravine formations. The project was originally conceived in 1850. The President of Pakistan inaugurated the Gomal Zam Dam project on 22 August 2001 that was long due since 1850. The project was approved at a cost of PKR 12.829 billion (214 million USD). Out of this 37% is meant for perennial and non-perennial Spate irrigation systems and rest 63% is for the dam and the power house. The command area is 66000 ha – 12,500 ha under perennial irrigation and 53,500 ha under non-perennial irrigation. The unit cost per ha for the whole of the project is USD 3240/ha. Whereas the unit cost of development of Spate irrigation facility is around USD 1200/ha.[10] The gross storage capacity of the Gomal reservoir is 1.4 billion m^3 with live storage capacity of 1.1 billion m^3.

In Khyber Pakhtunkhwa, 76 small schemes of non-perennial and perennial Spate irrigation were completed with a total cost of PKR 12.027 billion (USD 200 million) largely weir regulated with simple Headworks. These schemes provided new command area of 27,474 ha and provide improved facilities to 162,834 ha. The total command area benefited was 190,308 ha. The cost of development of perennial and non-perennial Spate irrigation systems comes to USD 1051/ha.

[9] The Agriculture Census is normally conducted after every 10 years. The data of 2000 is the latest available in the country. The Agricultural Statistics, which is being published annually, does not differentiate the Spate and Rainfed systems as both are lumped under non-irrigated areas.

[10] Gomal Zam Dam Multi-Purpose Project. Brief of Latest Status of Implementation. Water and Power Development Authority, Pakistan, August 2007.

In Balochistan province, schemes under the Governors funds were developed at a cost of PKR 173.3 million (USD 2.89 millions). The command area was around 1215 ha. The cost of development of perennial and non-perennial Spate irrigation systems comes to USD 2379/ha, which is higher than the KP.

There is large variation in water availability, land holding, climate, ecology and cropping pattern. Hardly any study is available which can provide precise information. The economics of Spate irrigation is attractive for systems solely constructed, managed, operated and maintained by the farmers. The economics of recently constructed or modernized headworks-type Spate irrigation systems is questionable in terms of cost-effectivity. By and large, farmers' managed systems are more economical both in investment and O&M cost. There is a need to formulate participatory scheme development process and the development schemes must be implemented by the user institutions rather than contractors. If there is a need for contractors to construct complex components of schemes, such contracts must be awarded by the communities. The recommendations for improving performance of Spate irrigation and farming in Pakistan are:

- Formulate strategy for participatory Spate irrigation development and management systems, options available for supplementary and deficit irrigation using available surface and groundwater from perennial sources (spring, wells, tubewells, etc.) and groundwater recharge to generate new aquifer or recharging the existing;
- Ensure that rights of lower riparian are protected while designing new schemes;
- Establish new institutional arrangements for Spate irrigation and farming;
- Formulate balance strategy for Spate farming considering both the options of extensification and intensification;
- Develop and introduce reliable water supply and integrated land use systems for risk aversion;
- Development of micro-water resources and conjunctive use for improving water productivity at the scheme and farm levels; and
- Initiate programme for the transfer of Spate irrigation and farming technology to all the water users.

There is a potential for developing 4 mha of Spate irrigation and farming systems in the country. Supplemental and deficit irrigation can be practiced if perennial surface and groundwater schemes are developed as a strategy. Spate irrigation scheme development must be linked with the objective of groundwater recharge by either replenishing the depleted aquifer or to generate new aquifers. The comparative advantages include production of oilseeds, pulses and feeds for livestock. The intangible benefits are large because country is now importing edible oils, pulses and coarse grains. The development of Spate irrigation further helps to generate new livelihoods in areas where poor-of-the-poorest is living.

There are two Best Practices undertaken during 1880 in Balochistan and in 1967 in Khyber Pakhtunkhwa, which seem the Best Practices for adaptation of impacts of climate change under the situation of floods and droughts – the extreme events. Both are selected as case studies. The details are presented in the following sections.

5.2. Case study of Shabo Headworks, Balochistan, Pakistan

The Shabo Headworks and Storage Tanks is the only scheme in Balochistan for Spate irrigation, where off-stream storage tanks were constructed to minimize tank's sedimentation. The Shabo Headworks is located in the Pishin District at Longitude of 33°18'N and Latitude of 30°07'E. The

scheme was constructed by the British Government in undivided India during 1888. The elevation of the location is 1587 m from mean sea level (Figures 26 and 27).

Currently, the scheme is being operated by the Balochistan Irrigation Department and they are responsible for the routine O&M of the headworks, main canal, and storage tanks. Farmers are responsible for the secondary level irrigation system and field operations at the farm level. The designed command area was 6512 acres in 1888, out of which currently 2171 acres are now under cultivation as tanks are silted and one is not functional.

The cost of construction of this scheme was PKR 104/ha or PKR 42/acre at the price level of 1888. Length of the Main Canal is 38 km with design capacity of 7 m^3/sec (247 cusecs). Four storage tanks were constructed to store floodwater so that it is available for irrigation for longer duration.

Figure 26: Gated weir controlled off-stream water diversion to water tanks

Figure 27: Un-gated weir controlled off-stream water diversion to water tanks

Figure 28: Meeting with spate farmers

The average cropping intensity of the scheme is 50 and 80% in Rabi and Kharif seasons, respectively, with an annual cropping intensity of 130%, which is reasonably high. Wheat, watermelons, cumin, and barley are grown. There are no reported conflicts between the water users as they can resolve their conflicts in a cooperative manner. There is no formal FO at the scheme level and the Department never tried to form such organizations. Farmers are managing secondary level system on their own.

The major findings of the Case Study of the Shabo Headworks are:

- Alternative concept of water storage, management, and sustainable farming systems is available in Balochistan since the last 124 years and performed well in this period. But all the developments after that were largely done in a limited concept of developing the on-stream storage dams without planning and constructing these schemes in an integrated fashion.
- Reduction in command area was mainly due to the reason of deferred maintenance where tanks were not cleaned and water conveyance system was not managed adequately. There is no other example of weir-controlled gated water diversion system in the country, which sustained so long on the ephemeral rivers. Even today 33% of the command area is still cultivated. This reduction is not only due to the deferred maintenance of the system because smuggling is now one of the major businesses of local people and agriculture has been neglected.

- Department of Agriculture could not introduce best practices for high efficiency and high value agriculture in the command area and next generation is involved in other ways of livelihood.
- The concept of managing sediments through off-stream diversion and storage worked well over a century and it can be tried in future projects especially in the regions where land is available for storage. Arid and semi-arid lands are most suitable for such type of systems.
- In future, such schemes can be designed in a comprehensive manner where water productivity should be the focus instead of the cropping intensity and/or the command area. The system can be operated in a semi-perennial mode and thus development of command area is essential so that light irrigations can be applied using furrow irrigation. For fruit orchards, drip irrigation can be introduced with additional sand filters to eliminate the sediments of the stored water. The system is also flexible enough to adjust the impacts of climate change in terms of drought and floods – the extreme events.
- The ecology is suitable for fruits and vegetables and more area can be brought under semi-perennial irrigation system. However, cereals can be grown using floodwater, which can't be stored in the tanks. There is a need for conjunctive water use, where floodwater, stored water, and shallow groundwater can all be used effectively.

5.3. Case study of Tanda Dam off-stream storage

Tanda dam is located in the district of Kohat in the KP at longitude of 33°34'28" N and latitude of 71°23'11" E and was completed in 1967 as an off-stream dam (Figure 29). The live storage capacity is 99000 acre-feet with culturable command area of 32000 acres. The cost per acre at the time of construction was PKR 17640. It was built on Kohat's Toi River towards the Hangu district. In order to fill this dam, a 300 meters tunnel was built in the hills. It is a medium sized dam, aimed to generate electricity for the region and provide irrigation to a large command area (Figure 30).

Figure 29: Tanda dam and command area

Tanda dam serves as a main source of water for irrigation to the adjacent areas. It irrigates agricultural lands up to Dohda Sharif and Dharma to grow wheat, sugarcane, and vegetables. Guava is one of the most famous fruit in the area and fetch premium price in the markets of

Northern Pakistan. Tanda Dam is acclaimed for its landscape and its ecology. It has also been designated as a wetland site under the RAMSAR Convention. The dam is used for irrigation, fisheries, and tourism.

The major findings of the case study of the Tanda Dam are:

- The off-stream storage helped in managing inflow of sediment load in water of the Tanda dam. One can see the blue colour of water, which is a clear indication of low level of suspended sediments. The dam has successfully worked for over 45 years and provides an excellent example of advantages of off-stream dams in arid and semi-arid regions.
- The cropping intensity is much more than the designed cropping intensity and some of the farmers are getting cropping intensity of over 200%. The higher cropping intensity is due to the use of groundwater, as the tail-end farmers are facing shortage of canal water.
- Fisheries production is relatively good and Department auction the contracts for fisheries. Fish of Tanda dam fetch higher price largely due to the freshwater fish of large size. Commercial varieties of fish are being produced in the reservoir.
- Tanda dam is a multi-purpose dam as it provides water for irrigation, hydropower, fisheries, and recharge to groundwater. Farmers of the command area have installed hundreds of dugwells or tubewells to meet their deficit in irrigation.
- Farmers work in a cooperative manner and they tried their level best to resolve conflicts but there is a lack of formal FO. Farmers are not getting any support from line departments for enhancing their water productivity or adoption of high-efficiency and high-value agriculture.
- The concept of integrated water storage dam is flexible enough to adjust with the impacts of climate change in terms if droughts and floods.

Figure 30: Reservoir of the Tanda dam, Kohat District of Khyber Pakhtunkhwa

Figure 31: Spillway of the Tanda dam, Kohat District of Khyber Pakhtunkhwa

Figure 32: Irrigation canal of the Tanda dam, Kohat District of Khyber Pakhtunkhwa

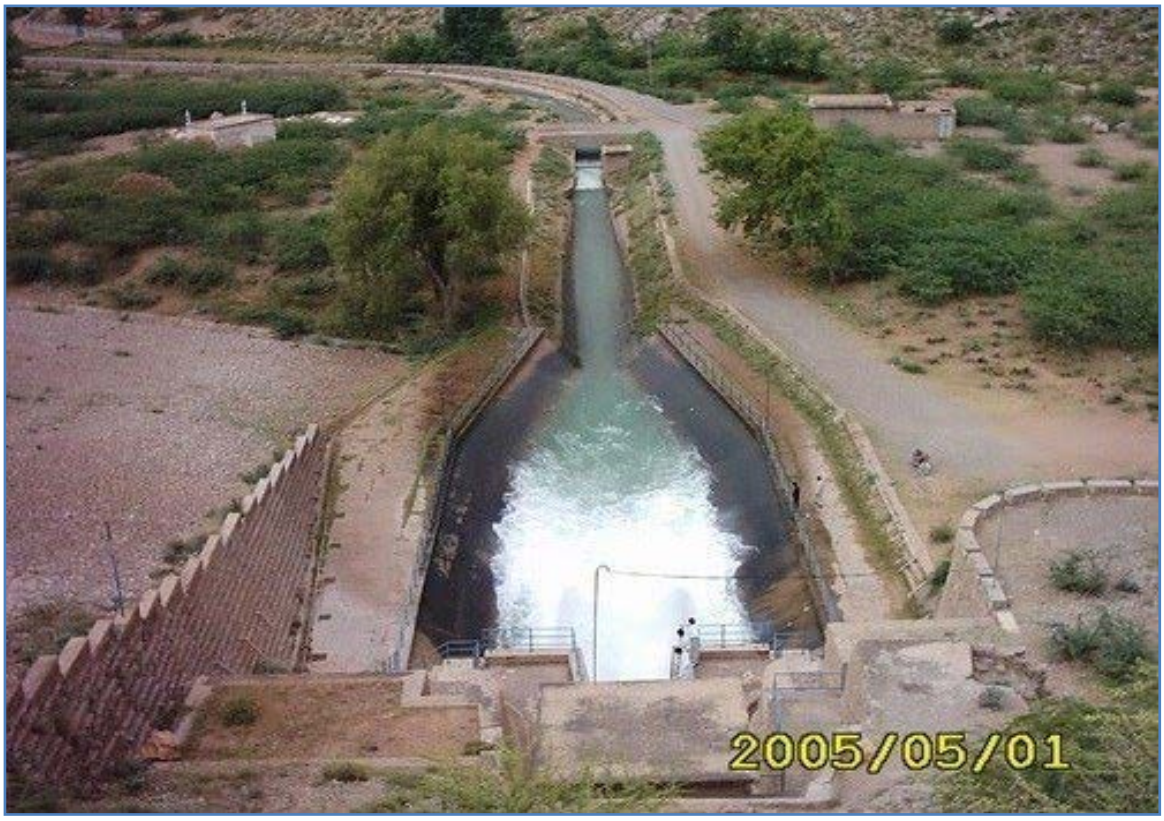


Figure 33: Irrigation canal of the Tanda dam, Kohat District of Khyber Pakhtunkhwa

5.4. Conclusions of case studies

Two Case Studies concluded that both of these are examples of Innovative Options already available in the country. The Shabo Headworks in arid environment of the Pishin district, Balochistan and the Tanda dam in semi-arid and sub-humid environment of Kohat, KP provide Best Practices for off-stream storages to avoid sedimentation in the reservoir, groundwater recharge, fisheries and tourism. The Shabo headworks provide an opportunity for developing off-stream water reservoirs in the Spate ecologies of the country. These two sites can be used for the conduct of the training courses for the development of integrated and innovative concepts of off-stream water storage and multiple uses of stored water. The Government of Pakistan and the provincial governments may look into this option of making these two sites as Model schemes and training platform for the future. Furthermore, these valuable historic developments must have to be rehabilitated and maintained as model sites. The schemes constructed since 70s, for Spate irrigation or Barani farming were hardly sustainable because we did not learn from the model historic developments. These are also Best Practices for the adaptation of the impacts of climate changes in terms of more frequent and severe droughts and floods.

6. MINI DAMS FOR MANAGING WATER SCARCITY – CASE OF RAINFED FARMING IN POTHOHAR PLATEAU OF PUNJAB, PAKISTAN[11]

Water resources development and management in Pothohar plateau is somewhat different from rest of the country, as the plateau is outside the Indus basin canal commands. The rainfall, runoff, and groundwater are the three sources of water. Rainfall occurrence and distribution is erratic and there are large variations in spatial and temporal contexts. The plateau has experienced droughts and localized floods even before the climate change and these events will be more frequent and severe in future. The option available for the management of droughts and floods is to store runoff in dams and recharge the groundwater. Water stored in small and mini dams is being used for aquaculture, irrigation, domestic and stock water needs. Mini dam resulted as a successful intervention because the farmers are partners in development, where the public sector provides a fix subsidy, which ranges 40 to 80% of the investment cost depending on the location and design of the dam. Rest is contributed by the farmers from 20% to 60% of the total cost. The design is made by the Agency for Barani Areas Development (ABAD) and implementation is done by the Directorate of Soil Conservation, Punjab. This intervention is one of the best practices in almost all the provinces as the ownership of the farmers is higher and they contribute in cash for the construction of the mini dam. The O&M of the mini dam is solely the responsibility of the farmers. Thus, this intervention is sustainable and addresses the impacts of climate change in relation to the increase in crop water requirement due to global warming. In Punjab in 2010, when the study was conducted around 1600 mini dams have been constructed.

6.1. Case of mini dams in Pothohar plateau

6.1.1. The context

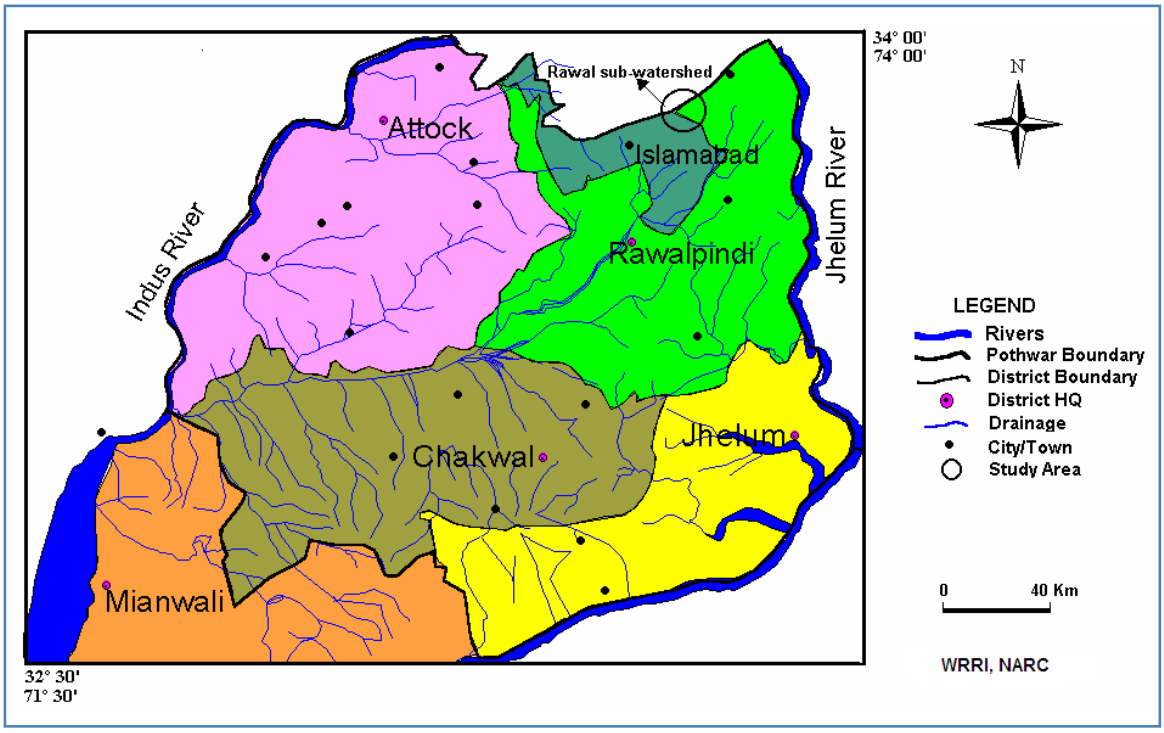
Pothohar plateau lies parallel to the outer Himalayas and between the rivers Jhelum and Indus. It includes whole of the Attock and Rawalpindi districts and parts of the Murree zone are included, besides 75% of Chakwal district, 15% of Jhelum district, and 20% of Mianwali district (Figure 34). The climate of Pothohar is arid in the southwest to humid in the northeast. Two seasonal Rivers Haro and Soan flow from east to the west and after crossing the region in the north and in the middle respectively, fall in the Indus. River Kanshi traverses the eastern part of the plateau from north to south and drains into the River Jhelum. These rivers and other hill torrents cut deep valleys and are of little use for irrigation. Agriculture is thus almost entirely dependent on rainfall and stored runoff in small and mini dams built across the streams.

There is a spatial variability in mean annual rainfall which is around 250-1500 mm, also there is temporal variability in mean seasonal rainfall, and during Rabi rainfall in Islamabad varies from 125-650 mm. Rainfall during Kharif season is 60% of annual rainfall in July to September.

[11] This section is based on the papers:

- Ahmad, S. 2009. "Global Warming Impacts on Agriculture and Adaptations." Paper presented in Workshop on Climate Change Impacts and Adaptations in Agriculture of Pakistan. Agriculture Foundation of Pakistan and University of Arid Agriculture, Rawalpindi.
- Majeed, S., I. Ali, S. b. Zaman and S. Ahmad. 2010. *Productivity of Mini Dams in Pothohar Plateau: A Diagnostic Analysis*. NRD Policy Briefings. Volume (2), No. (13), Natural Resources Division, Pakistan Agricultural Research Council, Islamabad

Figure 34: Map of Pothohar Plateau, Punjab, Pakistan



The Pothohar tract comprises mainly of a wide plateau, generally lying at 300-450 masl and a high mountainous belt in the north–east and west, rising up to 2,200 masl, having ridges and narrow intervening valleys. The mountains have steep to moderately steep slopes, while the plateau has level to undulating topography, with isolated gullies here and there. The area is subject to active water erosion and, at places; streams have cut very deep gullies and gorges through the land and rock strata. The texture of these agricultural soils mostly varies from sandy to silt loam and clay loam comprising from poor to fertile lands.

The major crops grown under Barani farming are wheat, chickpea, groundnut, millets, sorghum, oilseeds, and fodders. Maize and sunflower are grown in the high rainfall areas. Vegetables and orchards are grown where access to cities and irrigation water from dams and tubewells is available. The irrigated farming system is currently practiced on a relatively much smaller scale from small dams, mini dams, and tubewells.

In the Northern Punjab, rivers and canals have literally no significant role in irrigation and the availability of surface water is not in abundance as compared to other parts of Punjab. To cope with water demand, there needs to be an effective water management in place. The water scarcity trends are now clear in the Pothohar plateau and there are chances that it might result into water crisis in the near future. Experts are of the opinion that water crisis are already there, as the country is not effectively managing the available resources. The crisis is basically due to lack of management of water under scarcity so that basic needs for domestic and food purposes can be met. The water scarcity is now reality and in future new water resources are harder to find, therefore new water resources would largely come from the saving of existing losses through effective management of the available resource.

