HI-AWARE Working Paper 13

Classification of Adaptation Measures and Criteria for Evaluation

Case Studies in the Indus River-Basin

Consortium members

About HI-AWARE Working Papers

This series is based on the work of the Himalayan Adaptation, Water and Resilience (HI-AWARE) consortium under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) with financial support from the UK Government's Department for International Development and the International Development Research Centre, Ottawa, Canada. CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The programme supports collaborative research to inform adaptation policy and practice.

HI-AWARE aims to enhance the adaptive capacities and climate resilience of the poor and vulnerable women, men, and children living in the mountains and flood plains of the Indus, Ganges, and Brahmaputra river basins. It seeks to do this through the development of robust evidence to inform people-centred and gender-inclusive climate change adaptation policies and practices for improving livelihoods.

The HI-AWARE consortium is led by the International Centre for Integrated Mountain Development (ICIMOD). The other consortium members are the Bangladesh Centre for Advanced Studies (BCAS), The Energy and Resources Institute (TERI), the Climate Change, Alternative Energy, and Water Resources Institute of the Pakistan Agricultural Research Council (CAEWRI-PARC) and Wageningen Environmental Research (Alterra). For more details see www.hi-aware.org.

Titles in this series are intended to share initial findings and lessons from research studies commissioned by HI-AWARE. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the HI-AWARE consortium, they have only undergone an internal review process.

Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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Contents

Acknowledgements

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We want to extend our sincere gratitude to Pakistan Agricultural Research Council (PARC) for facilitating this work. We are also indebted to the whole HI-AWARE team at CAEWRI and to the stakeholders that took part in focused group discussions and key informant interviews.

Executive Summary

Climate is changing everywhere across the globe and the severity and nature of its impacts will vary over time and across the countries. In addition to striving to cut down greenhouse gas emissions it will be important to adapt to the impacts of a changing climate. Comprehending and scrutinizing what climate change will mean for Pakistan is only one step in the process. Climate change will hit hard at the country water resources with its consequent effects on food supply, health, industry, transportation and ecosystem sustainability.

This working paper is aimed at finding out the climate change adaptations going on across the three HI-AWARE Project Sites in Indus Basin, namely Hunza (High mountains), Soan Basin (Mid hill) and Chaj Doab (Flood plains). Both autonomous and planned adaptations have been enlisted after thoroughly reviewing published and grey literature. Some focus group discus-sions and key informant interviews were also held in order to know about people experiences, perceptions and existing practices that they are carrying out to sustain their livelihood.

Current study identified that communities are adopting climate change through diverse adapta-tion measures in different sectors. These include mix cropping, tunnel farming, solar water pumping, micro hydel, drought resilient crops and different water conservation technologies. The review of literature throughout the Indus Basin shows that communities are coping with both autonomous and planned adaptation measures. But it was identified that households are particularly focusing on short term adaptation measures. The study identified that, there is need of practical based climate change trainings and awareness workshops for vulnerable communi-ties residing in the mountains of HKH regions in Pakistan. The current study has also docu-mented some planned adaptation measures in the shape of case studies. The case studies shows that these adaptation measures are found more effective and highly helped full in reducing the climate vulnerability and enhancing the adaptive capacities of communities in face of climate change.

The present analysis implies that for better competing with the climate change issues, multi-sectorial approach should be considered involving stakeholders from all the major sectors like Water, Health, Energy and Agriculture. Besides, educational institutes and universities should direct their research on these lines. Developing and promoting climate smart technologies in agriculture, alternate energy and water resources will help vulnerable communities to adapt to the changes easily for their sustainable livelihood development.

Acronyms and Abbreviations

AKPBS	Aga Khan Planning and Building Service Pakistan
AMSL	Above mean sea level
BARI	Barani Agriculture Research Institute
CARIAA	Collaborative Adaptation Research Initiative in Africa and Asia
DFID	Department for International Development
FGDs	Focused group discussions
GB	Gilgit Baltistan
GLOF	Glacial Lake Outburst Floods
HEIS	High Efficiency Irrigation System
HI-AWARE	Himalayan Adaptation, Water and Resilience
ICIMOD	International Centre for Integrated Mountain Development
IDRC	International Development Research Centre (IDRC)
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resource Management
KII	Key Informant Interviews
KPK	Khyber Pakhtunkhwa
PIPIP	Punjab Irrigated Agriculture Productivity Improvement Project
RCTs	Resource Conservation Technologies
UIB	Upper Indus Basin
UNFCCC	United Nation Framework Convention on Climate Change
WAPDA	Water and Power Development Authority

1. Introduction

Pakistan has been witnessing a radical change in climatic trends coupled with increased incidence and intensity of extreme events due to global warming (Rasul et al., 2012). The selection of a right strategy to cope with climate induced stress is one of the challenging tasks. Adaptation ad defined by IPCC is "adjustments in human and natural systems in response to actual or expected climatic variation, with a view to lessening harm or exploiting beneficial opportunities is an area of growing concern and engagement for many developing countries" ((IPCC, 2007). Adaptation is a key factor that will determine the future severity of climate change impacts on agriculture and food production (Brooks et al. 2005, Lobell et al. 2008). Prioritizing climate change policies in the agricultural sector requires information on: (1) assumptions about the future climate, (2) characterization of regional disparities and local realities, and (3) sources of uncertainty in the assessment (Iglesias et al., 2010).

Both published and grey literature was reviewed to find ongoing autonomous and planned adaptations in Indus Basin (Pakistan). This paper aims to enhance our understanding about the potential of various adaptation practices going on across the Indus Basin i.e. Upper Indus Basin, Mid-hills and Plains of Pakistan. Climate Change Adaptation matrix is one of the important outcomes that will summarize the climate change adaptations measures both autonomous and planned which are in practice across three topographical domains.

Himalayan Adaptation, Water and Resilience (HI-AWARE) is one of the four consortia of the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA). This Consortium is headed by the International Centre for Integrated Mountain Development (ICIMOD) based in Kathmandu, Nepal. HI-AWARE is active in research and pilot interventions, capacity building, and policy engagement with respect to climate resilience and adaptation in the mountains and flood plains of the Indus, Ganges, Gandaki, and Teesta river-basins. The overall goal of H-AWARE is to improve climate resilience and adaptive capacities of the poor, particularly the vulnerable women, men, and children living in these river-basins. The Centre incorporates findings from research and pilot interventions to modify policy and practices according to the need of the people which will improve their livelihood.

2. About the Indus River-Basin

Physiography of Indus Basin

The Indus River is a trans-boundary international river, with headwater tributaries located in China (Tibet), India, Pakistan, and Afghanistan. The river originates north of Great Himalayas in the Tibetan Plateau, with the main stem flowing initially through the Ladakh district of Jammu and Kashmir and then through the northern mountainous areas of Pakistan (Gilgit-Baltistan) between the western Himalaya and Karakoram Range. Within Gilgit-Baltistan (GB) area of Indus, the volume of the Indus significantly increases due to additional waters from Shyok, Shigar, Hunza, Gilgit rivers in the adjacent catchments of Karakoram Mountains and from Astore River in the western Himalayas. The river takes a southerly direction from Nanga Parbat, and flows along the entire length of Pakistan, through the province of KPK, Punjab and finally Sindh, where it drains into the Arabian Sea near the port city of Karachi. Kabul, Swat, and Chitral Rivers emerging from the Hindu Kush Mountains join the main stream in the Khyber-Pakhtunkhwa (KPK) province and four major tributaries originating from the western Himalayas, ie. Jhelum, Chenab, Ravi, and Sutlej also join the main stream in the Punjab province of Pakistan. The total length of this river is 3,180 km, draining an area more than 1,165,000 km2.

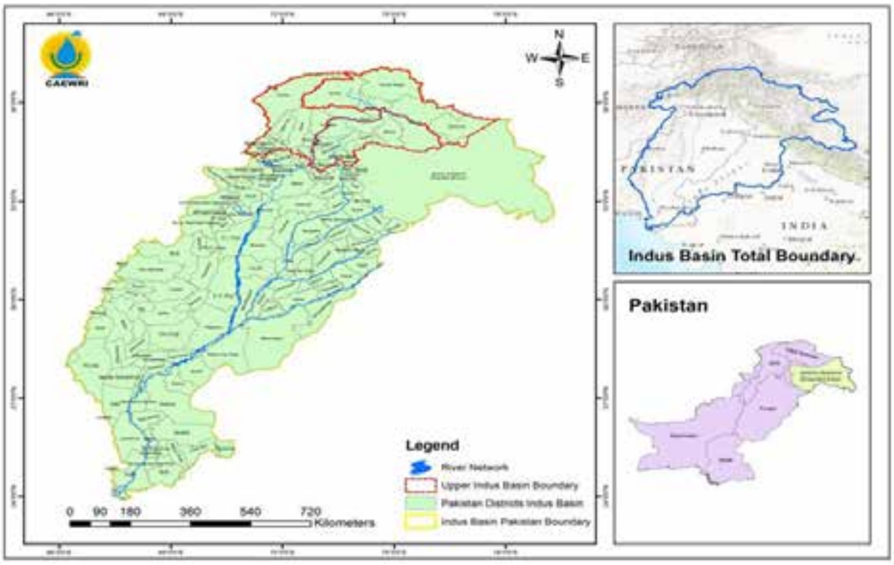

Figure 1: Physiographic zones of the Indus Basin

Catchment area of Indus is most unique in the sense that it contains seven (7) of the world's highest peaks after Mount Everest. Among these include the K2 (28,253 ft), Nanga Parbat (26,600 ft), Rakaposhi (25,552 ft) etc. Seven glaciers situated in the Indus catchment area among the largest in the world, namely, Siachin, Hispar, Biafo, Baltura, Baltoro, Barpu and Hopper (NDMA, 2010).