Water management becomes necessary for ensuring the long-term availability of clean water for the domestic use and for meeting the demand for food. The Water Apportionment Accord does not cover the Northern Areas and Pothohar plateau; therefore, the people of Barani areas are

deprived from having access to river flows from the Indus Basin Irrigation System. The water rights on the non-perennial floodwater streams are not precisely and sharply defined and any large scale water development in these areas sometime create conflicts among the community. Moreover, proper infrastructure to harness potential from non-perennial streams is also lacking.

The only source of water is rainfall, which varies between 250 and 1500 mm. About 30% of rainfall is lost which is sufficient to irrigate two million acres if properly harvested. During the dry spell (1997-2003) there was little rainfall and farmers started installing more tubewells. Consequently, the groundwater resource was exploited indiscriminately and water table lowered at a rate of 0.6 to 2.5 m per annum resulting in intrusion of saline water into fresh layer as well as extremely restricted well yield. One of the solutions to the problem is efficient management of groundwater as well as recharging of groundwater aquifer through construction of delayed action mini dams with sinking sumps which would help increase recharge to groundwater and raise the groundwater level. The scope for such development works is quite large in the Pothohar plateau.

In case of small dam, the ownership and management lies with the government. But unfortunately management is faulty and there are many losses which includes the conveyance losses. On the other hand, the ownership of the mini dams lies with the individual, the management is the task of the owner him/her self and cost of managing the dam is to be borne by the farmer. This is the reason the mini dams are more economical to make as compared to the small dams because in case of small dam the ownership is of the government and due to this it is highly uneconomical.

Multi-purpose dams entail many benefits for the community and are likely to have very positive impact on the livelihoods of the local population. Dams provide a range of economic, environmental, and social benefits, including recreation, flood control, water supply, waste management, and wildlife habitat.

Various public-sectors institutions are engaged in the development of mini dams in the Pothohar Plateau (Figure 24). The institutions involved in the construction of mini dams and water management are: (a) Directorate of Soil Conservation of Punjab Agriculture Department; (b) On-Farm Water Management Directorate; and (c) Agency for Barani areas development (ABAD). ABAD has successfully implemented two phases of ADB-sponsored project “Barani Areas Development Project.” The 1st and 2nd phases of BADP have developed good community based models for sustainable water and land management, which are being replicated in other projects. ABAD has also implemented Barani Village Development Project (BVDP) with the support of Asian Development Bank (ADB) and International Fund for Agricultural Development (IFAD) and constructed large number of mini dams.

Figure 35: Mini dam structure and command area with pipe-flow irrigation system

6.1.2. Study methodology

The overall objective of the study conducted by PARC was to evaluate the current productivity and potential of mini dams in the Pothohar plateau, their limitations and issues hindering cost-effective utilization of stored water using an approach of diagnostic surveys and analysis for enhancing future development of irrigated agriculture in the command area of mini dams.

The study for the mini dams was designed covering both the review and analysis of secondary data and collection of primary data in the mini dams selected out of the population database developed under the study. The data of all mini dams constructed in Punjab province by the Directorate of Soil Conservation was collected for the development of the database. The data includes: (a) total number of mini dams in Punjab; (b) spatial distribution; (c) age of the mini dam; (d) designed versus actual command area of the mini dam; and (e) cost and subsidy provided for mini dams. The data of 981 mini dams were used to develop database using MS Excel Files. These dams were constructed during the period from 1984 to 2009 – a period of 25 years. Out of the population of 981 mini dams 21 mini dams were selected for the conduct of diagnostic survey and analysis. Data from secondary and primary sources was triangulated for synthesis of findings and identification of key issues and potential options.

For the conduct of the primary data collection, a questionnaire was developed. Later on pretest of the questionnaire was conducted and necessary changes were made in the questionnaire. After the fine-tuning of the questionnaire, structured interviews were arranged for the owners of the mini dams. The sampling frame represents the dams with small and large command areas; range is 2.5-250 acres. The sampled dams chosen for the survey are of different ages based on the year of construction. The oldest dam selected for survey was constructed in the year 1996 and the most recently constructed is 2009. The primary data collection was targeted to answer specific questions about what farmers have experienced and their opinion about the dam, how has it affected their lives and livelihoods, and what types of externalities are generated by the dam. Data regarding physical characteristics of mini dams, outcome of mini dams, and contribution of mini dams in agricultural development and the limitations is collected through survey. Questionnaire is developed to acquire the information about physical characteristics of mini dams, initial and operational cost of the dams, maintenance, utilization pattern, impacts, core issues of the dams and option for betterments in view of the owners.

6.1.3. Findings of the analysis of the mini dams' database

- The rainfall pattern demands, that interventions like water harvesting, storage and supplemental irrigation for crops during the months of April to June and October to December may be undertaken considering the impacts of climate change in terms of droughts. The runoff available in the Pothohar Plateau is 3.5 MAF, of which 0.10 MAF is being utilized by small dams, mini dams, and ponds. The remaining 3.4 MAF is going to the Indus and Jhelum Rivers.
- The Pothohar Plateau is characterized as semi-arid to humid climate having average annual rainfall varying from nearly 1500 mm at the northeast and progressively drops to 250 mm in the southwest region. The Pothohar Plateau can broadly be classified on the basis of annual rainfall as: (a) high rainfall zone (> 750 mm annual); (b) medium rainfall zone (450-750 mm); and (c) low rainfall zone (< 450 mm). Secondary data reveals that most of the mini dams are concentrated towards the centre of the region i.e. the area that falls in medium rainfall zone. The factors involved in the spatial variability of mini dams in the Pothohar plateau are: (a) topography of the area; (b) drainage pattern of the streams network; (c) potential sites for storing water; (d) awareness of the farmers;

(e) target areas of various projects, implemented site focus; (f) riotous ownership of the potential site for dam; and (g) rainfall variation.

- The size of the dam is a function of available runoff volume in the stream and the potential command area. In most of the cases, the storage capacity of mini dams ranges from 30-50 acre feet which is enough to irrigate an average command area of 25 to 32 acres using the concepts of supplemental irrigation over and above the available incident rainfall. One mini dam is primarily constructed to satisfy the needs of a farmer for supplemental irrigation to the Barani farming lands.
- Total cost of a mini dams ranges from PKR 0.4 to 1.0 million, which a farmer alone can't afford, therefore subsidy is provided by the Punjab government. The analysis of secondary data on subsidy provided by the provincial government have large variations due to different cost sharing mechanisms followed over the last two decades. On an average, subsidy ranges from 41 to 77 %.

6.1.4. Findings of the diagnostic surveys, design and actual command area

- Most of the farmers are involved in freshwater aquaculture, as it is the most profitable farming compared to crops, thus command area could not be developed. Farmers' prefer the production system that is more profitable for them.
- The storage capacity of the constructed mini dams mostly ranged between 15-50 acre feet and adequate for aquaculture, crop farming and recharge to local shallow groundwater.
- Intervention of the mini dam resulted in significant improvement in the land use system. Before the intervention, the cropping intensity was low, as mostly Barani wheat was grown in the Rabi season. Out of the surveyed sample, 33% of the farmers were doing Barani farming and 61 % were doing nothing on their lands. After the intervention of the mini dam, farmers shifted to double cropping system and also some other activities mainly aquaculture. Around 85 % of the Barani wheat converted to irrigated wheat. About 61 % of the sample farmers started aquaculture. Almost 42 % of the farmers were cultivating vegetables (okra, onion, garlic, cauliflower, coriander, capsicum, reddish, and chillies). Yet 14% have started the fruit plants most of it was citrus, whereas each of maize, fodder and groundnut were grown by almost 19 % of the sample farmers.
- The cropping intensity was increased from 100% or less to up to 200% with higher use of fertilizer due to the irrigation input. Some farmers are also bringing more area under cultivation due to ensured water supply. Socio-economic condition of the beneficiaries improved. Before the intervention of the mini dam, the low yields were mainly due to the lack of water and inefficient use of agricultural inputs like fertilizer and risk aversion of the farmer due to uncertainty of the rainfall.
- A number of mini dams are built at the downstream end of the farmer's landholding and farmers have to depend on lift irrigation schemes provided by On-farm Water Management Directorate. The O&M cost of the diesel operated pumping system is high.
- The expected life of mini dam is 25-30 years, which is dependent on measures taken for watershed management. Well-managed watersheds help to increase the life of dam by controlling the occurrence of the sedimentation.
- In the periphery of the mini dams, the depth to groundwater is about 30 to 50 feet largely due to the seepage from the mini dam, which is being harnessed during dry spells.
- Farmers have already demonstrated shift from rain fed farming to irrigated farming which is one of the major factor for the sustainability of the mini dams and adaptation to the droughts and floods.

- Aquaculture is one of the most profitable activities, as the input required for aquaculture is very low but the return is very high if properly harvested. Out of the surveyed dams, farmers are mostly using the seeds of common corps, which grow relatively faster than other species even if farmer do not put the feed for fish this specie grows to 0.80-1.0 kg/annum but if fertilizer is applied and proper care is taken for their nourishment it can gain weight up to 2.5-3 kg/annum. Many farmers are putting the seed of grass corps, one of the main reasons for putting this seed is that there are wild weeds and this fish species eats these weeds.
- The whole investment on the dam can be returned only from the aquaculture within few years. Out of the surveyed dams, 61 % of the farmers were doing aquaculture.

6.2. Case study of Azam farms

Muhammad Azam residing in Hasanabdal, was found to be one of the progressive and enlightened farmer. He has constructed the mini dam in 2006 with a subsidy of 46% (Figures 36 and 37).

Figure 36: Command area of Azam Farms

Figure 37: Forest plantation at Azam Farms

Total cost of the dam was PKR 0.583 million. Most of the land was barren before the construction of the dam. Only Barani wheat was grown on his land. But after the construction of dam he even grew fruit plants like lychee, grapes, and plum, converted a part of Barani wheat into irrigated wheat. Out of his total land of 12.5 acres, 95 % was developed and he was irrigating 70% of the total land from his dam, he was not only realizing the maximum potential with all the available resources out of the dam but also expanding his area by purchasing more land as he has ensured water supply system.

His land use system includes cropping of wheat, fodder, seasonal vegetable, livestock, and aquaculture. Forest plantation was also there, some of it was natural, and most of it was planted. Moreover, he has planned to construct poultry and dairy farms with the resources available to him domestically like forest wood. The forest wood to be utilized for his dairy and poultry farm was of the value of PKR 0.2 million. He got benefit from vegetable farming, which includes garlic, onion, potato, okra, and cauliflower during the alternative seasons. He sold garlic for PKR 90000. He also took benefit from aquaculture, and he put 5500 seeds of fish, worth of PKR 1.0 million.[12] Yield of wheat doubled compared to the Barani wheat. He was getting Barani wheat yield of 2.0 to 2.4 tons/ha and after the construction of the mini dam wheat productivity doubled, as he is now getting 4 to 4.4 tons/ha of wheat. The gross value of his previous year wheat was about PKR 0.214 million, out of which PKR 0.166 was the value of irrigated wheat. Around 28 % of the total cost of the dam was recovered through the irrigated wheat alone,

[12] The average weight is taken as 1 kilogram, and 10% are considered as losses during the harvest of fish, prices vary from 180-4000/kg so the approximated price is considered which is PKR 250/kg.

whereas 15 % of the total cost was recovered only from the sale of one season garlic. As a whole 43 % of the total cost has been recovered only from garlic and irrigated wheat. The total cost of the dam can be recovered in two crop seasons if he only grows wheat and garlic. Thus the economics of mini dam farming is very high.

6.3. Case study of Khursheed Khan Farms

In Fatehjang, owner of the Khan farms had constructed 9 dams out of different schemes of mini dams from the subsidy provided by the ABAD. He owned 625 acres out of which only 19 acres were developed for irrigated agriculture, and rest is still being farmed under rain fed environment.

His land use system includes citrus, peach, olive and mulberry. Orchard having 4000 plants of oranges, 150 plants of olive, some plants of grapes and mulberry has been established. He shifted from wheat to fruit plants and also installed drip irrigation for grapes. The area on drip irrigation system was only 5 acres (Figures 38 and 39).

Figure 38: Orange orchard at Khan Farms

Figure 39: Vineyard on drip irrigation at Khan Farms

He did not benefit from aquaculture out of a single dam. Livestock holdings include small ruminants around 50 and 6-7 large ruminants mainly cows. There was not much of the problem of sedimentation in the any of nine dams. Water table depth in this area is not very high because of the hard rocks. He has established best practices for irrigated agriculture especially the fruit orchards, where very little water is required for supplemental irrigation

7. MANAGING WATER SHORTAGE – CASE OF INDUS BASIN IRRIGATED AGRICULTURE IN PUNJAB, PAKISTAN[13]

Water in the Indus basin irrigated agriculture was short by 26% during the monsoon season of 2009, which affected the storage of water and coupled with shortfall during Rabi season 2009-10, resulted in severe shortage of water for irrigated agriculture in Pakistan. The climatic variability in the Indus basin irrigation system is extremely high, even before the climate change the highest annual river flows are almost double than the lowest flows. In addition to this, the seasonality of river flows is extremely high, where Kharif season flows are five-folds of the Rabi season using the historical data of river flows of 1937 to 2008. The climate change is worsening the situation and experts are of the opinion that extreme events of floods and droughts will be more frequent and more severe. Taking in to consideration of extreme scarcity of water during 2009-2010, a strategy was developed and implemented at various ends. There was no shortfall in wheat production as water allocation to various canals in Punjab was adjusted with the availability of water to reduce the impacts of shortage of water. This was due to the Best Practice of shifting the roaster of water allocation and diversion to canals changed from 7 days to 14-21 days to manage the scarcity without affecting the hydraulic regime of the canal system. The other factor contributing the management of wheat production and productivity was that priority was assigned to the brackish groundwater zone so that there is no shortfall in production, whereas reduced allocation of canal water in the fresh groundwater zone was managed through abstraction of groundwater by the farmers.

7.1. The context

Drought impacts on water were experienced during 1999-2001 throughout the country; particularly the water shortage was severe during the Rabi season of 2000-2001. The monsoon rains were also erratic and below normal in the canal irrigated areas. The initial forecast of water availability prepared by IRSA indicated that the expected water-availability for Punjab canals during the Rabi period 1999-2000 would be about 20.9 billion m^3 against the water entitlement of 23.2 billion m^3 as per allocations of Pakistan Water Apportionment Accord. The actual water-availability was, extremely low as shortage of 40% was observed during the season from that of the Punjab Rabi season entitlements. The Rabi withdrawals of the canal in the Punjab province for the period 1990-2001 are presented in Table 3.

Table 3: Water entitlements and water availability in Punjab Canal irrigation system

Year	Water Allocation (billion m^3)	Variation (Increase or Decrease)
1990-91	27.43	18.18%
1991-92	23.79	2.50%
1992-93	26.17	12.75%
1993-94	23.06	-0.65%

[13] This sections is based on two papers:

- Haq, A. 2002. *Drought mitigation interventions by improved water management. A Case Study of Punjab, Pakistan*. Lahore: Department of Irrigation, GoPunjab.
- Ahmad, S. 2009. *Anticipated Shortage of Water in Rabi 2009-10 Season: Strategy for Efficient Water Use to Improve Water Productivity of Wheat*. NRD Research Briefings. Volume (1), No. (10). Natural Resources Division, Pakistan Agricultural Research Council, Islamabad.

Year	Water Allocation (billion m^3)	Variation (Increase or Decrease)
1994-95	25.21	8.62%
1995-96	25.94	11.76%
1996-97	24.55	5.77%
1997-08	22.64	-2.46%
1998-99	23.23	0.09%
1999-00	20.2	-12.97%
2000-01	13.9	-40.1%

7.1.1. Water management plan for Rabi season 1999-2000 and 2000-2001

The water shortages from that of the entitlement were 12.97 and 40.1% during the Rabi season of 1999-2000 and 2000-01, which had serious implication how to allocate water to different canals and how to manage the canal hydraulic regime so that canals are not silted up due to the reduced flows. For this purpose, the Punjab Irrigation Department and Punjab Irrigation and Drainage Authority formulated an action-oriented and comprehensive "Canal Operations for Adaptation to Reduced Canal Supplies during the two Rabi Seasons". The Plan was prepared through active consultation with the Punjab Agriculture Department and the Farmers' Organization representatives. The main thrust of the Plan was focused on the following innovative initiatives:

- Conserving water during the slack-demand especially during Rabi 2000-2001, when the canal diversion reduced to 13.90 billion m^3 by reallocating water at critical and sensitive stages of crop growth.
- Priority was assigned to the canals of the saline groundwater zone, as farmers in these areas can't use the brackish groundwater covering 30% of total canal irrigated lands in Punjab. The purpose was that ensure one to two irrigations in non-perennial canal commands of the saline groundwater zone.
- Farmers in the fresh groundwater zone can abstract more quantity of groundwater to meet the shortfall in the canal water supplies.

In order to implement the above strategies, the broad pattern of canal regulation/management was planned to optimize the operation of canals in the best interest of the province having minimal impacts on the production of wheat. The implementation of Rabi season Plan was closely monitored throughout the crop season by the senior irrigation-managers and the needed adjustments were made in real-time basis, in response to the actual water-availability. The information regarding the Rabi Plan and its subsequent operation was disseminated through the media and the extension wing of the Punjab Agriculture Department.

7.1.2. Canal operational plan for Rabi 1999-2000

The canal operational plan for the Rabi season of 1999-2000 comprise of followings:

- All non-perennial canals in the cotton zone were closed from 5 October instead of 15 October
- All perennial canals in cotton zone were closed from 15 to 31 October
- The flow period of the non-perennial canals in the rice zone was extended from 15 to 31 October

- All perennial canals in the rice zone were closed from 1-15 November
- 15 days watering schedule in non-perennial canals in the cotton zone was released from 20 November to 5 December
- All perennial canals were operated with 10% shortfall during January to 10 February 2000, to remain within Punjab share
- All perennial channels were closed for a period of 20-22 days during the month of January 2000, to undertake O&M of the Barrages, main canals and distributary system, as well as save water for use subsequently
- All perennial canals in Mangla and Tarbela command were raised to full capacity from February 11-29, so as to provide crucial watering during the development stage of wheat growth
- All non-perennial canals were given full watering for 15 days from February 21 to March 5
- All perennial canals were reduced to 60% capacity from March 6-31, to remain within the provincial share

This Plan was fully implemented and successful as the farmers at all level fully cooperated in this mission of managing the canal water shortages due to drought.

7.1.3. Canal operational plan for the Rabi 2000-01

The canal operational plan for the Rabi season of 1999-2000 comprise of followings:

- All non-perennial canals in cotton zone were closed 15 days in advance 1st October instead of 15th October
- All perennial canals in cotton zone were closed for 3 weeks 10-31 October
- Extension of flow period of non-perennial canals in rice zone by 5 days up to 20th October
- 10 days closure of all perennial canals in rice zone
- Two weeks watering in cotton zone for wheat sowing 20 November to 5 December
- Perennial Canals running
    - 55% capacity — Up to 15 February
    - 70% capacity — Up to 28 February
    - 30% capacity — During March
    - Non-perennial canals — Closed

7.1.4. Internal water management at canal command level

For improving internal water management regime, as well as to ensure farmers' participation in planning and operating the canals, for equitable and efficient distribution of irrigation water, Water Allocation Committees at the Canal Command level and at the Canal Division level were established throughout the Province, and details are given in below:

7.1.5. Canal Command Level Water Allocation Committee

7.1.5.1. Composition

- Superintending Engineer — Convener
- Director of Agriculture or his representative — Member
- Representative of Deputy Commissioner — Member
- Three Farmers' Representatives from head, middle and tail reaches of canal system — Members

7.1.5.2. Functions

- Receive share of each main canal system from the Directorate of Regulation for each crop and Kharif and Rabi season
- Prepare the water distribution programme on 10-day basis, taking into consideration the Accord allocations, cropping pattern and crop water requirement
- Review and monitor the actual operation of the canal system with reference to the water account, vis-à-vis the canal share
- Devise ways and means to streamline and improve the water management operations and affect equitable distribution of available supply.

7.1.6. Divisional Water Allocation Committee

7.1.6.1. Composition

• Executive Engineer	Convener
• Assistant Director Agriculture or his representative	Member
• Assistant Commissioner or his nominee	Member
• Three Farmers' Representatives from head, middle and tail reaches of canal system	Members

7.1.6.2. Functions

- Receive share of each canal system division from the Superintending Engineer
- Formulate regulation/rotational programme of the distributaries and minor in the canal division, for affecting equitable distribution of the available supply
- Assess the canal water demand in a crop season and assist the Executive Engineers in determining the indents of various canals on 10-day basis
- Monitor the operation of the canal system in the division and review the water account vis-à-vis the allocated share

7.1.7. Strategy for managing water shortfall without affecting productivity and production

A three-prong strategy has been used for managing shortfall in canal water availability in the Rabi seasons of 1999-2001, reduced rainfall, and increasing cost of energy for pumping groundwater. The purpose of the strategy was to enhance water productivity by managing the shortfall in canal water supplies and reduced rainfall. The elements of the proposed strategy are:

- Managing shortfall in canal water supplies by changing the canal operational schedules to maintain the canal hydraulic regime for effective management and performance of the canals. This strategy has been practised by the Punjab Irrigation and Power Department during 1999-2001 by increasing the canal rotational schedule from 7 to 21 days. This helped the provincial Irrigation Department to manage the severe shortfalls.
- Managing water productivity under deficit irrigation is a real task but it is possible, as 3-4 irrigations after the emergence of wheat crop can provide potential yield of 4-6 tons/ha if non-water inputs are effectively managed. The irrigations have to be applied in required amount and at right times to replenish the soil moisture depletion. In addition, advisory services were provided to the farmers through the provincial Agriculture Departments and the private sector Supply and Service Companies so that farmers do

not use excessive nitrogenous fertilizers (i.e. Urea, Ammonium Nitrate, etc.) to avoid unnecessary vegetative growth, which demands more water. PARC developed a package of "Best Practices" for dissemination to the farmers.

- Best practices are effective to have foliar application of anti-transpirants to reduce transpiration coupled with mulching of fermented plant materials to reduce evaporation from soil surface until the wheat has full effective cover. This message can be best taken to the farming community by the private sector companies.

7.1.8. Best practices for improving water productivity under deficit water supplies

A few "Best Practices" were suggested, which are cost-effective and can be applied easily by the Punjab Irrigation Department and farmers. These practices are illustrated as under:

7.1.8.1. Adjusting canal operational schedule with water availability

- The provincial Irrigation Department manage canal operational schedule in terms of canal rotations to adjust with availability of water at the canal head so that it can be effectively used by the farmers without adversely affecting the yield of Rabi crops including wheat.
- Irrigation and Agriculture Departments initiate a joint programme where farmers are informed well before time regarding the revised schedule of operation of canals.

7.1.8.2. Scheduling irrigations for wheat and other crops

- After the germination of wheat crop, three irrigations are essential – first at tillering, second at heading and the third at booting stages of crop growth. In case there is sizable amount of incident rainfall then the scheduling of irrigation can be adjusted accordingly.
- Similar scheduling is needed for other crops including fruits and vegetables.

7.1.8.3. Scheduling fertilizer for wheat and other crops

- In case of water shortage, application of nitrogenous fertilizers (i.e. Urea) has to be adjusted rather it has to be reduced so that vegetative growth is optimized. Optimal vegetative growth can help to maintain plant growth under water deficit situations without significantly affecting the productivity. It is better to use organic composts, which can be spread between the rows of crops including wheat.
- Similar scheduling is needed for other crops including fruits and vegetables.
- Foliar application of organic compounds can help to improve water productivity. Molasses is a "Tonic for the Plants" which works by energizing soil microorganisms, the backbone of healthy soil. Excellent when applied to soil in conjunction with fertilizers, such as Molasses as soil food, or sprayed directly on plants. Shake the molasses foliar food (MFF)14 well before mixing. As a foliar application, mix 1 tablespoon of Molasses foliar food per gallon of water to make ready-to-use foliar solution. Spray the entire leaf surface of the plant weekly with the MFF solution. Apply early in the morning or in the evening--avoid the hotter part of the day. As a soil conditioner, mix 2 tablespoons per gallon of water, and water plants as needed.
- Foliar application of humic acid on wheat and other crops as a source of organic foliar fertilizer or soil application whichever is possible.

[14] Molasses Foliar Food is a combination of materials including 1 unit of molasses, 1 unit of Organic Vinegar and 1 unit of Potassium Chloride. The mixture can be packed in plastic bottles and marketed.

7.1.8.4. Application of anti-transpirants to reduce transpiration

- Natural anti-transpirants can be made from pine oil and are mostly non-toxic and bio-degradable. They are sometimes used for the prevention of powdery mildew on roses and crape myrtles. They work by spreading a clear film over the leaves. They are also used to help control diseases. They also can help stop freeze damage. However, don't overuse or use when unnecessary. They are also used to coat the foliage of plants for the purpose of reducing transpiration in hot weather and increasing cold tolerance in winter. A 250 ppm solution of pine oil is recommended.
- Crops grown under moisture stress conditions can be treated with different chemicals namely, cycocel, lime wash, and potassium chloride to decrease leaf temperature, reduce transpiration rate and to increase diffusive resistance.
- Daily evapotranspiration can be reduced significantly after the application of stomata closing type chemicals (Phenyl mercuric acetate [PMA] or Atrazine) used in conjunction with reflecting type anti-transpirant (Kaolin). The moisture conservation effects of these chemicals lasted about two weeks under clear weather conditions.
- The 'film type' anti-transpirants can be used to reduce transpiration only at a considerably higher concentration than the 'stomatal type' of anti-transpirants. Of the 'stomatal type' of anti-transpirants phenyl mercuric acetate (PMA) is the most effective substance. Under actively transpiring conditions a 250 ppm solution of PMA reduced transpiration by about 30%. The effect of PMA is localized and there is no translocation to untreated parts of the leaf blade. A spray of PMA can reduce transpiration with gradually diminishing intensity for about 20 days, reduced vegetative growth of young plants grown both under non-water stress and water stressed conditions.

7.1.9. Impacts of water management and productivity enhancement best practices

The impacts of water management and productivity enhancement interventions resulted in to impacts on effective allocation and regulation of canal supplies both for the freshwater and brackish groundwater zones. The shortage in canal water deliveries was also managed effectively and efficiently to meet the economic targets of wheat production in the province. The impacts of canal water allocation and regulation coupled with water productivity are presented as under:

7.1.9.1. Impacts of innovative water management in canal operations

- The water management interventions for managing water shortage of 13% in 1999-2000 and 40% in 2000-2001 Rabi season, were unique in the sense that they were implemented on an unprecedented mega-scale, involving over 8.5 million hectares of the canal command area in the Punjab province.
- It has been demonstrated that there is considerable opportunity for optimizing the water management and canal allocations at the macro-level. It also brings into focus the significance of the optimization alternatives: (a) re-allocating water within the crop season to better match crop water requirement. Additional canal-closures can be planned for the purpose during the slack-demand periods. This also helps in improving the drainage environment in the root-zone, particularly in the waterlogged areas; (b) allocating preferential canal supply to the saline groundwater areas; (c) priority-water allocation during sensitive and critical stages of crop-growth; (d) providing one to two canal-watering to non-perennial areas, which traditionally do not receive canal-supplies during the Rabi season; and (e) conjunctive use of groundwater.
- The experiences of managing shortfall in the Rabi season canal supplies of 13 and 40 % during 1999-2000 and 2000-2001, respectively indicated the need for pre-season

planning for managing canal water supplies in both droughts and floods, in close collaboration with all the stakeholders (Department of Irrigation and Agriculture, Water-Allocation Committees, private sector input suppliers and service providers, etc.). The advantages and need for timely dissemination of the information regarding canal-operation plans to the farmers is essential for achieving the targets.

- Local-level management, through canal command and canal-division level water allocation committees can further enhance the beneficial impacts of the improved management regime.
- Close and continuous monitoring of the planned operations, along with timely adjustments in response to the actual water availability, holds the key to the successful implementation of an overall water-management regime. This is also critical for obtaining the desired enhancement in the levels of production.
- The successful model of canal water shortage management during the Rabi 1999-2000 has been a good learning experience, which has been replicated quite effectively during the next Rabi season of 2000-2001, when the water shortage was 40% from that of the entitlements.

7.1.9.2. Impacts of water management and productivity enhancement on wheat

- The wheat area, production and productivity in the last 10 years (1990-2001) indicated that despite 13% water-shortage during 1999-2000, the area under wheat increased by about 10%, wheat production by 28% and productivity by 23% compared to average of the decade (1990-2001).
- During the year of 2000-2001, the decrease in water was 40%, whereas the increase in area was 3%, production by 18% and productivity by 15% from the average of the decade (1990-2001).
- The wheat production in the Barani (un-irrigated) areas declined by about 5% during 1999-2000 over last five years average, due to erratic rainfall during 1999-2000.
- The wheat production in four selected districts having brackish groundwater and the only source of irrigation is canal water, increase in wheat area of 4% and increase in wheat yield of 28% was observed during 1999-2000 over the corresponding last 10 years data (1990-2001). Although wheat area and production declined slightly during 2000-2001, compared to 1999-2000. However, it clearly shows the positive impacts of priority water allocation to the saline groundwater areas.

7.1.9.3. Impacts of non-water Factors

The following non-water factors also contributed towards the record wheat production during the 1999-2000 Rabi season:

- Enhanced support price of wheat from PKR 240 to PKR 300 per 40 kg motivated farmers to have better wheat farming in both the years
- Timely sowing of wheat
- Improved availability of fertilizers, better seeds, and efficient extension-services both by the private and public sector.
- Favourable weather-conditions at the time of crop maturing.
- The enhanced dependence on groundwater has resulted in considerable depletion of aquifers and increased burden on farmers, because of high cost of pumped water.

8. EFFICIENT USE OF WATER – CASE OF BEST TECHNOLOGIES AND PRACTICES FOR INDUS BASIN IRRIGATED AGRICULTURE IN PAKISTAN[15]

The climatic variability is extremely high in the Indus basin canal irrigation system, which affects the canal diversions and farmers are very much affected due to water scarcity during the drought season. This situation is already prevailing in the system since its inception. The climate change will have further impacts on availability of water for canal diversions. The fresh groundwater zone is having an advantage that in the situation of canal water shortages, farmers can supplement the irrigation water supplies from the groundwater. However, the farmers in the saline groundwater zone are facing acute shortage of water during the drought season, as they can't use the groundwater, which is brackish in quality. Therefore, the Punjab On-Farm Water Management Directorate General in collaboration with PARC initiated programmes for water management at the farm level, with an objective to enhance water productivity. The involvement of local private-sector service providers (tractor rentals) was given priority to provide Laser Land Levelling and furrow-bed irrigation equipment and machinery at 50:50% cost sharing. Now these tractor rental companies or individuals are now providing services to farmers for Laser land levelling and furrow-bed irrigation, which resulted in saving of water of over 25% and increase of 20% in productivity of crops grown on beds. Both the Best Practices of Laser land levelling and furrow-bed irrigation have been adopted at large scale in central and southern Punjab. Rather Punjab of Pakistan has exported these equipment and machinery to other countries like India, Afghanistan, Bangladesh, etc.

8.1. The context

Water management technologies are designed to achieve objectives of: (a) improving irrigation efficiency from current level of around 40% to 50% within the next decade resulting in a saving of about 17 MAF; (b) optimizing the use of valuable resource leading to enhanced water productivity and control of waterlogging and salinity. The overuse of water in the Indus basin resulted in 25-60% reduction in crop yields (GoP 2002).[16] Thus, there is considerable potential to improve water productivity at the farm level using innovative technologies.

8.2. Best practices of water management

8.2.1. Canal lining

Geo-synthetic liners in the form of thin polymeric film such as Poly-Vinyl Chloride (PVC) and Polyethylene (PE) have been used in the world for control of water conveyance losses. PVC and PE were not designed, but were adopted for use under the soil as seepage barriers; they are relatively inexpensive compared to polypropylene (PP) and have been widely used as canal liners, particularly in the mild climates. These materials, however, have proven success but sometime susceptible to installation damage, puncture, rodent attacks, weeds growth, chemical reactions with soil chemicals, heat, and ultra-violet radiation. Moreover, the early developments

[15] This section has benefited from Ahmad, S. 2006. "Innovative Technologies for Integrated Water Resources Management in Pakistan." Paper presented in the seminar on "Problems and Politics of Water Sharing and Water Management in Pakistan" held on 7-8 November 2006 at Islamabad Policy Research Institute, Islamabad, Pakistan.

[16] Government of Pakistan. 2002. *Water Sector Strategy for Pakistan*. Islamabad: Ministry of Water and Power, GoP (supported by ADB).

could not be reliably seamed on site and offered only temporary control of seepage - a service life of 10-15 years in high temperature climates depending on specifications of the liner.

In the last 15 years or so, high performance, fourth generation reinforced (PE, PVC, PP) geo-synthetic liners having service life of over 50 years have emerged as highly dependable seepage control barriers for extremely demanding environmental applications. Their flexibility, low liner thermal expansion, dimensional and multi-axial stability, tensile strength, high temperature tolerance, chemical resistance and ease of seamability make them the ideal solutions for lining of canals, water storage reservoirs (for both irrigation and drinking) - now successfully in use by many countries around the world.

The reinforced geo-membranes available today are complete water barriers, have a service life of over 50 years and up to 5 km of a medium size canal can be lined in a day. The speed and output of lining effort is an essential requirement because the lining cost can be reduced tremendously, if the lining can be accomplished within the prescribed period of canal closure (30 days).

Vandalism, indiscriminate animal traffic in water channels and canal maintenance operations/desilting may necessitate a hard cover over the geo-membrane. In the USA, 8-10 inch earth cover is considered adequate, but for Pakistan a hard cover would be preferred. For hard cover, in-situ concrete or pre-fabricated concrete slabs of 2-2.5 inch thickness can be used. The hard cover would certainly add toward the initial cost of the lining system installation, but in terms of 50 years' life cycle cost, the PP geo-membrane based system with pre-cast concrete slab cover is still at least four times cost-effective than concrete lining.

8.2.2. Watercourse improvement

Watercourse improvement programme was initiated in the country since 1980 covered around 108,787 watercourses up to June 2010. Most of these watercourses were improved by the federal government under the National Improvement of Watercourses Project to improve 88000 watercourses under the President's Programme of Special Initiatives during 2002-07, with an objective to have larger impacts on availability of water through saving of existing losses. This programme took longer time than envisaged. The watercourse technology includes: brick lining or pre-cast concrete lining of around 10-30% length of the watercourse within the allocated funds, provision of *Pacca* control structures including *Naccas* and *Katcha* improvements (Figures 40 and 41). The maximum savings, which are possible from these improvements, would be around 8 MAF. These savings would be available if the *Katcha* sections are continuously maintained; otherwise the quantum of such savings would gradually reduce with time.

Figure 40: Improved lined watercourse

Figure 41: Improved Katcha watercourse

8.2.3. Improved layout of farm and fields

One of the neglected areas in the Indus basin is farm and field layout, as provincial On-Farm Water Management Directorates are largely engaged in watercourse improvement and laser land levelling. Rather, the laser levelling is being introduced without considering system of water conveyance and application. Integration of surface and groundwater use at the farm level is also neglected. Thus, there is a need to introduce innovative technologies covering aspects of: (a) laser levelling; (b) farm layout considering surface irrigation hydraulics (stream size, infiltration, advance and recession time); (c) conjunctive water use requirement; (d) type of irrigation system; and (e) cropping pattern. Thus hybrid systems are needed addressing farmers' preferences.

8.2.4. Conjunctive water use

In the Indus basin irrigation system, groundwater contributes around half of total water available for crop consumptive use. In Punjab, it contributes around two-third of total water availability for crop consumptive use. Computer based models are now available to manage

groundwater resources when seepage from canals is the major source of recharge other than precipitation. The conjunctive water management at the canal level would help to maintain salt and water balance.

At the farm level, conjunctive water use is needed to manage scheduling for both surface and groundwater resources and managing brackish groundwater – mixing for sodic water and cyclic use for saline waters. Sulphurous generators are now being manufactured in the country and are in use at experimental level to manage sodic and saline-sodic groundwater. EM biofertigation for organic farming (Figure 42) and EM bio-generators for amending sodic groundwater are examples of more sustainable solutions (Figure 43).

Figure 42: EM bio-fertigation system

Figure 43: EM bio-generator

8.2.5. Reuse of wastewater

Sewage and agricultural effluents are going to be the additional water resources in the future. Currently, raw sewage is being used for production of vegetables in the peri-urban areas. Drainage water is also being used without any treatment. The use of sewage for production of vegetables resulted into concentration of heavy metals when sewage waters are polluted with industrial effluents. The use of agricultural effluents is affecting health of soil due to higher concentration of salts, residues of pesticides and fertilizers.

Microbial and biological treatment systems can be used either separate or in combination to treat these waters in a relative concept. The traditional sewage treatment plants are energy intensive. Although some of the metropolitans have installed these systems but could not be maintained due to higher operational costs. The microbiological and biological systems are cheaper and require no or very little energy.

8.2.6. Enhancing water productivity

Improving water application efficiency: Water application efficiency can be increased under both surface and pressurized irrigation systems and the technologies available are:

- Surface irrigation systems
    - Basin and border irrigation
    - Furrow and bed irrigation
    - Surge irrigation
- Pressurized irrigation systems
    - Sprinkler irrigation
    - Drip/trickle irrigation

8.2.6.1. Surface irrigation

Farmers are primarily practicing flood irrigation. Thus adoption of border, basin, furrow and surge irrigation can improve application efficiency. These technologies demand that farm layout be designed considering principles of surface irrigation hydraulics. The effectively designed surface irrigation systems can improve application efficiency. For example, planting on beds and furrow irrigation can save 25% water from that of border and basin irrigation systems in Punjab of Pakistan (Figures 44 to 45). Surge irrigation can further save water in light textured soils having higher deep percolation losses.

Figure 44: Two-row bed-furrow system

Figure 45: Three-row bed-furrow system

Land leveling for surface irrigation

Forming the land to a planned grade is an objective of surface irrigation. The effects of this practice depend on the level of irrigation water management. If soil moisture is properly managed, then quality effects of surface and groundwater may be avoided. Under poor management, ground and surface water quality may deteriorate. Deep percolation and recharge with poor quality water may lower aquifer quality. Land levelling can increase cropping intensity from 60 to 70%, which helps to reduce water and labour requirement. Poor management may cause an increase in salinity of soil, groundwater, and surface waters. High efficiency surface irrigation is more probable when earth-moving elevations are laser controlled (Figures 46 and 47).

There has been realization that land levelling can have economic payoffs and result in saving valuable energy (OFWM, Punjab). Farmers'' education and reduced price of farm implements would help promote widespread land levelling especially where returns are high. The Punjab OFWM is now implementing the Programme, where Laser levellers are being provided to clients at 50% cost sharing. The AgriMalls established in Punjab under private-public partnership is a forward looking approach, which might end up as service providers for provision of technology to the clients.

Laser levellers provide highly precise land levelling. The farmers are now getting laser levelling service at their farms @ of PKR 2500 per acre resulting in 50% increase in irrigated area and 30% saving in fertilizer in the district of Okara.

Figure 46: Three-row bed-planter

Figure 47: Laser leveling unit in the field

8.2.6.2. Pressurized irrigation systems

Portability is useful criteria for describing available sprinkler irrigation systems. Under this classification, a system is fully portable when all of the components can be moved and fully permanent when none of them can.

Solid-set system

A sprinkler system, which remains in a single location during an irrigation season and supplied by a fixed network of pipes is generally, regarded as a solid-set system. There is no unique field layout for solid-set system because of the many ways the piping system can be arranged, but there are two basic types of components - aluminium and plastic. Aluminium piping is typically laid along the ground surface and collected to provide access for cultivation type farming practices. Plastic pipes, usually PVC, are nearly always buried permanently because sunlight deteriorates the pipe. If UV stabilizers and black carbon are added, the low-density polyethylene (LDPE) pipes can be installed on the surface.

Solid-set systems irrigate entire field with a single set of components and are costlier than many other sprinklers. The labour and maintenance requirement of solid-set systems are minimal, but cultural operations such as cultivation, spraying, planting and harvesting may be restricted. As a result, solid-set systems are mostly applicable for crops with minimum requirement of cultural practices.

Move-stop systems

To reduce equipment needs and minimum interference with other farming operations, many sprinkler systems are designed to move the lateral pipelines from set to set. The movement itself can take on any form from the hand-moved lateral to the tractor-towed lateral; hence, the common use of hand-move, end-tow and side-roll sprinkler systems.

Move-stop systems require more labour and maintenance than solid-set systems, but are less expensive to purchase and install. Energy requirements are approximately equivalent. Major disadvantage is the need to move the system from wet to dry areas, which not only increases the necessary capacity of the network but also tends to reduce crop yields by damaging the crops.

Locally manufactured range of Rain-gun sprinkler irrigation systems are the hand-move systems, where Rain-gun can be moved to next location after completing irrigation at a given setting. A number of field layouts can be developed for Rain-gun systems or any type of hand-move systems considering the farmers' preferences regarding hybridization between solid-set and hand-move systems (Figures 48 and 49). Reel-type sprinkler systems are the good example of move-stop systems and normally preferred for turf irrigation and for vegetables, flowers, and herbs (Figure 50 and 51).