Indus River System Basins

The Upper Indus Basin (UIB) is considered to be the glaciated catchment basin of the western Himalaya, Karakoram, and northern Hindu Kush Mountains.The Hunza River Basin in the UIB covers an area of approximately 13,734 km2 and contributes nearly one-fifth of the Upper Indus flows. Located at the confluence of the Kilik and Khunjerab Nullas (the gorges) in central Karakoram region at a mean elevation of 4631 m AMSL, it is fed by glaciers. Its volume is further augmented by the Gilgit River and the Naltar River before it draining into the main Indus River. With 2-3 feet snow in Hunza valley, the hydrological pressure increases in winters causing downward movement of landmass resulting into slides, mud flows and avalanches (APN project report 2003-04-CMY-Campbell: 16-17).

The mid-basin areas of the Indus; the Soan Basin selected for the mid-stream study is located in Pothohar Plateau, which is one of the highly vulnerable zones of Pakistan as far as climate change is concerned. The Pothowar Plateau covers an area of about 15,830 sq km and comprises of the districts of Rawalpindi, Attock, Chakwal and Jhelum, and the Federal capital area of Islamabad. Soan River is one of the left bank tributaries of the Indus originating from Muree hills and passing through steep slopes, after which it flows into main Indus near Dhok Pathan. The area is subjected to active fluvial erosion and, at places; streams have cut very deep gorges.

In the downstream, the Chaj Doab is bound by Chenab, river on the south-east (SE) and Jhelum River on the north-west (NW). This is situated in the Indus Basin Irrigation System (IBIS), the word 'doab' is used locally for referring to land between two rivers. It covers a vast network of canals covering the districts of Sargodah, Mandibahuddin, Gujrat, Jhang and Chiniot. The topography of the area is mostly flat and the general slope is towards the southwestern direction, characterised by more or less coarse textured soil (Ahmad, 2012). The canal system in the Chaj Doab area is fed by primarily by water supplies from the Jhelum River which in turn is fed by monsoon rainfall and only partially by snowmelt waters from the high mountains of Himalayas unlike the UIB (Ashraf and Ahmad, 2008). The sediments carried by the river water from the vast alluvial basin are deposited in the Chaj Doab which makes it very fertile for agriculture production.

Climatic conditions of the river-basin

The UIB is characterized by permafrost and annual precipitation in excess of 2,000 mm, while the glacier snouts extend into the semi-arid valley floors (2,700 AMSL) receiving annual precipitation of less than 100-200 mm. In this semi-arid environment, the summer temperature is frequently in excess of 25°C. During July and August, the mean maximum and minimum temperatures are normally above 35˚C and 15˚C respectively.

The temperatures in the mid-basin also fall below zero degrees in the higher altitudes in winter while in summers, rise in temperature up to 47° C at low altitudes is common, especially in the southern part of the basin. This is the tail end of the Soan river basin at Dhoke Pathan which experiences very hot weather. The winter in Muree hills is very cold and receives heavy snowfall.

The climate of Chaj Doab however, is characterized by very hot summers with maximum temperatures touching 50 degrees Celsius. The winters are cold, especially when winds blow from north-west. The average annual temperature is 22°C while average monthly minimum and maximum temperatures are 10.3°C and 31.2°C respectively. January is usually the coldest month, while June is the hottest month in the year similar to the mid-basin. Dust storms are common and sometimes damage crops. Precipitation has two peaks a year, the monsoon in summer and western storms in winter.

3. Objectives and Research Questions

The HI-AWARE project carried out a systematic review of on-going coping and adaptation measures, both autonomous and planned, with the aim to build on existing knowledge and evidence related to adaptation in the region. It set out to assess and document the adaptation approaches followed in policy and practice to address the risk and vulnerabilities of communities living in the Indus River-basin.

The following questions were formulated to guide the case study documentation

1. What is the major climate related hazards and risks in the area? And how it is impacting various sectors such as agriculture, energy, water and health?
2. What is the adaptation approaches being followed in policy and practice to address these vulnerabilities?

Specific questions were:

- What adaptation actions both autonomous and planned (including human, institutional and organizational capacity) are currently employed to reduce the effects of climate change on agriculture, water resources, health and energy?
- How effective are the adaptation approaches being practices in the basin?
- What are major obstacles/barriers to effective adaptation in agriculture, water resources, health, energy, and how can these is overcome?

4. Framework on classification and criteria for evaluating adaptation measure

4.1. Concepts: Classification of adaptation measures

Adaptation refers to adjusting in an ecological, social or economic system in reaction to actual or expected climatic stimuli and their associated impacts. This term indicates fluctuations in processes, practices and structures to counterbalance probable damages or to reap benefits from the opportunities associated with changes in climate. Adaptations include adjustments to minimize the vulnerability of communities regions, or activities to climatic change and variability (Smit and Pilifosova, 2003).

Traditionally, people who relied on agriculture for their livelihood used to deal with climate variations autonomously. But, today the swiftness of climate change will alter the patterns to such an extent that people will be opposed to situations that they won't be able to handle. This highlights the need to promote anticipatory planned adaptations in conjunction with autonomous adaptation. Since vulnerabilities vary from locality to locality, adaptions should also be location specific.

Autonomous adaptations are adaptations to climate change undertaken by individuals. This type of adaptation is important given that many adaptation decisions are likely be done most efficiently if they are done so based on private interests (Mendelsohn, 2000). While planned adaptations carried out by governments or other institutions may also be important at ameliorating the costs of climate change (Lobell and Burke, 2008).

The UN Framework Convention on Climate Change (UNFCCC) has highlighted that the most important adaptation approaches in developing countries are those that encompass a blend of environmental stresses and factors. Strategies, policies and programs having greater prospects of success concentrate and coordinate their efforts at alleviating poverty, enhancing food security and water availability, combating land degradation and soil erosion, reducing loss of biological diversity and ecosystem services as well as improving adaptive capacity and improving the food production chain within the framework of sustainable development.

Table 1: Basis for identifying adaptation

Distinguishing characteristics (Attributes)	Description
Intent and Purposefulness	It differentiates the adaptation measures between autonomous or spontaneous with Planned adaptation measures which are specifically taken in the light of climate specific risks. This may be autonomous to planned, Passive to active etc.
Timing and Duration	Timing of adaptation differentiates responses anticipatory, concurrent or responsive. While duration of any adaptation shows the time frame, such as you need tactical adaptation like adjustment made within a season, which is duration specific. Timing include Short term to long term; anticipatory to responsive; proactive to reactive

Scale and Responsibility	Adaptations can be differentiated according to the scale at which they occur and the agent responsible for their development and employment. Adaptation measures are taken at different scales in each sector, i.e. Agriculture, Energy, Health and Water. At the same time responsibility can be differentiated among multiple actors, from individual to an organization.
FORM	Adaptation form varies from place to place, region to region at any given scale and also with respect to any stakeholders. Adaptation may be Structural - Legal - Institutional - Regulatory - Financial – Technological For Example, at any farm level, adaptation varies, from crop diversification, soil management, water management and use of climate resilient crops.
Spatial Scope	Localized to Widespread

4.2. Criteria for evaluating effectiveness of adaptation options

Evaluating adaption includes identifying both their merits and demerits. The following criteria has been adapted from Darryl et al., (2012)

Table 2: Examples of Criteria for Evaluation of Adaptation Options

- Effectiveness is the capacity of a system to adapt, to achieve its objectives. It is the reduction of impacts, exposure, or risks, the avoidance of danger, or the promotion of security (Adger et al., 2005).
- Efficiency is measured in terms of economic benefits - mostly the cost and benefit of any adaptation option (Noble et al., 2014).
- Adaptation action is appropriate if it is commensurate with the nature and magnitude of the impact it is intended to manage (Noble et al., 2014).
- Flexibility – flexible adaptation options will be more responsive and flexible to changing future conditions, can be modified or adapted, will allow for adjustments due to unforeseen changed conditions and can be implemented with flexibility (Fankhauser et al., 1999; Hallegatte 2009; UKCIP 2011).
- Robustness – robust adaptations can operate and perform under a wide range of uncertainties and future climatic scenarios. They are not dependent on any particular future scenario.
- Equity – this is a critical dimension, as it is generally recognized that the poorest and most vulnerable groups will disproportionately experience the negative impacts of climate change and that adaptation options can have negative spill-over effects (Adger et al., 2005; Adger et al., 2009).
- Coherence/synergy - alignment – it is important to consider the interaction and alignment between an adaptation option and other policies, measures, and sectors, to ensure its implementation does not negatively affect other policies or sectors and, so, lead to sub-optimal results (Hallegatte, 2009).
- Coherence/synergy - enhancement – adaptation options should also seek to enhance and strengthen the outcome of existing policies and initiatives.
- Acceptability (political, bureaucratic, community and private sector) – the acceptability of an adaptation option by different stakeholders is a critical factor that will influence the successful uptake, implementation, and outcome of an adaptation option.