Figure 48: Raingun sprinkler system

Figure 49: Portable rain-gun systems

Figure 50: Reel-type sprinkler system

Figure 51: Mini-reel sprinkler system

Continuous-move systems

A remedy to the labour, maintenance, and downtime problems with move-stop systems is the system that covers the irrigated area by continuously moving. Centre-pivot, linear-move, and big-gun systems are typical examples of the continuous-move concept. Although, the equipment must be automated and made mobile, some reduction in pipe lengths and pipe sizes is possible to offset higher equipment costs (Figure 52).

Figure 52: Centre-pivot sprinkler systems installed in Punjab and Sindh provinces

Major advantage of the continuous-move system is labour saving. On a smaller scale, the sweeping action of these systems also tends to improve irrigation uniformity. Mobility problems, sticky soils and difficulty in maintaining alignment plagued early systems. Today, a major problem is high precipitation rates leading to excessive field runoff and high-energy requirement. Nevertheless, the continuous-move systems are most popular and most widely used sprinkler systems in agricultural applications in the USA and many other countries. In Pakistan, these systems are suitable for farms of over 100 acres in size and are being installed in the country. There are now over 200 systems already installed in the country with size ranging from 100 to 220 acres per system (Figure 53).

Drip/Trickle-irrigation systems

Drip/trickle irrigation is a system where water and fertilizer are applied directly to individual plants, instead of irrigating the entire area with sprinkler and surface irrigation systems. For

orchards and other widely spaced crops, it is accomplished with small diameter laterals running along each plant row. Emitters attached to the lateral supply water to each plant to meet crop water requirement. In the case of row or truck crops, thin-wall tubings are available with small diameter orifices, spaced at regular intervals along a thin-wall hose (Figure 54).

Figure 53: Standard drip irrigation system

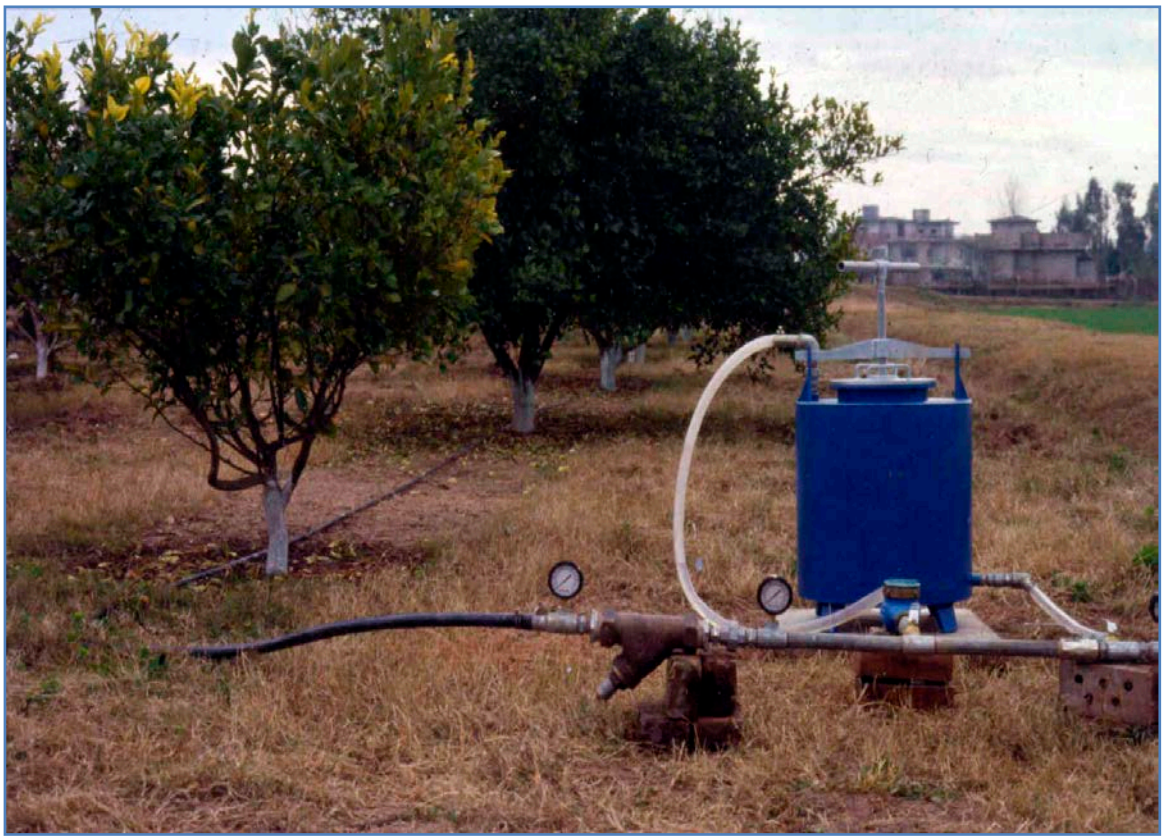


Figure 54: Hand-pump based drip irrigation

With trickle irrigation, water may be provided to the crop on a low-tension, high frequency basis, thereby creating a near optimal soil moisture environment. Because of the high irrigation frequencies, very high water use efficiencies are possible. Water productivity is defined as the crop yield per unit of applied water. Research indicates that water productivity can be increased by 50% or more by using drip irrigation as compared with surface irrigation systems.

8.2.7. Improving water productivity

Water productivity is the ultimate aim of irrigated agriculture, where water is at premium. The increased water productivity should ultimately improve profitability of irrigated agriculture. Water productivity is objective of irrigation manager and agricultural experts. Farmers are mainly interested in profitability of irrigated farming systems. Technological interventions related to water productivity are:

8.2.7.1. Adjusting cropping pattern with water availability

Cropping pattern of various canal commands need to be adjusted with availability of water by adopting promising crops and water efficient cropping patterns. Country has already experienced this technological change in post-Tarbela period when low delta crops were replaced with high-delta crops (fruits, vegetables, sugarcane, rice and cotton).

8.2.7.2. Tubewell irrigated agriculture

Increase in area under fruits and vegetables outside the Indus basin was mainly due to the development of tubewell irrigated agriculture, where farmers started installing deep tubewells and comparative advantage of micro-climate in different ecological zones was fully utilized. Introduction of high delta crops (apples, onions, vegetables) was primarily due to subsidy on

electric tariff in Balochistan and the market demand. Thus, there is a need to introduce protected agriculture to grow vegetables under controlled environment conditions.

8.2.7.3. Provincial crop improvement programme

Current programme is mainly focused on development of varieties, which are high yielding and disease-resistant. In future issue of water shortage or heat tolerance or salt tolerance has to be considered as an objective of varietal improvement.

8.2.7.4. Access to laser levelling and irrigation services

Private sector involvement is essential to provide services to farmers for laser levelling and micro-irrigation services.

8.2.7.5. Water use and precision irrigation

Precision irrigation is the key factor for raising water productivity because water is going to be scarce in future. Thus, furrow-bed system of planting may be adopted through pneumatic precision planters and furrow irrigation.

8.2.7.6. Design of new canals

Water development institutions are still designing and implementing new canal development projects in a way the country uses to build the irrigation infrastructure in the last two centuries. Alternative irrigation systems based on sprinkler and drip irrigation could have been considered for new canal development projects like Kachhi, Thal and Rainee. Thus there is a need to consider alternative approaches for developing new irrigation infrastructure in future, where farmers are given facility to use canal water for sprinkler and drip irrigation.

8.2.7.7. Canal water allocations

Current authorized water allocations of various canal commands are not in line with Et requirement or cropping pattern or intensity. Thus revision of canal water supply allocations is needed based on Et, cropping pattern, intensity and soil requirement and the saving of water thus made can be utilized by the province for developing new projects or allocating water to commands where gains in water productivity are possible.

8.2.7.8. Sugar crops

A research study was conducted for comparison of sugarcane and sugar beet in terms of crop water requirement and water productivity. Net crop water requirement of sugar beet (686 mm) is almost half of sugarcane (1200 mm). Water productivity of sugar beet is almost double of sugarcane having same quantity of sugar as marketable product.

8.2.7.9. Promising crops and cropping pattern

Promising crops and cropping patterns need to be ranked in terms of water productivity for the agro-climatic zones and districts within each zone. How to implement such promising cropping patterns is an issue to be addressed through policy support.

8.2.7.10. Non-water factors

Non-water factors affecting water productivity should also be considered while considering non-water inputs: (a) lack of availability of quality seed; (b) timely availability of other inputs; and (c) poor crop production practices.

8.3. Good practices for efficient use of water in irrigated agriculture

The elements of good practices for efficient water use in irrigated agriculture are presented in Figure 55.

Figure 55: Elements of good practices for efficient use of water in irrigated agriculture

9. WATER & SANITATION SERVICES – CASE OF WATER SUPPLY AND SANITATION, PESHAWAR, GOVERNMENT OF KHYBER PAKHTUNKHWA[17]

The current system of services for water supply and sanitation is not sustainable both in terms of quality of services and recovery of O&M cost, thus these services are performing under a subsidized environment and adequate water supply is not available to the water consumers. The climate change is going to have impacts on the availability of water for urban uses therefore sustainable services are needed. In addition, due to global rise in temperature and improved living conditions of urban households would result in increased water demand for domestic, commercial, landscape, and industrial purposes. Further, the Green Growth strategy in the province of Khyber Pakhtunkhwa would also require water for landscape. In future, the new water resources will come from saving of existing losses. Taking in to consideration the gravity of the issues related to water and sanitation, the Khyber Pakhtunkhwa government has established the first autonomous civic body of the country in Peshawar for providing water and sanitation services to people in urban areas. The new body, Water and Sanitation Services Peshawar (WSSP), is a public limited company owned by the government. The proposed company is responsible to provide services of water supply, solid waste management and sewerage and drainage in the urban areas. The company is registered under the Companies Ordinance 1984, with the Securities and Exchange Commission of Pakistan. The proposed civic body covers the urban areas in Municipal Committee Peshawar and Peshawar Development Authority. It also coordinates with the Cantonment Board Peshawar for providing services in some areas in cantonment. The existing 3,700 sanitation staff is working in WSSP on deputation without any layoffs. However, since there was hardly any managerial or professional staff available with the existing civic bodies, the same has been hired afresh on market based salaries to be organised into a modern organisational structure on performance based contracts.

9.1. The Context

The Government of Khyber Pakhtunkhwa is of the opinion that there is hardly any experience of private sector engagement in water supply and sanitation services, thus it is considered a public sector responsibility and domain. Furthermore, this sub-sector of water use is highly subsidised, thus private sector is not motivated to engage in water supply and sanitation services, except for bottled water business. The only recent experiment is of the Water and Sanitation Services Peshawar (WSSP), which was established in September 2014 under the Companies Ordinance, 1984 as public limited municipal utilities (water supply, sewage and solid waste) providing services as first of its kind in Pakistan. It covers 45 urban and 22 semi-urban Union Councils consolidating water and sanitation in municipal, cantonment, and semi-urban areas of Peshawar.[18] It is governed by an independent Board of Directors. Based on the experience of one year in WSSP, the GoKP intends to replicate it at all divisional headquarters.

Supported by the Water and Sanitation Programme of World Bank, and working closely with the PHEDs, and Local Government, WSSP has introduced a new model of municipal services provision through: (a) strengthening the institutions and water governance (such as through bringing private sector and elected representatives on the Board of Directors of WSSP) for

[17] The case study is based on the information available on the website of WSSP (http://wsspeshawar.org.pk/) and the personal discussions with the Executives of WSSP during January 2016.

[18] Water and Sanitation Services Peshawar (http://wsspeshawar.org.pk/).

service delivery; and (b) engaging citizens in the process, through adding water supply and sanitation under the Right to Services Act, and reaching out to communities through alternate media such as mobile phone applications.

It has also planned to use the solid waste for three products: waste for energy; refuse derived fuel; and composting. The income from these by-products will compensate the cost of service delivery, which currently is being subsidised by the KP government (around PKR 1.5 billion per annum). WSSP was successful to increase the recovery of water fee by 25% during 2015 while improving the water supply and sanitation services (SDGs Targets 6.1 and 11.b).

9.2. The WSSP

The Chief Executive of the WSSP in his message indicated, "Soon after the establishment of WSSP, one of the gigantic tasks was to immediately deliver, so as to ensure efficient and effective service delivery to the residents at their door step. Now, after almost one-and-half year of the establishment of WSSP, all the four zonal offices have been made operational with all the managerial team on board and necessary tools and equipment in pipeline. I would also extend my heartiest commendations to the 'WSSP Family' for their tiring and dedicated efforts in achieving the assigned goals in the areas of solid waste management, sanitation and drinking water supply services of Peshawar city"

The WSSP is a newly established urban utility in Peshawar as a public limited company, registered with the Securities Exchange Commission of Pakistan, (SECP), and fully owned by the Government of Khyber Pakhtunkhwa, under the companies Ordinance, 1984. It has become the first Water and Sanitation Company in Pakistan to have urban water and sanitation services delivered by ring fenced; fully autonomous, professionally managed and corporate governed utility. The geographical area of WSSP comprises of 45 urban and 22 peri-urban Union Councils.

The vision of the WSSP is "to bring Water and Sanitation Services of Peshawar according to international standards."

WSSP is a company, governed by the Board of Directors, headed by the Chief Executive Officer, supported by three General Managers and Chief Financial Officer. Four zonal offices have been established headed by Zonal Managers with a team of Managers and Assistant Managers for efficient delivery of civic services to consumers at doorstep.

The key functions of WSSP are planning, designing, construction and policy matters at the head office where all supporting units including HR, ICT, Media, Procurement, Finance and Projects are working to implement the core objectives of the organization.

9.2.1. Functions

The functions of the WSSP are: (a) ensuring clean drinking water supply; (b) solid waste management with international standards; (c) efficient drainage systems; (d) environment friendly disposal of solid waste; (e) collection, treatment and disposal of waste water; and (f) innovative initiatives e.g. conversion of wastes to energy.

A pilot project of door-to-door solid waste collection has been initiated in different parts of the Peshawar city with an aim to evaluate and assess the ground realities for replicating the same in rest of the provincial metropolis. So far, the door-to-door solid waste collection is highly appreciated by the residents and it's even convenient for WSSP to maintain streets as 'waste free'. The vehicles of WSSP reach the target area as per the pre-defined time with an

announcement for bringing out the solid waste. The announcement is warmly responded by the residents and the vehicle gets filled within no time (Figure 56).

Figure 56: Disposal of solid waste in Peshawar City

9.2.2. Achievements

- As a first important step toward improvement of civic services, the WSSP has identified a suitable site for the scientific disposal of solid waste of Peshawar, in Badaber Maryam Zai area for which the land acquisition has been processed on fast track.
- Provision of customer care services at the door step.
- Regular night-time cleaning of main roads and periodical washing.
- Door to door solid waste collection on pilot basis.
- The solid waste collection and disposal has been increased from 58 to 75% within 6 months.
- Up to 22000 meter rusted water pipe lines have been replaced till now
- WSSP with the collaboration of KPBOIT has floated an advertisement for waste to energy project where several national and international companies have shown interest
- Water quality tests are being carried out
- Customer baseline door to door survey with the assistance of World Bank conducted for planning of future projects.

The data and information regarding the solid waste generation, collection, and disposal are presented in Figures 27 to 59.

Figure 57: Average solid waste generation in Peshawar

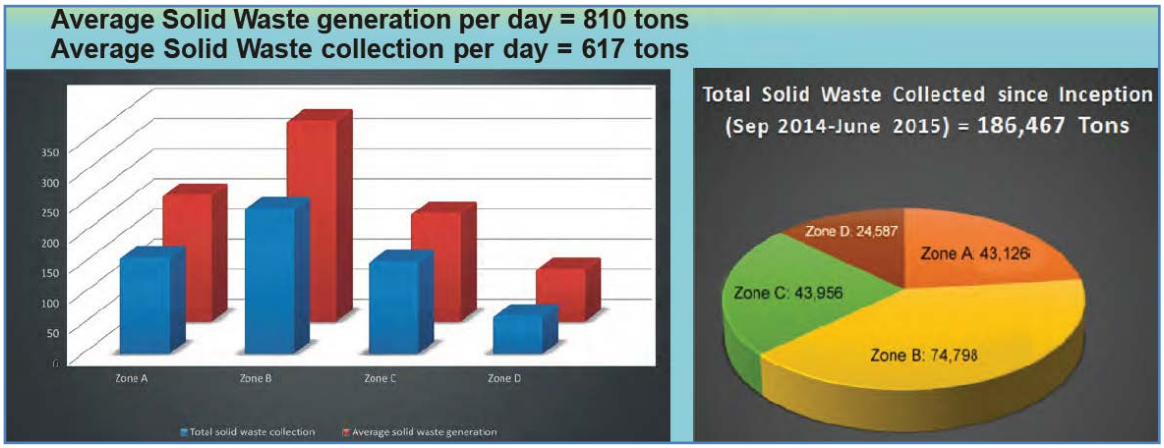


Figure 58: Total solid waste collected during cleaning operation and dumps cleaned

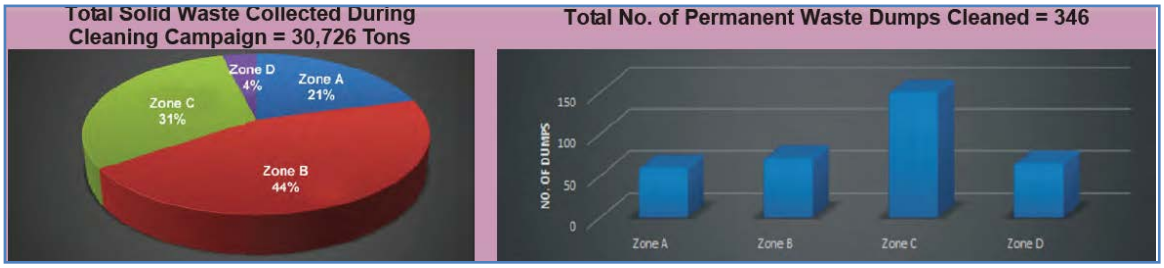


Figure 59: Complaints received and addresses in WSSP

9.2.3. Next steps – in pipeline and planned

9.2.3.1. Solid waste management

- GIS based solid waste management system
- Implementation of 3Rs strategy i.e. Reduce, Reuse and Recycle
- Introduction of door to door solid waste collection
- Disposal of environment friendly solid waste such as land filling, composting, waste to energy,
- Refuse Derived Fuel (RDF)
- Promotion of biodegradable bags.

9.2.3.2. Water supply management

- Water filtration plants.
- Water metering at both source and residential level.
- Installation of Auto Chlorinator at water source level.
- Effective water resource management by utilizing surface water after treatment.
- Replacement of existing water supply pipelines from GI pipes to HDPE pipes.
- Rehabilitation/Construction of overhead tanks.

9.2.3.3. Wastewater management

- Construction of wastewater treatment plant.
- Installation of new sewerage lines and introduction of PVC pipes.
- Prevention of drinking water mixing with sewerage/drainage carrier channels.
- Removal of encroachments on drains.

9.2.3.4. General

- Capacity building of staff and internships.
- IT initiatives using latest technology for real time decision making.
- Customer baseline survey at door step level for planning future projects.
- Company standard branding and marking on vehicles and personnel.
- Environmental Impact Assessment Study of land fill site.
- Collaboration with civil society organizations.
- Social mobilization, advocacy and behavior change communications.

9.2.4. Good practices for water supply, sanitation and solid waste management

The elements of good practices for water supply, sanitation, solid waste management and treatment of wastewater are presented in Figure 60.

Figure 60: Good practices for water supply, sanitation, solid waste and wastewater treatment

10. THARPARKAR DESERT – CASE OF DESERT PASTORALISM[19]

Tharparkar is the largest Desert located in the Sindh province, extending eastwards from irrigated plains on the left bank of River Indus towards the Indian states of Rajhistan and Gujrat, constituting the largest Desert in South Asia. The geographic area of greater Thar Desert is around 200000 km^2, of which 50000 kms^2 falls in Pakistan, covering the districts of Tharparkar, Mirpur Khas, Umerkot, Khairpur, Sukkar and Ghotki in Sindh Province. Total estimated population living in the districts of Thar Desert, according to 1998 census, is around 4.5 million. Most of the population in these districts live in settled cities and villages, however a significant number of people live deep inside the desert as a nomadic life and depends heavily on raring livestock for their livelihoods. The vegetation type can be classified as scattered trees and shrubs, mainly thorny and drought resistant species of plants and grasses. With rainfall, lush green grasses sprout all over the Desert providing rich source of forages. The desertification in Thar is quite old even beyond 4000 years. The climatic variability in terms of rainfall and droughts is extremely high even before the climate change, which will further worsen the situation of droughts and desertification. The more sustainable land use system of the Thar Desert is the range-livestock using the desert breeds, instead of agriculture using the groundwater, which is already scarce. Most of the groundwater is of brackish quality. Thus, the best practices for pastoralism are important to sustain the desert farming system and to have adaptation to the climate change in terms of drought.