5. Research approach and methods

Our research relied on case studies for data collection as discussed by Yin, 2003. A case study matrix was used to categorize and review systematically prevailing and on-going adaptation measures across Indus Basin. This matrix looks for various potentials of acclimatizing to changing climate from local to national level and quotes several illustrations of adaptation measures. Adaptation practices have been segregated sector wise in the plains hills and mountains.

Table 3: Adaption matrix

Climate change risk across geographical areas	Adaptation options per sectors			
	Agriculture	**Health**	**Energy**	**Water**
Mountains (e.g., temperature increase)				
Mid hills (e.g., drought)				
Terai (e.g., flooding)				

Methods and Tools

Data collection was based on detailed literature review as well as project websites and on personal communication with all partner organizations for information on undocumented projects. The literature review was used to scan documents pertinent to climate change adaptation in the study basin. It proved to be really helpful in sorting out adaptation measures taking place at different levels across the Indus Basin. In addition, the review provided a list of various coping and adaptation options in the river-basin, also across the 4 major sectors of agriculture, water, health, and energy. The team shortlisted 11 potential case studies based on the field visit and literature reviews which are mentioned in Table 4.

Table 4: List of potential adaptation case studies across the Indus Basin

Climate Change Adaptation measures along Indus Bain			
Sector	**Hunza River Basin**	**Soan Basin**	**Chaj Doab**
Agriculture	Mix Cropping and crop diversification and Vegetable seed production	Grapes and Olive farming, Mix cropping, Livelihood diversification	Tunnel Farming
Water	Early warning system for GLOF Hazard	Integrated Water Resource Management (IWRM)	Water Saving/ Conservation Technologies
		Development of small, mini and medium dams etc.	
Energy	Micro Hydel	Solar Water Pumping	Bio-gas
		Bio-gas	
Health		Improved drinking water filtration in Islamabad	

The team agreed to focus on four adaptation options for extensive study. In order to shortlist key adaptations for detailed case studies, our team used different criteria. It opted for a comparative and cross-scalar approach keeping in consideration a range of climates prevalent at the study sites and across four climate-sensitive sectors i.e. agriculture, water, health, and energy, different hydrological settings (upstream – downstream) and altitudes (high mountains, hills, plains), and variable cultural and socio-economic contexts in the three river-basins, with an emphasis on the most vulnerable people. A summary of the selected case studies is presented in Table 5.

Field visits were organized in selected areas of the Indus River-basin to enlist, comprehend and prioritize adaptations in practice across the 4 sectors. Participatory approach to collect data was adopted and the tools entailed semi-structured interviews with farmers and adaptation practitioners working in the area.

Table 5: Summary of the case studies

Adaptation studies	Location	Focus	What problems are addressed?
Olive and grape farming	Chakwal district of Soan Basin	Promoting Climate Smart Agriculture	Drought Olives and grapes can flourish in dry areas as well as they require limited hydration
Micro-hydel	Hunza District of Upper Indus Basin	Micro-hydel can make valuable contribution in the energy sector and boost economic development	Energy crisis
Solar water pumping	Soan Basin	Renewable energy resources Environment friendly alternative	Water crisis and irrigation problems
High efficiency irrigation system	Chaj Doab	Resource conservation	Water scarcity and efficient utilization of water resources

6. Review of adaptation strategies in the Indus River-basin

What follows is a review of the adaptation practices taking place across different sectors of the Indus Basin. To give viewers a clearer picture, autonomous and planned adaptions have been segregated into Table 6 and Table 7 respectively. According to the literature, in all the three geographical terrains, the role of extension field staff has been diversified. People are now keener to cultivate climate resilient cum climate adaptive crops and seeds (Salman 2011; 22011b). Considering the Water sector, it has been reported that rainwater harvesting is being given significant value and irrigation channels are also being rehabilitated. Use of solar driers, solar water heaters and biogas units is gaining popularity. A few of the other adaptation measures taken at autonomous level are mentioned in table 6.

Adaptations at planned level entail but are not limited to digital simulation models for assessing climate change impacts on agriculture and water availability, Flood forecasting and warning system, evacuation strategies in case of glacial lake outburst floods (GLOF). A few other planned adaptation approaches that have been introduced in the mountains, hills and flood plains are documented in Table 7.

Table 6: Autonomous adaptation measures adopted by communities in the Indus River Basin

Sectors	Geographical variation + adaptation activities		
	Mountains	**Hills**	**Floodplains**
Agriculture	Diversification of the role of extension field staff (Saleem Ashraf, 2013). Developing climate resilient, adaptive crops and seed varieties (Salman 2011; 2011b). Localized rainwater harvesting and surface water storage (Salman 2011; 2011b). Change crop plantation time (Sultana et al., 2009).	Diversification of the role of extension field staff (Saleem Ashraf, 2013). Developing climate resilient, adaptive crops and seed varieties (Salman 2011; 22011b). Change crop plantation time (Sultana et al., 2009). Use of deep tillage for rainwater harvesting and preserving moisture (Ahmad et al., 2013). Installation of dug wells/turbines increased to minimize drought impacts (Ahmad et al., 2013). Diversion of river/spring/stream water through private water channels (Ahmad et al., 2013). Deep rooted mustard crop adopted as a drought resistant specialized oilseed crop (Ahmad et al., 2013). Wheat sowing has generally been delayed by 15-20 days to avoid higher temperature level (above the normal) from mid-October to early-November (Ahmad et al., 2013)	Diversification of the role of extension field staff (Saleem Ashraf, 2013). Developing climate resilient, adaptive crops and seed varieties (Salman 2011; 2011b). Change crop plantation time (Sultana et al., 2009). Diversion of river/spring/stream water through private water channels (Ahmad et al., 2013). Deep rooted mustard crop adopted as a drought resistant specialized oilseed crop (Ahmad et al., 2013). Farmers have replaced guar seeds and cotton crops with mung bean (Ahmad et al., 2013).

Water	Migration due to water shortage (FGDs and KII) Rehabilitation of irrigation channels Village-level Disaster Management Plans (RCRRP-2010)	Rainwater harvesting; Brining water from springs during water shortage Source (author)	Traditional methods to store rain water in tanks; Rain water harvesting; Source: author
Energy	Insulating material like thermo foil, plywood is being used in construction Solar cooker (Rijal K.) Solar lit park in Gilgit city (Nasim 2013) Pico/micro hydel system at community level (RCRRP 2011, PCRET 2016)	Solar water heaters (WEC 2000) Household biogas plants (Hussain 1997) Biogas units (PCRET 2016)	Solar dryers (WEC 2000)
Health	Drinking boiled water in remote areas of Gilgit-Baltistan, (FGDs/KII) Medicinal plants for some diseases e.g. flue, cough (FGDs/KII)	Boiling of water to control salinity and bacterial contamination (Direct observations, FGDs in Soan River Basin, May 2015)	Use of Insulation materials in homes to beat hot nights and heat stress (Assessed through FGDs and KII during field visits); Migration as an adaptation measure to cope up with heat stress (Mueller, 2014); Home Water Treatment Systems(Pako Swiss)

Table 7: Planned adaptation measures adopted by communities in the Indus River basin

Sectors	Altitudinal variations		
	Mountains	**Hills**	**Flood plains**
Agriculture	Digital simulation models for assessment of climate change impacts on agricultural production (Draft national climate change policy, 2011). Quality datasets on crop-, soil- and climate-related parameters to identify ideal cropping patterns for each region (Draft national climate change policy, 2011).	Digital simulation models for assessment of climate change impacts on agricultural production (Draft national climate change policy, 2011). Quality datasets on crop-, soil- and climate-related parameters to identify ideal cropping patterns for each region (Draft national climate change policy, 2011).	Digital simulation models for assessment of climate change impacts on agricultural production (Draft national climate change policy, 2011). Quality datasets on crop-, soil- and climate-related parameters to identify ideal cropping patterns for each region (Draft national climate change policy, 2011).
Water	Indus River Basin Flood Forecasting and Warning System (WAPDA) Development of evacuation strategies in case of Glacial Lake Outburst Floods (GLOF) (Climate Change Policy 2012) Disaster Risk Reduction and mitigation (NDMA 2011, FOCUS)	High Efficiency Irrigation systems; Rain water harvesting; Water Storage tanks; Ground Water lifting; Source (author)	Rain water harvesting; High Efficiency Irrigation systems;