10.1. The Context

In the arid regions of Pakistan, complexity, variability, and uncertainty characterize the grazing systems. Therefore, management practices are not simple. In desert rangelands, pastoral people respond quickly to available opportunities and challenges. The desert land pastoral communities usually practise an opportunistic form of resource utilization.

Livestock grazing practices in the Thal, Cholistan, Kohistan, and Tharparkar deserts are similar. The desert pastoral communities have ecologically adjusted themselves to utilize marginal areas which would otherwise not have been utilized. The nomadic system is an excellent way of converting scarce vegetation into animal protein. Most of the population is migratory. In early winter, people leave their villages in search of better grazing and migrate into irrigated areas. In the early monsoon season, when forage is abundant during July to November, they return to their villages and leave their animals to graze. Private livestock are allowed to graze state owned rangelands after paying nominal grazing fees. Cattle, sheep, goats, and camels graze the Tharparker rangelands. Despite good breeds of cattle, sheep, and goat, the economic status of nomads is poor (Figures 61 and 62).

[19] This section is based on the papers:

- CBD. 2010. *Pastoralism, Nature Conservation and Development: A Good Practice Guide*. Montreal: CBD.
- Mohammad, D. 2006. *Country Pasture and Forage Production Profile – Pakistan*. Islamabad: FAO.
- Farooq, U., M. Ahmad and I. Saeed. 2009. *Livestock Productivity in the Desert Ecologies of Pakistan: Setting the Development Priorities*. Islamabad: Pakistan Agricultural Research Council and Pakistan Institute of Development Economics.

Figure 61: Grazing of cows and bulls, and stock water facility in Thar Desert

Figure 62: Grazing of small ruminants in Thar and lush green forage after summer rains

10.2. Case study of marketing sustainable products

In the Thar Desert, camels have traditionally been indispensable for transportation and agricultural work. The local people have developed a sustainable system for managing camel breeding herds and making use of the desert without depleting groundwater resources. However, in recent years, the camel population has decreased significantly due to several reasons, including reduced demand for camels as work animals and reduction in grazing lands.

Figure 63: Camel grazing and stock water facility in Thar Desert

New ways of using camels are being developed. The camel breeders of the Thar Desert are now focusing efforts on the marketing of camel milk as a health food and beauty product. Camel milk contains enzymes with anti-bacterial and anti-viral properties, and also contains an insulin-like substance that reduces blood sugar levels in diabetes patients. Awareness-raising and education of consumers about the beneficial effects of camel milk and low calorie ice cream has established demand for camel milk.

The promotion of camel milk as a health food item, combined with training of camel breeders and organizational support, have improved the livelihood of pastoralists, while facilitating the maintenance of their traditional way of living.

10.2.1. Economic, financial and market-based instruments — emerging financial mechanisms

In addition to traditional markets, on-going international policy discussions may be yielding new opportunities for financial incentives for sustainable pastoralism. One such opportunity may arise from climate change mitigation, while on-going programmes for payments for ecosystem services represent another possible financial mechanism.

10.2.1.1. Carbon markets

Pastoralists are the custodians of more than 5000 million hectares of rangelands, which currently account for about 30% of the world's soil carbon stocks. Improved rangeland management, as a carbon sequestration strategy, has the potential to store up to 2000 tons of CO2 equivalent by 2030. In order to participate in the international carbon market, pastoralists will need to develop appropriate institutions to aggregate carbon assets, and develop and demonstrate improved water and land management techniques. At the same time, international

carbon markets will need to recognize the potential of carbon sequestration in rangelands and improve data and information on the carbon sequestration impacts of different land management techniques.

10.2.1.2. Payments for ecosystem services

Sustainable pastoralism maintains a number of critical ecosystem services. However, these services are typically not valued or traded on markets. Tools such as economic valuation and payments for ecosystem services can internalize the value of biodiversity and ecosystem services, and provide a strong economic incentive for conserving biodiversity. Payments for ecosystem services involve financial payments in proportion to the approximate value of the ecosystem services to those who manage their lands in a way that maintains the service (e.g. water quality, carbon storage). In order to implement effective payments for ecosystem services it is necessary to implement pricing policies for natural resources that are appropriate at the national level and are sensitive to social needs, and to establish market mechanisms to reduce the loss of ecosystem services in the most cost-effective way.

10.2.1.3. Other incentives

A number of other market-based incentives for sustainable pastoralism exist including niche marketing for pastoral products and the development of labelling and certification schemes such as for organic products or goods produced using sustainable means.

10.2.2. The elements of good pastoralism practice

Pastoral livelihoods are complex and diverse—they have the potential to be sustainable in areas prone to drought and relatively low fertility, in which few other livelihood options exist. However, in order to achieve sustainable development objectives, pastoralism must be based in a number of good practices, as illustrated in Figure 64.

Figure 64: The elements of good pastoralism practice in the Thar Desert

11. MANGROVE PLANTATIONS - CASE OF REHABILITATION OF COASTAL AREAS AND INDUS DELTA IN SINDH PROVINCE[20]

Mangroves are salt tolerant bush type trees, which grow in inter-tidal zones of tropical and subtropical areas, Indus river delta and along the coasts of Sindh and Balochistan. They are of great economic and environmental importance, especially in the context of climate change and expected rise in Sea levels. The mangrove trees have special aerial roots, which hold the trunk, leaves and foliage above the water surface. The aerial roots and tap roots can filter out the salt in the brackish water they grow in. Support roots grow directly into the mud to anchor the tree. Other roots wind up and down with the upward loops rising above the salt water level. Salt crystals taken up by the roots are stored in the leaves. The mangrove tree rids itself of the salt by shedding its leaves. The potential benefits of mangroves are normally assumed that the delta and seawater are either not polluted with sewage and industrial wastes or plantation is not degraded with human actions and infrastructure development. Therefore, one has to differentiate in theory and practice in a real-life situation where delta and coastal environments are now severely polluted. Therefore, mangrove plantation and rehabilitation of Indus delta and coast have to be seen in the context of polluted environment of mangrove ecology even before the climate change. An integrated approach is needed beyond plantations, where the regulations for environmental control of Indus delta and coastal areas are fully enforced. The Case study reflects the adaptations to climate change in terms of plantation of mangroves and/or rehabilitation of degraded mangrove areas.

11.1. Case of Mangrove plantations in Indus delta and Sindh coast by Sindh Department of Forestry

11.1.1. The context

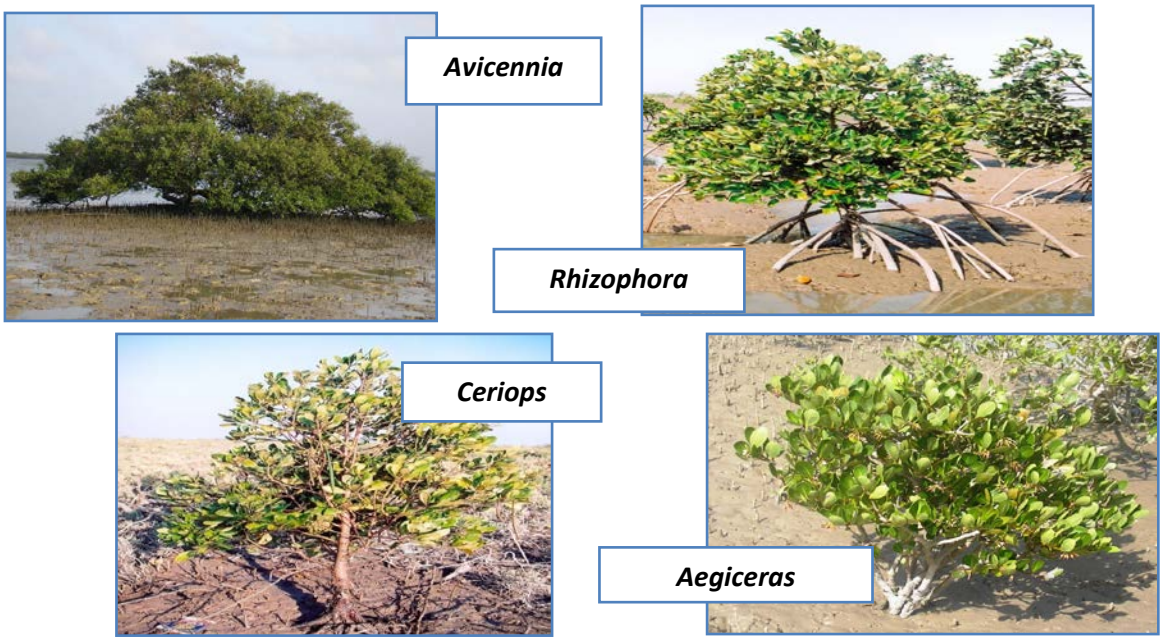
The Pakistan's coast is about 1050 km long extending from the Indian border on the east to the Iranian border in the west. The Exclusive Economic Zone (EEZ) of Pakistan is about 240000 km^2 with an additional continental shelf area of about 50000 km^2. As such, the total maritime zone of Pakistan is over 30% of the land area, as stated by the National Institute of Oceanography.

In the province of Sindh, mangroves of the Indus Delta are present in the districts of Thatta and Karachi. However deltaic area devoid of mangroves is also present in Badin district as well. Early records show eight species of mangroves exist along the delta. Presently only four are found, i.e., *Avicennia marina, Rhizophora mucronata, Aegiceras corniculatum* and *Ceriops tagal* (Figure 65).

[20] The section is based on the studies:

- Ahmad, S. 2013. *Coastal and Delta Ecosystem Management using Mangrove Plantations – A Critical Diagnostics*. Water for Pakistan Technical Series, Vol. (1), No. (2), IUCN, Islamabad, Pakistan.
- Sindh Forest department. 2014. *Sindh coastal community development Project*. Karachi: Government of Sindh.
- Oxfam International. 2009. *Climate Change Adaptation in Practice - Community-based Adaptation and Advocacy in Coastal Pakistan*. Islamabad: Oxfam International.
- UNEP. 2011. *Institution and Ecosystem Functions: The Case of Keti Bunder, Pakistan Ecosystem Services Economics (ESE)*. Working Paper Series. Division of Environmental Policy Implementation Paper No. 10. Environment for Development; by John M. Gowdy and Aneel Salman.

Figure 65: The mangrove species prevailing in the coastal areas and Indus delta



The protected forest plantations and area under these plantations is presented in terms of institutions managing these plantations like Sindh Forest Department, Sindh Board of Revenue, Port Qasim Authroity and Karachi Port Trust. Total area under mangrove plantation is around 606870 hectares of the planted area (Table 4). The map of the mangrove forest resources is presented in Figure 66.

Table 4: Protected forests plantation in the coastal areas and Indus delta by different organizations

Organization/Department	Area (Hectares)	Legal Status
Sindh Forest Department	280,470	Protected Forests (1958)
Sindh Board of Revenue	260000	Protected Forests (Nov. 2010)
Port Qasim Authority	64,400	Protected Forests (1958)
Karachi Port Trust	2000	Protected Forests (Nov. 2010)
Total	**606,870**	

All the four varieties currently available in the coastal areas and Indus delta are having different plant characteristics and are shown in (Figure 65). The mangrove plantations are presented under three density levels – sparse mangroves, medium mangroves and dense mangroves.

Figure 66: Mapping of mangrove forest resources in coastal and delta region using GIS by Department of Forest Sindh and SUPARCO

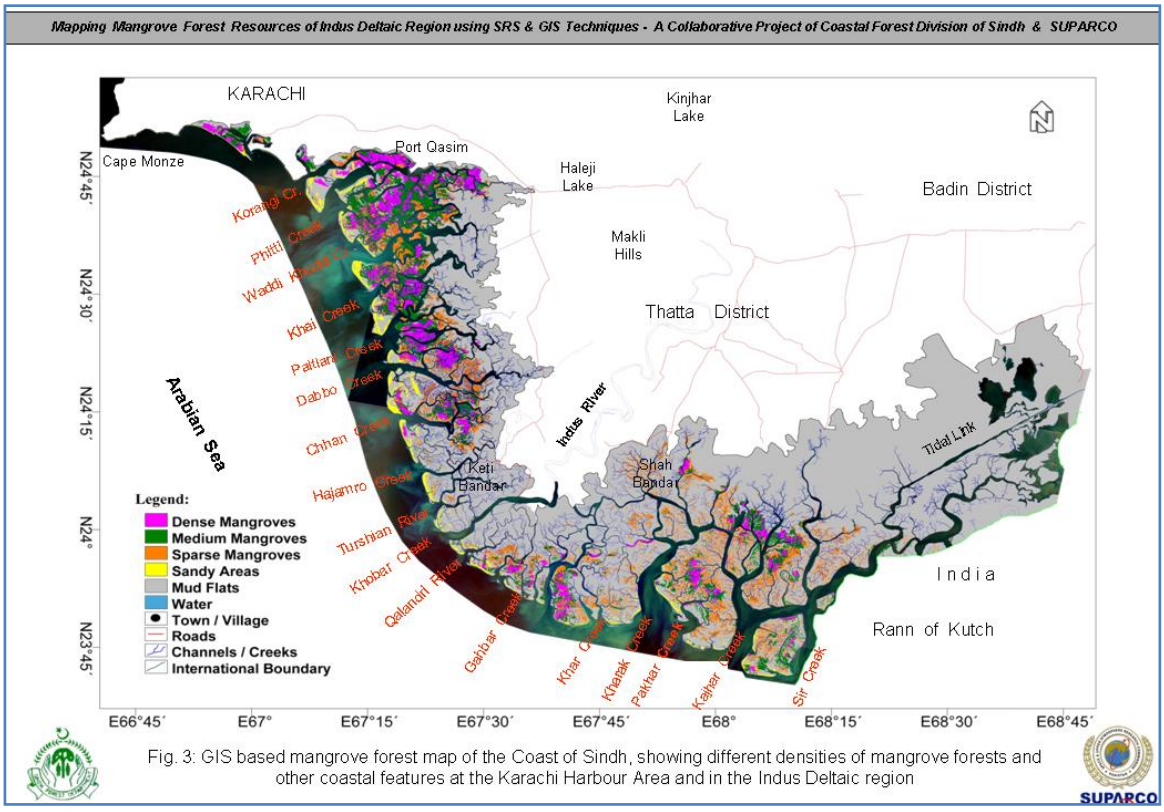


Fig. 3: GIS based mangrove forest map of the Coast of Sindh, showing different densities of mangrove forests and other coastal features at the Karachi Harbour Area and in the Indus Deltaic region

The area of reserve forest does not mean that the area is fully covered with mangrove plants. Currently, the productive Mangroves forests of Pakistan are estimated as 129000 hectares in the Indus delta and over 3000 hectors in Miani Hor, Kalmat Khor and Gwadar bay areas. Mangroves are natural habitat to a large number of insects, micro-organisms, birds, mammals as well as snakes. Mangrove areas act as physical breeding grounds and nurseries for fish, shrimp and crabs. During winters, many guest birds from north also come to breed here. The mangrove forests protect the coasts from cyclones and hurricanes. Mangroves slow the water flow, helping to protect the coastline and preventing erosion. They also reduce sedimentation in the sea. Over time, the roots can collect enough debris and mud to extend the edge of the coastline further out. Hundreds of thousands of people directly or indirectly depend on the mangrove ecosystem for living. For centuries they have been used by human being for getting fuel wood and fodders for animals. Over the last five decades, mangrove forests in Pakistan have been subject to over-exploitation due to massive population pressure, and are deteriorating fast in the quantity as well as quality.

Without realizing the global significance, mangroves are being cut mercilessly. Near urban areas, mangroves are cleared for infrastructure development. Reduced water flow in the Indus River, sixth largest river in the world, after the completion of the Indus Basin Project is causing damage to mangrove forests and ecosystem.

Mangroves need to be managed and conserved. Concerned agencies, government departments, and NGOs have already started taking steps and visible efforts are being made in this regards. Department of Forestry, Sindh, IUCN and WWF are the most active organizations in this regard. New mangrove nurseries near Karachi, projects to grow more forests, mobilization of

communities through awareness for livelihood and by persuading them to take responsibility for conserving mangroves are the current activities under different programmes.

To stop the degradation of mangrove areas, the World Bank, in 1999, had suggested that the mangroves forests in Pakistan be protected by declaring the Arabian Sea coastal areas a national park. This sort of sustainable solution will have important effects on the environment in the longer run. Until this is done the field activities with continued increase in disposal of pollutants will not lead us anywhere.

The Sindh Forest Department is now actively involved on a large scale for the plantation of mangroves and rehabilitation of the Indus delta and coastal areas. IUCN, WWF, Oxfam International, and PSO are also contributing in this regard through implementing pilot activities. The case study is based on the success made in developing adaptations for mangrove plantation to address the issues of climate change and Sea level rise.

The Sindh Forest Department has initiated a development project entitled "Sindh Coastal Community Development Project" with a goal to improve the sustainable livelihood of the poor inhabitants of eight coastal talukas of Thatta and Badin districts. There are three specific objectives to: (a) diversify household income generation options and access to service in ways sustainable to the fragile ecosystem; (b) improve coastal zone management by stabilizing environmental degradation, protecting coastal areas from accelerated coastal erosion; and (c) strengthen institutional capabilities for coastal zone planning and development and management of fisheries resource. The focus of the project is to increase income, improve access to public services and capacity of local communities (who are mostly agriculturalists and fishermen) to manage the natural resource base on which they live. The Project also strives to improve conditions of coastal forestry and fisheries, as well as improve coastal zone management. The cross cutting themes being addressed are gender, climate change and DRR. The outcome of the project is "improved, ecologically sustainable earnings and access to public services for poor residents of the eight coastal Talukas (sub-districts) of Thatta and Badin Districts.

11.1.2. Coastal resources and sources of livelihood

Fish is the major coastal resource and provide livelihood to the local fishermen. The deltaic networks of creeks are a major breeding area for commercially important coastal fisheries that include shrimps, finfish, crabs, etc. with average export value of US $110 million per annum. The shrimp is a major resource for the export purposes but due to the pollution of pollutants (sewage and industrial effluents) the quality of fish produced is not safe for export purposes as the countries importing shrimps are now having very stringent quality control parameters.

The average annual catch of shrimps from Sindh coast is 27,500 tons whereas; from the Balochistan coast it is only 800 tons. Although the potential is much higher in the Balochistan coast if this resource is developed for export purposes, as the pollutants inflow to the coastal area is almost non-existent. The annual finfish harvest in Sindh is 231000 tons as compared with 103000 tons from the Balochistan coast. The economic importance of mangroves is significant in terms of coastal resources and management of the coast. The mangrove plantations are important supplier of nutrients and oxygen, if the inflow of pollutants is controlled. Otherwise in areas around the Karachi coast the sewage and industrial effluents are now at a level where even fish production is not possible.

The mangroves plantation also provides environment for nurseries for many species of fish and shrimp. The mangrove plants also help to stabilize shorelines and reduce coastal erosion, which

is quite common in the coastal areas. The mangrove plantations also protect coastal areas from storm damage and act as carbon sinks. Their contribution in terms of adaptation to the impacts of climate change is immense for managing the impacts of Sea level rise, hurricanes and cyclones.

The IUCN studied that one hectare of properly managed mangrove plantation can yield products with annual benefit of: (a) 100 kg of Fish, 25 kg of Shrimp and 15 kg of Crab meat. In monetary terms the contribution is: (a) direct valuation of USD 37500/ha from fishery and forestry products; and (b) indirect valuation of USD 1700/ha from protective services. Even if the actual contribution is half of the estimated this is much higher than any other rural livelihood – agriculture, livestock, etc. (Figure 67).

Figure 67: Fish products produced in the deltaic creeks

The human population in and around mangrove forests on the coast of Pakistan is estimated to be about 1.2 million. Nearly 900000 reside in the Indus Delta and 300000 on the Balochistan coast. The number of households is estimated to be about 140000 in the Indus Delta and 30000 on the Balochistan coast. The coastal population of about 210000 is directly dependent on coastal resources and are illustrated as under:

- Around 90% of the households in the coastal communities rely on fishing and other fisheries related activities as highlighted by Oxfam-GB
- A diagnostic survey of Indus delta conducted by the Oxfam-GB indicated that 25% of households depend on Mangrove wood for cooking and heating purposes. Each household uses 173 kg of mangrove wood per month giving a total annual consumption of 2.08 tons per household (Figure 68).
- The survey conducted by Oxfam-GB indicated that there are total of 6000 camels and 3,200 cattle in the coastal area and they are using the resources of ecosystems and consume about 19500 tons of grasses and 67000 tons of leaves annually (Figure 69).

The following development projects for the plantation of mangroves undertaken by various Department of the Sindh Government are:

- Planting of Mangroves over 5000 hectares in the lands under the control of Board of Revenue and Port Qasim
- Planting of Mangroves over 8000 hectares in Keti Bandar and Shah Bandar areas with the assistance of Asian Development Bank
- A project on climate change and Sea intrusion effects is under implementation. Spanning over 7 years, mangrove plantations for 50000 hectares would be developed by

the Sindh Forest Department. A Joint project with IUCN on mangroves is also in progress in Keti Bundar and Kharo Chan areas.

Figure 68: Use of mangrove wood for fuel purposes in coastal areas

Figure 69: Camel browsing mangroves leaves

11.1.3. Initiatives undertaken by Government of Sindh

The activities and achievements related to mangrove plantation are presented in Table 5. This covers plantation made on black mudflats, high lying mudflats and natural regeneration. The total area covered is around 50000 hectares. Three species of mangroves are used for plantation.

Other achievements are presented as under:

- Sindh Forest Department is the pioneer in the management of Mangroves in the Sindh Coast and Indus delta. The most important achievement is the re-introduction of an

extinct tree species from Indus delta, *Rhizophora mucronata*. The species have been successfully established to an extent that enough seed is available for planting operations from the local sources. Now the trial planting of near extinction species *Ceriops tagal* is also underway

- Socio-economic survey and studies on species survival rates are also being undertaken
- The Sindh Forest Department is actively collaborating with IUCN-Pakistan, WWF-Pakistan and National Rural Support Progarmme
- Developed methodology for the demonstration plots and techniques for raising nursery of mangroves including publicity and print materials for awareness and capacity building
- The July 2009 record set for planting 541,176 *Rhizophora* plants

Table 5: Activity and achievements of mangrove plantations in coastal area and Indus delta

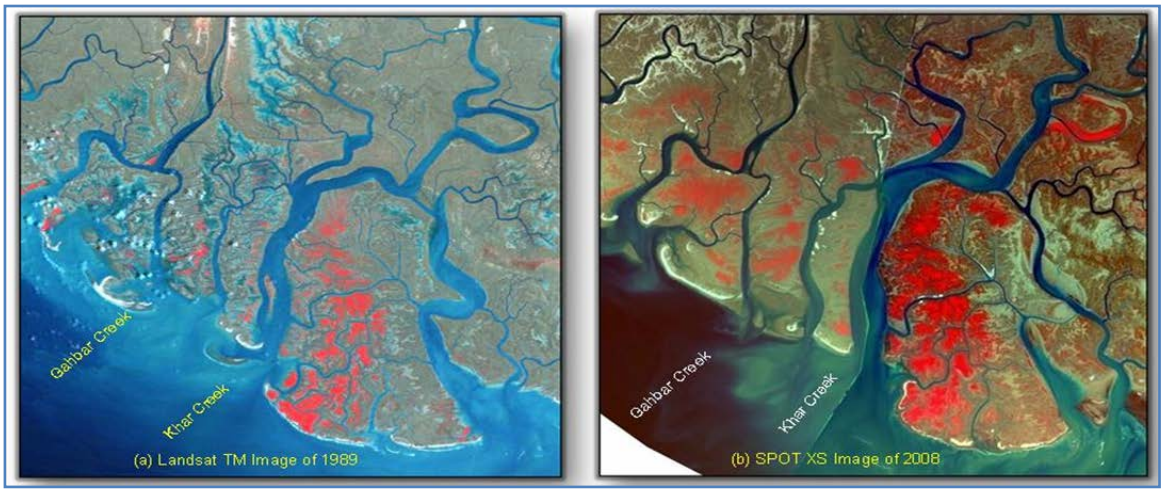
Activity	Achievement
Planting on Blank Mudflats	31,400 ha
Planting on High Lying Mudflats	4000 ha
Planting to Assist Natural Regeneration	15,632 ha
Total	**50032 ha**
Planted Species	*Avincennia marina; Rhizophora mucronata* and *Ceriops tagal*

Evident changes in mangrove coverage are presented in Figure 70.

11.1.3.1. Mangrove restoration activities

The mangrove restoration activities have been undertaken in the coastal areas. However, the work done by the IUCN, WWF and NRSP demands cost-benefit analysis so that cost-effective technique can be developed for the restoration of mangrove plantation areas. The current cost per plant is much higher than the country can afford for large-scale action, which is designed to have impacts (Figure 70).

Figure 70: Mapping of mangrove forest resources of Indus deltaic region at Gahbar Creek using SRS and GIS techniques



Source: Sindh Forest Department and SUPARCO

11.1.3.2. Community participation

The community participation is essential in restoration of mangrove areas and plantation of mangroves. Until and unless community ownership and involvement is ensured the interventions made could not be sustained. Community also has to be made aware that mangroves are necessary for the livelihood and the mangrove ecosystem has to be sustained including plugging of entry of sewage and industrial effluents, so that the ecosystem is supportive for the sustainability of the coastal resources including fisheries (Figures 71 and 72).

Figure 71: Mangrove restoration activities undertaken in the coastal area and Indus delta

Figure 72: Community participation for plantation of mangroves in coastal area and Indus delta

11.1.3.3. Awareness raising

In the Pilot initiatives awareness campaigns were arranged to further strengthen the local community and their organizations so that these communities owned these interventions fully. So that component of cost sharing by the community can be included in the future projects. Without cost sharing it is not possible to have full ownership of the community.

11.1.3.4. Community protection model

Sindh Forest Department is protecting newly planted mangrove forests through a family unit by paying a monthly sum of PKR 6000/family for every 60 hectares of plantation. This arrangement helps in effective protection, conflict resolution and offers direct financing option to coastal communities. In future such plantations would be a source of carbon credit earnings for poor

communities of the coastal belt. However, there is a need to ensure some cost sharing by the communities so that full ownership can be ensured by the community.

- Overcutting of mangrove trees by the communities and local mafias as a source of fuel wood and input to the industrial boilers
- Pollution of coastal areas due to inflow of sewage and industrial effluents, which is major issue of polluting the coastal areas
- Clearing of mangroves for developing additional lands by the mafia which is involved in housing and other infrastructure
- Lack of awareness in the civil society, coastal community and urban metropolitans and industrial units for not polluting the coastal and delta areas and indiscriminate cutting of mangroves
- Shortage of required freshwater and silt depositions from River Indus have enhanced salinity levels in the delta
- Sea intrusion and erosion in the delta caused by sea level rise
- Grazing and browsing by camels

11.1.3.5. Plantation raised in Keti Bandar

The plantations made in Keti Bandar are presented in Figure 73.

Figure 73: Plantation if Keti Bandar and Shah Bandar in coastal area of Sindh coast

11.2. Case of climate change adaptation in practice - community-based adaptation and advocacy Pilot in coastal Pakistan by Oxfam International and Oxfam-GB Pakistan

11.2.1. The context

The expected climate change is going to have impacts on the Indus delta and coastal area in terms of rise in air temperature, more frequent and severe droughts and floods, hurricanes and cyclones. In the recent past, the coastal areas of Sindh and Balochistan coast have experiences increased frequency and intensity of rainfall and cyclones.

The impacts are now evident in terms of reduced freshwater fish and prawn catches from intrusion of saline water due to reduced flows during the droughts prevailing in the Indus river system. This also resulted in reduced agricultural production and degradation of land due to

intrusion of saline water. The impacts on reduced livelihood also resulted in seasonal out-migration due to reduced productivity.

The objective of the Pilot Initiatives undertaken by the Oxfam International in collaboration Oxfam-GB in Pakistan with an objective to "enhance the capacity of coastal/rural communities for the adaptation to the climate change".

The Machoo Mallah, 61 years old fisherman in the Sindh coastal area expressed that "20 to 30 years ago we had many sources of drinking water, there were sweet water lakes and well water. Now that has all become brackish and we can no longer use them. The only source left for us and our livestock is the canal water, which is not clean as all the factories are throwing their waste there. This is making our children sick."

Another 60 years old fisherman, Bhaagi, stated that "In the old days (30 years ago), the land here used to be under cultivation, we grew wheat, tomatoes and watermelon. But now because of repeated flooding and heavy rains, and the cyclones, the seawater has intruded making the water brackish and leaving the land degraded, we can no longer grow anything."

One of the major challenge the project faced is to encourage increased gender equality that will enable women to have equal participation in project activities including a strong voice in decision-making. This would demand empowerment of women so that they are mainstreamed and hd full benefit from the activities to be undertaken in the Pilot.

11.2.2. Expected lessons

It is expected that the pilot project will demonstrate how existing resources can be modified to adapt successfully to climate change. By proving the case for employing different approaches to community education in the management of land and human resources, local communities will be empowered to take control of their lives and livelihoods.

The coastal district was home to one of the world's earliest settled civilisations and also became one of the largest tomato producing regions in Asia. Now this area is waterlogged and can barely sustain agriculture.

Extreme weather events have persistently affected coastal areas of Badin, often provoking humanitarian disaster. Now the prospect of global warming in delta regions brings added problems, including salt-water intrusion of crops and the increased risk of extreme climatic events. These problems are having tremendous impacts on areas already affected by severe environmental strain as a result of human activity.

In 2008, Oxfam GB in Pakistan undertook community-based research to better understand the implications of climate change for communities living in the Badin coastal region of Pakistan. This research was initiated following discussions between programme staff and partners about the Inter-governmental Panel on Climate Change's (IPCC) 2007 reports, as well as the UNDP Human Development report of the same year.

This case study is an analysis of a pilot climate change adaptation project designed by Oxfam GB in response to the research.

The Project area covers two villages; Mohammad Ali Chandio and Village Khamoon Mullah, in the Union Council of Bhugra Memon in Tehsil and District Badin. This is home to some of the most poverty-affected people in Pakistan. Communities in the area have seen profound and bewildering changes to their environment. Mismanagement of natural resources has

contributed to their plight. Large areas of what was productive land are waterlogged, salinized, or parched. Seawater intrusion is now a fact of life and coastal habitats, essential for the well being of marine resources and livelihoods, are under enormous stress.

The Project has been divided into two components; adaptation measures and advocacy activities. The community adaptation component provided benefits directly to the most vulnerable communities. Advocacy activities supported the activities on the ground by initiating dialogue that was aimed at policy change to help coastal communities adapt to climatic changes.

11.2.3. Activities undertaken in pilot area

• Expansion and lining of existing water ponds including installation of solar-powered pumps	Existing water ponds were strengthened through linings and the size was enhanced to increase yield and water collection for drinking purposes. Solar panel pumps were installed to pump water from these ponds into the agricultural fields. This had dual benefits for the community and the environment; more reliable source of water for agriculture and low-carbon alternative for pumping of water. Furthermore, the O&M cost of these systems is quite low or minimal, therefore farmers can sustain this type of solar-powered irrigated farming system and their profitability of farming was increased at least by 25% form that of the diesel-operated pumping systems.
• Construction of embankments using pressed earthwork	More than 20 villages were protected from the surges and sea intrusion at surface level. On the landside of the embankment, fields were protected from degradation by planting flood tolerant plants (trees and shrubs).
• Rehabilitation of degraded land and use of appropriate crop varieties	Over 25 acres of land was rehabilitated using organic and biological processes for agricultural use.
• Advocacy	Seminars, workshops, co-ordination and meetings with legislative bodies were carried out with proactive participation of communities.
• Disaster preparedness activities	Activities like training, simulations and drills, as well as the construction of flood emergency shelters were undertaken.

11.2.4. Project highlights

The Pilot initiative project was aimed to improve the capacity and sustainability of existing resources, empowering affected communities with their own adaptive capacity for the foreseeable future. The Pilot project helped to mobilise human resources more effectively and capacitated communities so that they are better prepared to deal both with extreme and unpredictable events as well as stresses that are set to increase over time. Despite of a lack of technical knowledge and information, the communities know their areas well, and with the provision of required technical assistance, they were able to recognise problem areas and acted

accordingly. Knowledge of their land and climatic patterns combined with the technical know-how have enabled communities to be better prepared for the future and fight prevailing poverty through adaptation to climatic changes.

11.2.5. Lessons learned

The project demonstrated that how existing resources can be modified to adapt successfully to climate change. By proving the case for employing different approaches to community education in the management of land and human resources, local communities were empowered to take control of their lives and livelihoods. The interventions undertaken in regard of shift from diesel-operated prime-movers to solar-powered prime movers helped to communities to reduce or minimize the O&M cost of pumping system resulted in reduced cost of production and increase in profitability.

12. DISASTERS AND COMMUNITY RESILIENCE – CASE OF CBDRM IN CHITRAL DISTRICT OF KHYBER PAKHTUNKHWA[21]

Chitral is a district of the province of Khyber Pakhtunkhwa. Historians and anthropologists have described Chitral as the most romantic, captivating, and enchanting place tugged into the mighty Hindukush mountains in the extreme northwest of Pakistan with the indigenous people proud of their centuries-old unique culture and traditions. The weather of Chitral is extremely harsh and cold in the winter and pleasant in the summer. Temperatures in summer range between 25 and 40°C while in the winters it plunges below freezing. In the year 1969, Chitral was merged into the Malakand division of the Khyber Pakhtunkhwa as a settled district. The district is facing acute climatic variability and with the climate change, the extreme events of floods and droughts are getting severe. Especially the floods during the summer season July to September are now more frequent and severe. The GLOF phenomenon has further worsen the impacts of flash floods.

12.1. CBDRM Pilot in Chitral by UNDP and Flood of 2015

The historical profile of natural disasters in Chitral is stuffed with major natural events with varying degrees of loss to human, infrastructure, and household belongings. On the 16th of July 2015, riverine and flash floods along with Glacial Lake Outburst Flood (GLOF) events of high to very High intensity hit different areas of Chitral sub-division and Mastuj Sub-division of Chitral District, which were caused by heavy rains (Figure 74). The phenomenon started on 15 July 2015 and was periodically reported till 2 August 2015. In district Chitral, the 2015 flood have caused substantial damage and losses in the productive, public infrastructure and social services sectors, including private and community assets. The floods washed away livestock, destroyed buildings, houses and assets, and damaged roads, bridges, irrigation infrastructure, water supply schemes, crops, school and health facilities.

In response to the 2015 flood, the district administration of Chitral district promptly took the leadership in the disaster relief and emergency response operations under the umbrella of provincial disaster management authority (PDMA) of Khyber Pakhtunkhwa. In doing so, the district disaster management unit (DDMU) has successfully engaged and collaborated with a number of important stakeholders: Chitral Scouts (Pakistan Army), the Pakistan Red Crescent Society (PRCS), National and International Organizations those operationally present in the district since last many years.

In the aftermath of the widespread devastation and based on the initial different reports, the humanitarian organizations, e.g., Malteser International (MI), Handicap International (HI), Islamic Relief (IR) and HelpAge International (HAI), realised to conduct a joint need assessment to assess and analyze the multi-sectoral damages. UNDP also worked in the district in association with other partners including the DDMU and PDMA. As UNDP has completed the CBDRM project prior to the onset of the July 2015 floods, they also had an opportunity to

[21] This section has benefited from:

- UNDP Pakistan. 2015. *CBDRM in the Chitral Valley*. Islamabad: UNDP.
- UNDP, ISDR and ITC. 2010. *Local Governments and Disaster Risk Reduction. Good Practices and Lessons Learned*. Geneva: ISDR.
- NDMA, German Cooperation, GIZ, Government of KP. 2013. *Building resilience by learning. The DRM Handbook. A learning experience of the DRM Model, Mansehra, Pakistan*.

evaluate the impacts of the floods and the response of the communities and the DDMU in the Pilot area.

UNDP's CBDRM Pilot Project was implemented from October 2014 to April 2015 in five hazard-prone districts in three provinces. Working with local implementing partners across 30 communities in Chitral and Lower Dir districts of Khyber-Pakhtunkhwa province, Ziarat and Jaffarabad districts of Balochistan province, and Tharparkar of Sindh province, UNDP helped communities identify their specific hazards, risks, vulnerabilities, and capacity gaps. With guidance from UNDP and its partners, the communities developed risk maps, preparedness and response plans. Community members were also trained in basic First Aid and Search and Rescue skills and were provided basic response equipment.

Figure 74: Flood 2015 in Chitral District of Khyber Pakhtunkhwa

Alongside this community initiative, UNDP held consultative meetings with line departments at the district and provincial levels, to help ensure that provincial and district DRR planning and community-level preparedness measures were aligned. District officials were deeply involved in risk assessment exercises, and developed strategies for mainstreaming DRR in various sectors.

In Chitral district, UNDP implemented CBDRM in seven communities distributed across three Union Councils. A total 286 men and 272 women from the communities were trained in CBDRM and other DRM skills, and learned how to apply them to their own situations.

In Chitral, as elsewhere in the Pilot Project areas, a participatory assessment approach was used to drawn up village DRR plans, and Village Disaster Management Committees (VDMCs) were established.

The intervention sites where the UNDP Pilot project introduced the interventions are: Uchusht, Mughlandeh, Goldoor, Balach, Singoor, Danin and Jughoor. Shortly after the end of the CBDRM pilot, Chitral district faced a serious natural disaster. In July 2015, floods engulfed many areas of the districts as a combined outcome of multiple hazards (glacial lake outburst or GLOF, cloud outburst, flash floods and heavy downpour), poor infrastructure and housing construction, the changing climate, and the understudied relationships between all of these. By the end of July, the flood disaster had caused 32 fatalities, and extensive damage to buildings and infrastructure. Access to many areas was cut off, hindering timely response. There were also secondary impacts, such as lack of drinking water, medicine and food, delayed clearance of debris and the displacement of more than 300000 people.

Though flooding has historically been rare in the affected areas of Chitral district, the district and provincial governments have been aware of the potential impacts of GLOF and climate change. In recent monsoon contingency planning, the National and Provincial Disaster Risk Management Authorities (NDMA and PDMAs) have sought to implement preparedness and mitigation measures in the district. Given the loss and extensive damage caused by the floods, however, this crisis underlines the importance of addressing the underlying causes of disasters, including inequality, poverty and risk perception, and of integrating DRR and climate change adaption into planning.

12.1.1. Impact of CBDRM interventions in Chitral by UNDP

The July floods offered an opportunity to assess the impacts of the CBDRM interventions including the functionality of VDMCs; the relevance and effectiveness of coordination mechanisms, and the network of volunteers in each village. In short, this was an opportunity to evaluate the effectiveness of each community's disaster preparedness strategy.

The VDMCs in all seven communities were instrumental in monitoring the situation and coordinating preparedness, rescue and relief with their District Disaster Management Unit (DDMU). The VDMCs activated and coordinated the volunteer networks formed in each village during an earlier phase of CBDRM.

An assessment of each village as reported by the UNDP is based on the discussions with the chairperson of each of the VDMC.

12.1.1.1. Mughlandeh

The water supply schemes were damaged by the floods but no significant damage to houses or other assets was reported. Trained male VDMC members were mobilized during the floods and the VDMC chairperson coordinated with the district government for relief work. VDMC members met with the Chief Minister of the Khyber Pakhtunkhwa during his visit to Chitral and shared with him the VDMC's contingency plan, the importance of capacity-building for VDMC members, and of the need for better rescue equipment.

12.1.1.2. Uchusht

While drinking and irrigation water supplies were suspended, no other major damage occurred. Male members of the VDMC hold monthly meetings and have regular contact with the DDMU. The VDMC members were in contact with the district government; and through their volunteer network, made community members aware of the possibility and importance of evacuation. In the event, during the floods, trained VDMC volunteers helped to evacuate people residing in the flood-affected areas to shelters despite the hindrance to access posed by blocked roads.

12.1.1.3. Danin

No flood damage was reported in this village. Since the implementation of CBDRM, male members of the VDMC have met monthly, but women have not been able to attend due to cultural constraints, while male volunteers have passed information on to their female counterparts. VDMC members coordinated with FOCUS Humanitarian Pakistan, an NGO working in the area. The Chairman of the VDMC actively engaged with district government and was in regular contact with DDMO during the floods. The VDMC volunteers offered their services to DDMO on a voluntary basis until the army was deployed in the affected areas.

12.1.1.4. Goldoor

Goldoor was affected by the Chitral Gol hill torrent which occurred due to GLOF. Parts of the village were inundated thrice during the last two weeks of July and 10 houses were damaged. VDMC members actively disseminated early warnings through religious facilities and helped evacuate people to safe areas. Vulnerable groups comprising women, children, and the elderly of about 200–250 households were evacuated to elevated sites during times of high flow. The VDMC facilitated evacuation thrice during July 2015. VDMC members gathered community members trained in 'search and rescue' and designed interventions in their own villages. As in other villages, trained community women were not allowed to participate due to cultural constraints.

12.1.1.5. Balach

No damage was reported in Balach. The VDMC was established with gender equality in mind, and comprised 30 trained male and female members. The male members of the VDMC registered as volunteers with a registered village organization, the Humnasheen Village Society-Balach. After the end of the CBDRM initiative, the VDMC continued to coordinate activities, and a network of volunteers trained in 'search and rescue' remains active for potential interventions.

12.1.1.6. Singhoor

High level flooding in upper Chitral, caused the water level in the Chitral River to rise and inflict damage on its banks. On 18th July 2015 it was reported that the rising water would damage a power plant north of Singhoor. This was on the Eid holiday, and immediately after the morning prayers the VDMC mobilized community members to construct a wall on the river bank to protect the power plant. Throughout the three days of Eid, volunteers continued to work to prepare for floods. The VDMC members evacuated families living near the riverbank and after the end of the crisis, submitted a resolution to the DDMO for DRM volunteering activities.