Energy	Major Hydro and micro hydel power plants (Farooq 2011); Small solar panels for only household electrification.	Installing macro solar power systems and PV systems for households, schools and mosque. (AEDB,2015) Installation of biogas plants by public and private institutes (NRSP, 2011) Hydropower plants on rivers and dams (WAPDA, Power-technology)	Focus on hydro, wind and coal power. (Planning Commission 2007) Micro financing for installing clean energy systems (Buksh Foundation) Domestic biogas plants
Health	Telemedicine for administering health issues in remote areas of Gilgit Baltistan Region (UNOCHA 2013) Protecting groundwater through management and technical measures like regulatory frameworks, water licensing, artificial recharge especially for threatened aquifers(Climate Change Policy 2012)	Water Filtration plants in Islamabad region (PCRWR, 2005). Access to Safe Drinking Water in City Slums Through Household Water Treatment System (HWTS), (SDPI, 2011) Inform, sensitize, educate and train health personnel and the public about climate change related health issues (Climate Change Policy 2012) Indus River Basin Flood Forecasting and Warning System(WAPDA)	Introduction of heat/temperature resistant varieties of wheat to ensure proper nutrition (Ortiza et al., 2008) Drought tolerant diversified agriculture for food security in irrigated plains (Ahmed et al., 2016) Pilot Project on Oral Hygiene (NRSP, 2014) Ensuring preventive measures and resources such as vaccines, good quality medication and clean drinking water availability to the general public during climate related extreme events(Climate Change Policy 2012) Installation of solar water disinfection systems (SODIS) in Faisalabad (Dawn)

7. Case studies on adaptation measures in the Indus River-basin

Four adaptation case studies in sectors like Energy, Water, Agriculture and Health are documented in detail for this working paper. Each study provides in depth view of the socio-economic and climate change scenario within its respective area. It also describes the climate smart and efficient innovation put in to practice over there and the consequent betterment in livelihood and improved community resilience. The studies have also probed the various challenges that people are facing or are still confronted with when planning to adopt any local adaptation practice.

7.1. Grapes and Olive farming in Chakwal district; A way for sustainable agricultural development

Context

The impacts of climate change have raised food security issues for Pakistan's farmers up to an alarming scale. The vulnerability of rural households in Pakistan has recently been highlighted by the experience of heavy flooding in 2010 and 2011.A key question for Pakistan's economy is whether farm-level adaptation is adequate to deal with the potential effects of climate change on future crop productivity. The occurrence of fewer rains than before prompts the need to cultivate fruits an.d crops that require less moisture and are drought tolerant.

The Potohar-rain fed areas of upper Punjab landscape have been declared as "olive and grape valley" by Punjab Minister Farrukh Javed in 2015. Since then the project has been pursued very seriously. The two factors leading to the early success are: import of exotic varieties of olive and grape and hugely subsidized (up to 60pc) high efficiency irrigation systems (drip and sprinkle) in the region. In early 90s, eight varieties of olive viz., Ottobratica, Frantoio, Coratino, Leccino, Moraiolo, Pendolino, Carocea and Biancolilo of Italian origin were planted at Barani Agricultural Research Institute, Chakwal and after monitoring and evaluation of these varieties for 8-10 years under local environmental conditions, four varieties viz., Ottobratica, Frantoio, Coratina and Leccino were found promising with a fruit yield of 15-35 kg per plant having oil contents from 18-22 percent. Performance of the said varieties is not uniform in all climatic pockets; hence there is a need to test these verities in different areas of the Punjab extensively.

Cultivation of olives and grapes, effectiveness, efficiency and sustainability of the practice

Olive and grapes farm were visited at Balqasar and included a farm owned by Haji Ghulam Akbar, ALATTA farm under the project titled "Promotion of olive cultivation for Economic Development and Poverty Alleviaton" funded by Italian Government and Izhar farm that is located at a distance of 6km from Talagang.

Working at the farms:

The Balqasar farm extends over an area of approximately 150 acres. The crops are supplied with water with the help of gravity based drip irrigation system. A submersible pump is also installed that effectively delivers water where and when required. Besides, a storage tank is also developed to meet water requirements in case of water shortage. The zonation of farm area has been done so that each zone in the farm gets adequate amount of water. The system also facilitates automatic delivery of manure and insecticides.

At **ALATTA** farm, olive was being cultivated here under the project titled "Promotion of olive cultivation for Economic Development and Poverty Alleviaton" funded by Italian Government. Olives have been planted here at a distance of about 15x15 feet. Italian Government provided 1000 olive plants for this farm, the varieties naming Frantoio, Leccino and Coratina. Olive plants were also given by BARI later. later. Olives have been planted here on area of 56 acres and grapes cover an area of 15 acres. The whole farm is supplied with water with a drip irrigation system that was installed by Government.

Izhar farm covers an area of 550 acres and has a manpower of 30-35. Mr. Taimoor is serving as a Farm Manager at Izhar Farm. He told that the land was purchased in 2008-2009 and the first plant was cultivated here in October 2010. Around 41,000 olive plants and 10,00 grapes are grown here. Grapes nursery has also been established here. Water scarcity is the main challenge here and drip system is used all over the farm for water supply. Deep wells have also been built here to resolve the issue of water shortage.