12.1.1.7. Jughor

The VDMC here issued an early warning of floods to people living near the banks of the Chitral Gol hill torrent through existing networks of mosques and individual contacts. They mobilized community members to construct temporary embankments using logs, and evacuated at-risk residents to safe places. Since the first phase of CBDRM, the VDMC has organized four monthly meetings to inform village people on disaster risk reduction.

12.1.2. Lessons learned and way forward

The lines of communication established between UNDP, the VDMCs, DDMU and the PDMA during the floods demonstrates how a coordination mechanism between vulnerable communities and the authorities can be established. This is one of the main achievements of the first phase of the CBDRM project.

The recent floods in CBDRM villages were not disastrous, but the activation of volunteers at the initiative of each VDMC chairperson demonstrates the importance of active village disaster management committees. The regular VDMC meetings after their establishment in the first phase showed the strength of the initial activation, and the continuation of these regular meetings, especially after disasters, as initiated and planned by VDMC chairpersons, highlighted the commitment of VDMCs to strengthen their own coordination mechanisms.

VDMCs have stated their intent to organize further coordination meetings including all members, women, to improve emergency preparedness through more active and wider participation throughout the process of DRM.

The two key challenges, frequently mentioned by VDMC chairpersons, are: (a) the inadequacy of search and response equipment; and (b) the difficulty of involving women volunteers during disasters, especially in rescue activities for remote communities.

12.2. Case of institution-building and capacity building for local governments by ERRA, Pakistan

12.2.1. The context

The October 8th 2005 Earthquake was the most devastating to have ever affected Pakistan. The Government of Pakistan quickly established national agencies for relief and reconstruction. Since inception, the Earthquake Reconstruction and Rehabilitation Authority (ERRA) has been integrating DRM into its community preparedness work, with results such as a guidebook for mainstreaming DRR into development, hazard indication maps for the districts of Mansehra and Muzaffarabad, and Disaster Management Committees and Emergency Response Teams being established in 112 Union Councils across the two districts.

12.2.2. The initiative

The earthquake that struck the northern part of Pakistan on 8 October 2005 was the most devastating disaster to have ever affected the nation. The earthquake claimed over 73000 lives, injured over 128000, rendered 2.8 million people homeless and affected 3.5 million people in an area of 30000 km^2 (Figure 75).

The response from the Government, civil society, and international donors was swift. The Government established a Federal Relief Commission (FRC) and an ERRA to support medium to long-term recovery and reconstruction efforts. ERRA integrated DRR in all its reconstruction work, and initiated a DRM programme for community preparedness in the affected districts.

In its reconstruction work, ERRA follows a DRM approach of risk reduction, risk avoidance, risk transfer and risk management. Since its founding in October 2005, ERRA has worked on strengthening community-based disaster preparedness in line with Priority Five of the Hyogo Framework for Action. This initiative has worked directly with local governments to build institutional and community preparedness through new Union Council Disaster Management Committees and Union Council Emergency Response Teams.

The initiative aims to reduce disaster risk by increasing the disaster resilience of local authorities and communities. This would require due consideration of disaster risks in the planning processes of local authorities and communities, increased capacity to respond to and prepare for disasters, and more ability to adapt to changing risk factors such as climate change and environmental degradation.

UN Office for DRR and UNDP Pakistan fielded an advisor to ERRA in February 2007 to ensure that DRR was part of the post-earthquake reconstruction process. The advisor organized awareness workshops on DRR for ERRA senior management, for key partners and stakeholders, compiled guidelines based on internationally accepted literature (UNISDR, ProVention, ADPC, Tearfund UK etc.) for mainstreaming DRR. ERRA also prepared a more specific project for DRR, particularly preparedness, in the earthquake-affected areas. The objectives of the project have been to:

- Improve disaster preparedness at the community level and in the relevant government departments as well as NGOs and other key stakeholders through distilling best practices and strengthening information dissemination. This was to be achieved through the introduction and promotion of disaster preparedness practices in the affected districts of Mansehra and Muzaffarabad, as a pilot.
- Strengthen community-based DRR in the earthquake-affected districts, employing a gender-sensitive approach. This was to result in enhanced community participation through community sensitization, mobilization, and organization. A functional CBDRM system would improve stakeholder capacity to respond to the current challenges and those in the future.
- As such, the programme aimed to support safe lives and livelihood of local communities and reduce the negative impact of disasters in the area.

Figure 75: Meeting with the community members and training sessions

The project has been implemented through a team comprising:

- Project Director (DRR Advisor), a DRR expert, GIS expert and a Programme Officer with the capacity for coordinating mainstreaming all located at ERRA Islamabad.
- In the districts, a District Project Coordinator-cum-Trainer, assisted by a team of Master Trainers. The Master Trainers team have the desired capability and skill to train communities in DRM, including hazard awareness, basic search and rescue, emergency first aid, fire fighting, evacuation and early recovery and reconstruction.

- An international expert, provided on the basis of need, to guide and backstop the first phase of programme implementation in the affected areas. The Project was launched in March 2008 and its first phase (two districts) was completed on 30 June 2009. The project is funded by the World Bank, and receives technical support from UNDP Pakistan.

12.2.3. Results

12.2.3.1. Mainstreaming, planning and risk mapping

Mainstreaming and planning workshops were held for ERRA senior management and development planners from the district governments in Khyber Pakhtunkhwa and Azad Jammu and Kashmir. The workshops produced guidelines for integrating DRR in future ERRA reconstruction planning.

This initiative will be followed up with the production of district level hazard index maps for the area. A risk that clearly needs to be mapped is the potential impact of climate change and environmental degradation on landslides and flash floods. Slope-instability was also aggravated by the 2005 earthquake. Maps were developed for debris flow, snow avalanche, slope instability, possible valley blockage (remote hazard), flood and simplified physical risk, after capturing exposure data. A historic event register was an important part of district level hazard indication mapping.

As well as mapping, the following activities have been initiated to mainstream DRR in existing institutions:

- A series of consultative meetings and workshops were carried out with government line departments, district administration, and representatives of CBOs, NGOs, and INGOs in both districts.
- Planning processes in local government units have been identified for spatially relevant development activities and planning.
- A mainstreaming guidebook for local authorities has been compiled.
- Capacity-building for key government officials (planners) in DRR is being carried out, especially in reading hazard maps and related products, assessing disaster risks and planning for DRR.

12.2.3.2. Community based disaster risk management

CBDRM is an integral component of the ERRA DRM project. The specific objectives are to:

- Raise the capacity of the local authorities and communities to manage risks and to respond to disasters.
- Make tools available (training tools, equipment and stockpiles) to local authorities (district, tehsil, Union Council level) for DRR in general, and effective response in particular.
- Build the capacity of local authorities (District Disaster Management Authorities, established under the NDMA) to form volunteer teams (response teams) for responding in times of crisis.
- Strengthen awareness of government officials about various aspects of DRR. Union Council level institution building and community responders' trainings have been completed in the two districts.

12.2.3.3. The status of trained volunteers

Union Councils of Muzaffarabad district in Pakistan Administered Kashmir and Mansehra district of Khyber Pakhtunkhwa, have been trained, galvanized, and equipped with response tools and equipment. District level officials have also been trained and sensitized, and hazard indication mapping was completed. At community level there has been a substantial improvement in preparedness capacity and institutional knowledge, which has decreased disaster vulnerability.

12.2.3.4. Institution building and skills training

The primary local government authority for people is the Union Council, which is the fifth tier of government. Union Councils are an elected authority led by the Union Nazim. Institution building was carried out in 112 Union Councils by establishing Union Council Disaster Management Committees and Union Council Emergency Response Teams. Through these committees and teams at Union Council level there has been basic skills training in: hazard and risk mapping, hazard safety, response planning, coordination, basic search and rescue, first aid, fire -fighting, public information, communication and disaster management. This new community response and preparedness structure is directly linked to the district level institutional framework.

12.2.3.5. Increasing response capacity

Stockpiles of emergency relief and response items like tents, blankets, disc cutters and shovels at the District and Union council level have been established.

12.2.3.6. Increasing planning capacity

Disaster response plans were developed for each community with strong involvement and input of all concerned sectors. This helped the community and the local authority in effective and timely response to any disaster situation.

12.2.4. The good practices

- The project mainstreamed DRR into district development processes with technical support from national and international partners. Workshops developed guidelines for integrating DRR in future development planning, and in national reconstruction planning. A concise mainstreaming guidebook has been compiled for district planning officials.
- Particular attention was paid to the Hyogo Framework Priorities 3 and 5 in carrying out preparedness and capacity building for local communities and district-level officials.
- Priority 2 of the Hyogo Framework was addressed by hazard and risk mapping, which identified, assessed and monitored disaster risks, and enhanced early warning.

12.2.5. Role of local government

District-level and community-level local governments and institutions bear the responsibility in this case for frontline implementation of resilient reconstruction, and for improving preparedness. The line-departments of district-level local governments have been delegated the responsibility for the reconstruction of earthquake affected areas. These local governments have contributed to developing specific DRR guidelines for each sector. They also have full ownership of the ERRA DRM programme, mobilize volunteers to attend trainings, and provide secure sites for storing emergency equipment. The Union Council level local institutions in the earthquake-affected areas started with a very low capacity for disaster preparedness.

However, due to the earthquake's devastation of people's lives, the process of organizing the Disaster Management Committees and Emergency Response Teams was met with an overwhelmingly positive response from residents, Union Councils, and district-level local governments.

12.3. Case of community response to a real time event

On 15^{h} January 2009, a fire accidentally broke out in a shop in Ghari Habibullah Town, Tehsil Balakot, Mansehra District, Khyber Pakhtunkhwa. A shopkeeper was filling a customer's gas cylinder and there was a lit gas-heater nearby. After filling the cylinder, as he flung the hose without turning off the valve, the gas caught fire from the heater.

The fire quickly spread to engulf six nearby shops. Dr Muneer Qureshi, one of the participants in the Union Council Disaster Management Committee training and Team Leader of the Information & Communication team of the Union Council Emergency Response Team, informed his team members. Emergency Response Team members reached the spot within 15 minutes and controlled the fire. Ms. Yasrab from Muzaffarabad stated her experience after completing a training in CBDRM, which is reproduced as under:

> *I lost my two daughters age 3 and 6 in the earthquake in Muzaffarabad. Time has passed and life continues after the tragedy. I have taken ERRA's CBDRM Course because, although I could not save my daughters and all the other children struck by the earthquake on that fateful day, on this course I have now received training to help people in emergencies. We are trained to handle disastrous situations, how to locate and treat the injured. Had we known all these life-saving skills before 8th October 2005, we could have helped many people and the loss would have been much less.*

12.3.1. Lessons learned

Mainstreaming DRR in the development process is a slow and sustained process. In situations where there is an almost total lack of skilled human resources in DRM, and a lack of awareness about the subject among decision-makers, obstacles and delays should be expected. To combat this following points are important:

- Project planning processes must be participatory and transparent
- A multi-sectoral approach is crucial to project success
- There must be close coordination with local government to ensure ownership and sustainability of a project. Moreover, despite the damage they cause, major disasters provide an opportunity for shifting paradigms in communities, governments and funding agencies from disaster relief to preparedness.

12.3.2. Success factors

The two essential success factors are elaborated as under:

12.3.2.1. Sensitization

The destruction of 2005 earthquake elicited a strong response from donors, national institutions, and from communities who survived the devastation. Donors have been proactive in supporting DRM programmes, although this support obviously cannot be relied on long-term. Commitment has been clear at a national, local, and community levels. Governments at the district and local levels have been unusually responsive, and now understand the cost of being unprepared for hazards. This has resulted in an enabling environment for DRR.

12.3.2.2. Effective organizational structure

The ERRA has an effective presence on the ground in the affected areas in Khyber Pakhtunkhwa and Azad Jammu and Kashmir through a network of programme offices and other infrastructure. This has been helpful in coordination and implementation.

12.3.3. Potential for replication

ERRA has implemented this project in a limited geographical area, considering the limitations in local capacity. Due care has been taken to closely collaborate with the NDMA so it can be more easily replicated in most parts of the country; at least in physically similar regions. A positive evaluation by an international expert has been carried out, and based on this there has been agreement in principle by NDMA to extend the programme to other earthquake-affected areas in Pakistan. With regard to different contexts, by moulding the methodology and strategies to suit specific local conditions, the project can be considered for replication. It comprises three basic elements of DRM: assessment of hazards, mainstreaming into development processes and enhancing communities' capacities. Therefore, the overall approach can, by and large, meet the preparedness needs of any community anywhere in the world.

13. KAREZ SYSTEM IN BALOCHISTAN – CASE OF AN INDIGENOUS, ENERGY EFFICIENT, SUSTAINABLE AND SOCIALLY JUST SYSTEM OF WATER SUPPLY[22]

Karez system or Qanat is a very old technology indigenous to Iran and Pakistan's Balochistan. The technology is energy efficient and sustainable because the abstraction is in line with the groundwater level, therefore excessive abstraction of groundwater is not possible. Furthermore, in the Karez system water for livestock and human are available free of cost to all segments of the rural society. However, for irrigation purposes it is available to those who have shared the cost while constructing the system and the owner of the land from where the Karez main water channel is passing through. Therefore, it is a socially just system, where allocations are made for domestic water, stock water and irrigation purposes, without looking at various segments of the rural society. These systems sustained over millenniums where the hydrologic equilibrium was maintained. The equitable availability of water for domestic and stock water is a good indicator of equality among the rural society. The introduction of tubewells in the last 40 years resulted in lowering of water table and rapid depletion of aquifers and farmers are now installing tubewells beyond a depth of 300 m. This affected the Karez system adversely to the extent that in few river basins the damage is irreversible. However, in localities where the damage to the Karez system is reversible, rehabilitation can be made easily. Furthermore, modernization of the Karez system is possible to eliminate the water delivery losses by lining the earthen channels using PVC pipes. This will also reduce the need for skilled manpower for cleaning the Karez channels. Currently, there is a realization to restore the feasible Karezes where the damage is reversible. The impacts of climate change and climatic variability are much less on the Karez system; therefore, it is the best adaptation for the arid mountainous region.

13.1. Modernizing Karez Irrigation System – A Case of Qila Iskan Khan, Pishin

13.1.1. The context

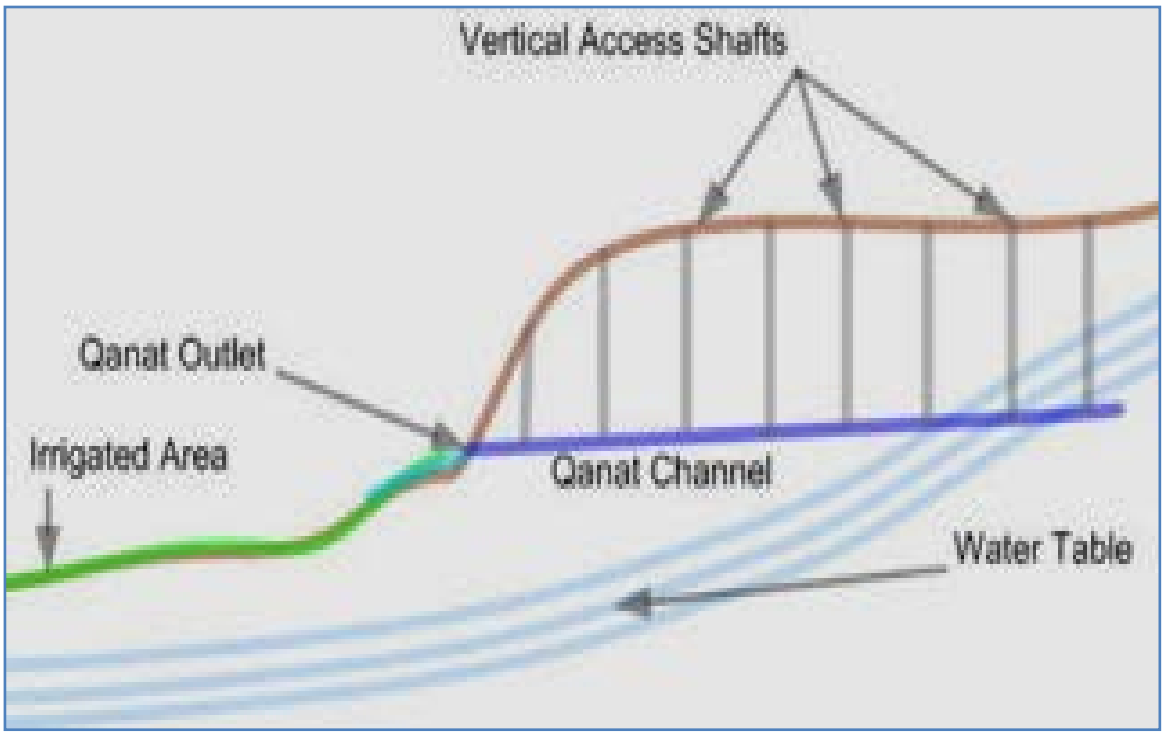
In the beginning of the 1st millennium BC, under the Persian influence, the Balochistan farmers started constructing elaborate Karez systems for harvesting groundwater in the arid river basins of Balochistan (Figure 76). Karez tunnels were hand-dug, just large enough to fit the person while digging. Along the length of a Qanat, which can be several Kms, vertical shafts were sunk at intervals of 20 to 30 m to remove excavated material and to provide ventilation and access for maintenance. The main Karez tunnel sloped gently down from pre-mountainous alluvial fans to an outlet at the command area through a water channel to distribute water for irrigation. These amazing structures allowed farmers to have sustainable farming even during persistent droughts when surface water is not available. Many Karez systems are still in use stretching from Pajgoor on the south to Zoab in the North and Chagai in the west.

[22] The section is based on the papers and personal discussions held with the BRSP staff engaged in the Karez Pilot Project:

- Ahmad, S. 2007. *Karez – A Cultural Heritage of Natural and Agricultural Sectors and an Interminable System of Harvesting Groundwater in Balochistan*. Vol. (3), No. (14), TA-4560 (PAK), Quetta, Pakistan.
- IUCN. 2015. *Establishment of Integrated Water Resource Management, Qila Iskan Khan, Pishin – Completion Report*. Quetta: IUCN.
- Personal discussions with the Staff of BRSP, Quetta, Balochistan, and unpublished material in terms of pictures and brochures.

The components of Karez system (Qanats) are: (a) infiltration part of the tunnel; (b) water conveyance part of the tunnel; (c) open channel; (d) vertical shafts; (e) small storage pond; (f) command area; (g) sand and gravel; (h) layers of soil; and (i) groundwater surface.

Figure 76: General Schematic for a Karez system



Source: http://www.answers.com/main/Record2?a=NR&url=http://commons.wikimedia.org/wiki/Image:Qanat-3.jpg.

There are significant advantages to Karez system water delivery system including: (a) putting the majority of the channel underground reduces water loss from seepage and evaporation; (b) since the system is fed entirely by gravity, the need for pumps is eliminated; and (c) it exploits groundwater as a renewable resource. The third benefit will be discussed further while discussing sustainability of the Karez system.

The rate of flow of water in a Karez system is controlled by the level of the water table. Thus a Karez system can't cause significant drawdown in an aquifer because its flow varies directly with the subsurface water supply. When properly maintained, a Karez system is a sustainable system that provides water indefinitely. The self-limiting feature of a Karez system, however, is also its biggest drawback when compared to the range of technologies available today.

In Balochistan during 1904, there were 496 Karez systems and 1803 springs in the administered area and were important source for irrigated agriculture, as the two-third of the cropped area in Quetta and Pishin Districts was irrigated by Karezes and springs (Gazetteer of Balochistan). In reality, the number of Karez systems were much more if the un-administered area is also included.

Before discussing further details it may be interesting to quote a statement from the Gazetteer of Makran District "the importance attached to irrigation from Karez systems may be gauged from the Baloch saying: A mosque should be demolished if it obstructs the course of Karez (Makran District Gazetteer, P-187, published 1906, reprinted 1986)".

It is believed that in Balochistan, until 1970, around 3000 Karez systems were in use, providing water supply to towns and for irrigated agriculture. Afterwards, with the availability of electric power and tubewell technology, the Karez systems started declining and over one-third are still functioning or in a situation of reversible damages, constituting as one of the major source of groundwater in certain areas of Balochistan.

The internationally sponsored irrigation surveys in the 1970s viewed the Karez as traditional and outdated system not amenable to updating. The transition to dugwells and tubewells was encouraged, lowering the water-table and decreasing the flow of water in the Karez. This was a very short-sighted view of looking at this indigenous and energy efficient technology. However, after 46 years, now there is adequate awareness and understanding that in areas where the Karez systems are still in a situation of reversible damage, this technology may be rehabilitated with interventions looking at the concepts of modernization.

During the drought period (1998-06), the survey conducted by the Irrigation and Power Department (IPD) revealed a different set of Karez distribution in the province. The highest concentration of Karez systems is found in Qila Abdullah (243) followed by Panjgur (188), Turbat (138), Pishin (123), Qila Saifullah (122), Zoab (70), Ziarat (67), Chagai (56) and Lorali (50). Rest of the districts each is having less than 50 Karez systems. The sample survey includes documentation of 1146 Karez systems in Balochistan.

The survey conducted by the IPD for 1146 Karez systems in Balochistan was used to develop probability distribution for the command area. There is wide variation in command area as 90% schemes are having command area of <100 ha, 75% schemes <70 ha, 50% <35 ha and 10% schemes <8 ha. The command area is quite high for 25% schemes.

There is wide variation in Karez discharge in Balochistan as 90% schemes are having discharge of <57 litres/sec, 75% schemes <50 litres/second, 50% schemes <21 litres/sec and 10% schemes <7 litres/sec. Thus, the discharge of 25% of the schemes is very high. The groundwater abstractions from electric-operated tubewells are 2.025 billion m^3, the diesel-operated tubewells/wells abstract 0.712 billion m^3 and dugwells abstraction is 0.427 billion m^3 per annum. About 294 perennial schemes (Karez and springs) provide 0.862 billion m^3 of groundwater annually.

Probability analysis was made for assessment of water allowance of Karez (lps/100 ha) to evaluate the potential of irrigated agriculture. The distribution indicated that hardly 6% schemes are suffering from scarcity of water having water allowance of <28 lps/100 ha. Around 75% schemes are having water allowance of >56 lps/100 ha (equivalent to 8 cusecs/1000 acres considered as very high water allowance in canal irrigated areas). In the command area of the Karez system, where water allowance is high, the water productivity is normally low. The scarcity of water always results in the efficient use of water.

Almost equal area is irrigated by canals and groundwater in Balochistan. A total of 0.595 million ha are irrigated through three main sources Karez/springs (140001 ha), dugwells (80976 ha) and tubewells (373774 ha) corresponding to 24, 14 and 62% irrigated area, respectively. Thus, roughly one-fourth of the area irrigated by groundwater is contributed by Karez and springs. There are four main kinds of abstractions: (a) electric-operated deep tubewells; (b) diesel-operated tubewells/dugwells (shallow to medium); and (c) dug-bore wells.

In the Karez system, underground galleries were manually dug, just large enough to fit the person while digging. Along the length of a Karez, which can be several kms, vertical wells were dug at intervals of 20 to 30 m to remove excavated material and to provide ventilation and access for maintenance. The Karez underground gallery sloped gently down from pre-

mountainous alluvial fans to an outlet at the command area. These structures allowed farmers to have sustainable irrigation and water supply system.

IUCN implemented a project financed by the Royal Government of Netherlands entitled "Balochistan Partnerships for Sustainable Development (BPSD)" in the six districts of Balochistan. The programme is focused on conservation and sustainable management of natural resources, rangeland improvement and rehabilitation, water resource development and management of other natural resources contributing towards maintenance of ecosystem. The IUCN hired an Advisor to prepare an Action Plan for the IWRM Pilots to be implemented in Balochistan under the BPSD. An approach of river basin, sub-basin or catchment was suggested for the implementation of the IWRM Pilots. Karez system was considered as a unit system covering the watershed, groundwater transportation system, command area and water storage tanks.

Figure 77: A view of the Pilot target area of Qila Iskan Khan

The Qila Iskan Khan Karez was selected for the implementation of the IWRM Pilot with an objective to modernize the existing Karez system. The Pilot Target Area is located near Pishin, known as Qila Iskan Khan situated at the base of alluvial fan of Toba Kakari Range (Figure 78). The village, where farmers were enjoying a high standard of living prior to the drought, suffered due to excessive mining of groundwater in the Pishin-Lora basin, because the water availability in the Karez system was reduced to the extent that it affected the irrigated agriculture in the command area. Around 1400 acres of the command area were uncultivated due to water scarcity. Majority of the residents migrated to the nearby town of Pishin in the search of alternate livelihoods.

The target Karez system did not dry entirely during the drought but the drought did squeeze the saturated zones at the upstream of the Karez system and reduced the flow of mother well from 4 cusecs to merely 0.5 cusecs or even less in summer. The Karez Pilot was designed to assist the community towards sustainable management of water and efficient irrigated agriculture in the command area. Under the Pilot, it was envisaged that in addition to rejuvenation of the Karez system, the downstream main distribution network would be remodeled using PVC pipes and additional storage was developed using geo-membrane liners for eliminating the seepage losses.

13.1.2. Identification of interventions and community mobilization

Topography and other salient features of the Pilot area are given in Figure 78. The village is located 18 km north-east of Pishin city (30o 43' 54"N; 67 o 09' 18" (e) at an elevation of 5368 feet above mean sea level. The village and its associated command area is like a delta between the two major waterways namely Tore Murgha and Barshore Manda. Both these seasonal rivers join at the downstream side, of the western boundary of village and empty their major volume of waters in Bund Khushdil Khan, while the remaining flows downstream of Bund Khushdil Khan.

Figure 78: Pilot area topography and other features at Qila Iskan Khan

The village comprises of 80 households of which many live below poverty line. The youth who have attended some schooling are jobless and have nothing to do. Since the village lies at base of an alluvial fan of Toba Kakari range, therefore, its soils are shallow and the underlying layers are either very coarse or gravelly in texture. The entire top strata is underlain on a thick rocky layer that not only works as hard pan but also restricts deep percolation of water; hence it can be said with maximum probability that groundwater recharge at this location of the alluvial fan does not happen. However, the rocky layer is also a blessing and disguise, as it prevents penetration of drilling tools in it, hence all the efforts made by the villagers to install new tubewells have failed. Thus the only source of drinking water and irrigation is a Karez; which draws its water from a mother well dug at the toe hill of Kakari Range situated some 3 km

upstream of the village. The water drawn from the mother well then travels almost 3 km in a tunnel, which also acts as infiltration gallery during rains, bring water to a day light point. Apart from difficulty in the installation of tubewell; the old agreement of the villagers of Iskan Khan with the downstream villagers refrains farmers in the installation of tubewell in the vicinity of the Karez. This mutual agreement also restricts any sort of rehabilitation work in the mother well and delivery tunnel. In this way the community is left with only one option of maintaining the Karez as a sole source of water. The major source of income is agriculture and livestock and some of the village members work in different government departments in the Pishin city because they do not earn enough to meet the needs of the families. The children and women are the most affected segment of the local population because of marginalized income of their families.

This ironic situation of water scarcity and increasing poverty in the village was first noticed by a group of village activists who noted with concern the depletion of the Karez system and decrease in cultivated area due to shortage of water. These activists joined hand and organized themselves into a 'Community Organization' to address issues related to the Karez system. The community organization since its establishment have only been able to line only 3000 rft of the main channel which is 8000 ft long; and have carried out cleaning of channels, the infiltration gallery and the mother well. But the community and the organization were so deprived that they could not carryout additional work due to their limitations in terms of financial resources.

Figure 79: The condition of the water delivery channel at Qila Iskan Khan

The community managed to visit the local office of IUCN in Pishin and the representatives of the community organization narrated their problem and shared their ideas with the IUCN staff and

concluded that the impacts of droughts in terms of reduced water supply can be taken care by lining the water delivery system using PVC pipes to eliminate the delivery losses (Figure 80). The past research studies conducted by the national research and development agencies indicated that the water delivery losses in an earthen system are significant. The idea of lining the delivery channel using PVC pipes was first introduced by the Advisor on IWRM and implemented by the IUCN Field Team.

The IUCN Field Team and the Community Organization jointly designed the following interventions to modernize the Iskan Khan Karez system:

- Rehabilitation of main channel 628 m downstream of daylight point using 14" PVC pressure pipe.
- Construction of main water storage tank 34 x 34 x 1.23 m, lined with geo-membrane liner of 0.25 mm thickness.
- Construction of secondary water storage tank 50 x 20 x 1.2 m, lined with geo-membrane liner of 0.25 mm thickness.
- Cleaning of channel and mother well of Karez system (1 km).
- Construction of micro-catchments for storage of runoff and infiltration in to the soil.
- Construction of two washing pads for women.

After the identification and design of interventions, the cost of the Pilot intervention was estimated, which comes to PKR 2.09 million. The IUCN contributed 79% and the rest 21% was contributed by the community.

13.1.3. Execution of interventions

13.1.3.1. Rehabilitation of main channel

The critical intervention designed for the Pilot was the improvement in the critical sections of the main water channel streaming out of the Karez using PVC B-Class pressure pipe of 14-inch diameter. Prior to the installation of the PVC pipes, the watercourse was excavated by the community using labour and machinery. Thereafter, the pipe was laid by the community members. Furthermore, the community also contributed around 21% in the total cost of the Pilot, which was used for the procurement of materials like PVC Pipes and accessories. In addition to above-mentioned intervention, the community took the liberty of constructing a manhole at the daylight point of the Karez system. Community also provided labour in the implementation of number of interventions, indicating the demand and urgency for the implementation of the Pilot (Figure 80).

Figure 80: Improvement and lining of main water channel in the Iskan Khan Pilot

13.1.3.2. Cleaning of main channel upstream of daylight point

After the installation of PVC pipe line, the community carried out the cleaning work of the main channel at the upstream of the day light point (Figure 81). Though, it was not a hard task but the zeal of the community made it possible in merely 13 days. Resultantly, a total of 1200 m of main channel was cleaned by the community. IUCN provided 50% cost of labour whereby the remaining 50% cost was borne by the community itself.

Figure 81: Cleaning of main channel upstream of daylight point

13.1.3.3. Construction of main water storage tank lined with geo-membrane

A 34 x 34 x 1.2 m water storage tank was constructed in 3 steps. Firstly, the selected site was cleaned by the community and after that the earthwork was completed as per design. The community deployed labour and tractor for construction of the water storage tank. Once the earthwork was complete the community under the direct supervision of IUCN engineers lined the bed and banks of the water storage tank with geo-membrane. The lined section was then covered with one-feet depth of sieved soil to protect the geo-membrane from the sunlight and vandalism. The job-was completed in 14 working days using 12 labour and 32 hours of tractor use (Figure 82).

13.1.3.4. Rehabilitation of existing water storage tank

An existing 50 x 20 x 1 m water storage tanks was also lined with geo-membrane but prior to lining of the tank with geo-membrane on its banks and bed, the water storage tank was cleaned by the community and the side banks were re-constructed using tractor as per design. After completion of earthwork, geo-membrane film was spread on the bed and banks of the water storage tank. The entire lining was then covered with soil of one-feet depth to protect the lining from sunlight and other possible failure threats (Figure 82).

Figure 82: Rehabilitation of water storage tanks at the Iskan Khan Pilot

13.1.3.5. Construction of washing pads for women

In order to facilitate the women of the village to wash their clothes two washing pads (2 x 1 m) were constructed at two locations near the main water channel.

13.1.3.6. Construction of micro catchments for water storage in situ and plantation

Around 80 micro-catchments were constructed using labour and tractor at the upstream side of the Karez with a view to offset the runoff during rains and ensure groundwater recharge in the catchment area along with increase in vegetation. The quantity was much less therefore the impact could not be assessed. In addition, the retaining walls were also constructed for the management of floodwater and runoff (Figure 83).

13.1.4. Immediate payback of the interventions

Soon after completion of the Pilot, an effort was made to assess the immediate impacts of the interventions and the benefits gained by the community, which are illustrated as under:

- The discharge of the Karez system after the improvement of the main water delivery channel was almost doubled. This was largely contributed by the reduction in water

delivery losses through eliminating these losses from the PVC pipes and cleaning of the underground water galleries.

- The water storage capacity for irrigation purposes has been increased from 432 m^3 to 2000 m^3, which is almost an increase of five-folds.
- Around 30 acres of additional land has been brought under wheat due to increased supplies of water.
- The community has started land development in the pilot area using their own resources, in order to make use of increased quantities of water available after the completion of the interventions in the Pilot for Iskan Khan Karez.

Figure 83: Micro-catchments and retaining walls in the Iskan Khan Pilot

13.2. A case of Landai Karez, District, Qila Abdullah by BRSP

13.2.1. The context

Qila Abdullah is a bordering district of Balochistan that links border with Afghanistan. It is the smallest district in terms of geographical area of 3,293 kms^2, with 4 Tehsils and 25 Union Councils. The climate of the district is from arid to hyper-arid due to low and erratic rainfall and higher evapotranspiration. The population of the district is involved largely in groundwater irrigation for irrigated agriculture and livestock.

Landai Karez is one of the villages falls in the Union Council of Purana Chaman in the west of Chaman city at a distance of 4 km from Chaman town, district Qila Abdullah. The village population is around 1520 and the economy largely depends on minor businesses, livestock and agriculture farming. The agriculture is dependent on groundwater irrigation. The water table is lowering at a rapid rate and farmers are now installing tubewells at a depth of 700-900 feet.

The last persistent drought has adverse impacts on the poor segment of the rural population, irrigated agriculture and livestock. On the other hand, Afghan refugee influx and presence has also over-burdened the limited natural resources in terms of vegetation and water. In the consequence, deforestation, over grazing, over abstraction of groundwater through tubewells and 13 Karezes. This enforced the inhabitants to migrate to the nearby urban areas. The farmers have also lost their source of livelihood due to lack of water during drought. The Forest department strived and planted forest trees that were compatible to the existing environment but the survival rate was extremely low due to lack of ownership by the communities.

Balochistan Rural Support Program, BRSP, vision is that people participation is essential for sustainable development. This is achieved through building the mutual trust; understanding that there are mutual rights and responsibilities related to accountability and transparency; observing the principle of benefitting the community at large, rather than individuals, and ensuring that the poorest and most vulnerable people are equally included in the programming.

13.2.2. Pilot interventions

The BRSP initiated a Pilot Project in the district of Qila Abullah entitled "Social cohesion and stabilization through sustainable water management in refugee affected hosting areas" funded by the Foreign Office, Republic of Germany. In this project BRSP carried out RSP's approach of three-tiers social mobilization process fostering community organizations, village organizations and then federated these into local support organizations at the level of Union Council.

13.2.2.1. Social mobilization and plantation in watershed

After constant social mobilization process BRSP constituted 12 community organizations in Landai Karez and then federated these into village organization repressing 60% population of the village. Under the guidance of the watershed consultant, BRSP through effective coordination with the relevant stakeholders (public-sector departments, private-sector organizations, community institutions, political and tribal leaders) at the provincial and district levels, provided inputs to the BRSP in terms of area, plants species and plantation management. The frequency of meetings with the forest department, IUCN, district management and community organizations was on weekly basis and with other institutions on need bases. Eventually in the Pilot Project, the community with the support of the BRSP, planted 8000 native plants species - almond, Saltbush, acacia and Ghaz over 200 acres (Figure 84).

Figure 84: BRSP GIZ-RAHA project pre-interventions satellite image of district Qila Abdullah

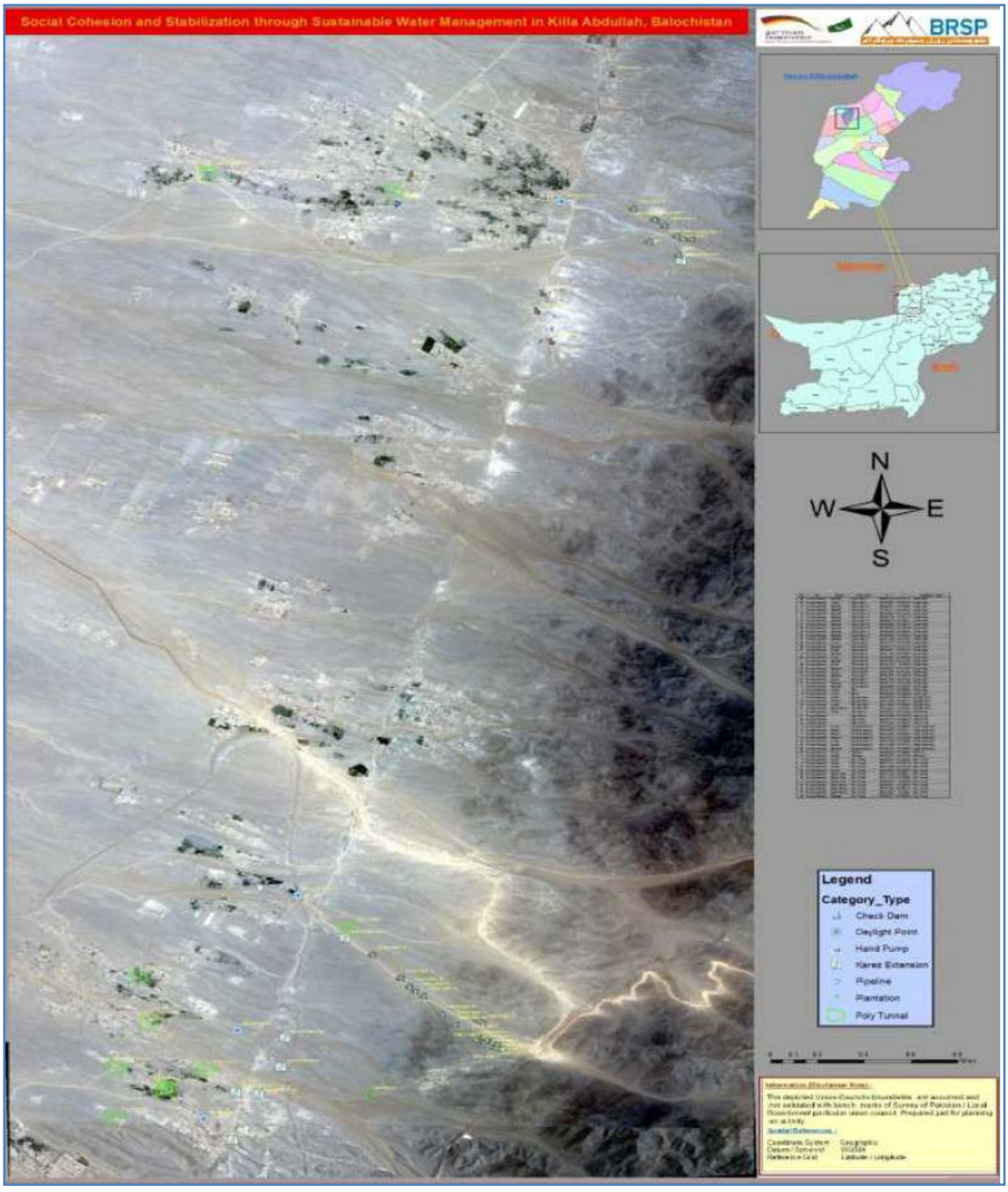


Figure 85: Micro-catchments developed for plantation and harvesting of runoff

All these plant species selected for plantation are drought tolerant. In addition, community provided 200 acres of land voluntarily after signing resolution with the BRSP district social mobilization team. The plantation was successfully completed in the month of March 2015. The worth mentioning aspect of the Pilot intervention is that the community provided labour to the contractors for constructing micro-catchments (eyebrow terraces) in the watershed area (Figure 85). BRSP facilitated village organization and formed planation committee consisting of four members, who continuously supervise the plantation. This committee is also engaged to avoid livestock grazing in the young plantation area for achieving higher survival rates. Watchman was hired by the BRSP to perform supervisory work of plantation including need for irrigating plants in dry spells. The micro-catchments developed in the area helped to harvest the runoff and ponded water was stored in situ. Community involvement, quick response, voluntary provision of 200 acres of land and supervision are the clear indicators of the ownership of the community. The target community is now anticipating that the plantation would be the future picnic spot in the city of Chaman. This plantation would ultimately result in restoring the degraded lands of watershed and contribute in recharging the groundwater and sink for CO2, as one acre of planted area can remove up to 2.6 tons of CO2 per annum. In addition, the planted area will provide forage, fuel wood and fruits as an additional source of livelihood.

13.2.2.2. Modernization of the Karez system

The following interventions were introduced to modernize the Karez system and to have adaptations due to climate change.

- Cleaning of the underground galleries for water conveyance and use of PVC pipe for the lining of water delivery channel
- De-siltation of water storage ponds to store water especially the excess water during night time
- Check dams for recharging the groundwater (Figure 86)
- Stock water for livestock
- Washing pads for women to wash their clothes
- Installation of handpumps for drinking water
- Training of farmers in O&M of the Karez system, efficient use of water, plasticulture for off-season vegetables, small-scale enterprise development, etc.

Figure 86: Check dams and desiltation of water storage tanks

13.2.2.3. Impacts of interventions for modernization of Karez system

- The survival rate of new plants in the watershed area using the micro-catchments for harvesting runoff was around 80% as per evaluation of the third party, which is quite a high rate in arid and hyper-arid environments
- Local community considers that the plantation once fully established will provide livelihood source of income from fuel wood and forages in addition to groundwater recharge
- The savings in water due to the lining of the water delivery system using PVC pipe eliminated the water delivery losses and the water supply was almost doubled as conceived by the farmers
- Community is of the opinion that once established the planted area would be the only picnic spot for the local community

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