Effectiveness: Olive and grape farming in different areas of Chakwal is really proving to be fruitful in the face of changing climate. Grapes and olives are helping the community in strengthening their livelihood like the landowner at Balqasar farm stated that grapes are providing him with a satisfactory income and for fruiting one has to wait for only one year. The average yield of grapes is about 13-14 mon and one kilogram of a good quality grapes ususally brings 250-300 rupees to the owner. Likewise olives cultivated ALATTA farm are fullfilling both domestic and commercial needs. The ready plant is usually sold at the rate of Rs.200/ plant and per acre field of the fruit varies from zone to zone. . Olives have been promoted at Izhar farm because they can flourish even in arid areas successfully. Average yield per olive plant is 2-3 kg.

Efficiency: The farmers at Chakwal have easy access to varieties of olives and grapes as BARI extends full support in the provision of these fruit varieties and at subsidized rates. The fruiting time is also suitable and growers don't have to wait for prolonged periods of time. Additionaly both fruits are drought resistant and can serve as good livelihood weapons as water stress continues to grow in Pakistan.

Sustainability: Farmers have grouped up to form community based organizations that are playing an effective role to sustain cultivation practices. There is division of labor and management roles that will certainly pave the way for farms to become more resilient and productive. There is a farm management team at Izhar farm which is supervised by a forest officer and they all are actively engaged in upgrading their food production system and livelihood development.

How Olive and grape farming addresses climate change?

Through FGDs at three farms, it was found that people are facing erratic weather patterns since from last ten years, like sudden increase in temperature, less rainfall during sowing time which has ultimately shifted their sowing period. Current adaptation practices include crop diversification, change in crop planting time, change in fertilizers input and soil management practices. Farmers in Potohar region are facing problems due to climate change and need professional guidance. Promoting the growth of climate resilient crops is one of the viable solutions for reducing the impact of weather fluctuations on overall crop yield. Olives and Grapes have proven to be great in improving livelihoods of farmers as these fruits require limited hydration for adequate growth and certain species can even flourish in arid lands. The Federal and Provincial Government Institutions should extend their maximum support to the farming community and there should be more campaigns addressing the issue of climate change adaptation.

Strengths to cultivate Olive and Grapes:

- The climatic conditions of Chakwal District suit the growing conditions of olives and grapes and will greatly improve the livelihoods of communities because;
- Both olive and grapes have low water requirements, it can be cultivated through little supplemental water.
- Grapes will ripen earlier due to early onset of summer season than the crop from our hilly areas. Early entry into market means more cash flow to farmers.
- Grapes are ripen before the onset of monsoon rains so the chances of spread of insect pests and diseases are less.
- Olive oil is a highly demanded item in our country due to its high nutrition value. Farmers can earn premium prices by putting this commodity in markets.

- Olives can be successfully cultivated in any barren land. In this way farming communities can earn their livelihoods from the land that is considered as uncultivated waste.

Barriers/Limitations:

- Olives and grapes are "New Crops" because the farming community is not accustomed to their cultivation. So intensive motivation and training is required for the adoption of these crops.
- The training system for grapes is expensive and farmers usually cannot afford that on their behalf, so they need subsidy.
- Large scale adoption of olives needs a successful model from cultivation to processing and oil extraction, which at present is lacking.

7.2. Community based micro hydel plants, a Climate Smart Technology

Context:

This Case study has been conducted in Gircha Village of Upper Hunza in Hunza District. Gircha is a small village located in the upper Hunza. It provides dwelling to 60 households with a population of 450 people. People have small land holding and they cultivate their own vegetables and crops. Moreover, abundant fruit trees are present in this village. The electricity to this village is supplied from the hydropower plant located at Khyber. But due to a huge gap in the demand and supply, people had to experience a lot of load shedding. Moreover, due to climate induced hydro meteorological hazards like floods, river bank erosion and land sliding the electric towers and transmission lines get damaged in each season. Gircha has abundant of spring and people are dependent on the springs for their domestic water needs and for agricultural activities. After meeting the needs of the villagers, approximately 5 cusec of water flows down directly into the Hunza River. This water discharged approximately at height of 40 feet's. This Flow is sufficient to produce micro hydel based electricity to meet the needs of people and to get rid of the energy crisis.

Figure 2: Showing micro hydel plant in Gircha valley

Upper Hunza is highly vulnerable to climate change events, like flash flooding, erratic rainfall, Glacial Lake Outburst Flooding (GLOF), seasonal shifts unusual snowfall in early spring season and river bank erosion. The climate extremes usually disturbed their main electricity system from Khyber valley. The community based micro hydel plant is a good source of electricity for Gircha community. The mountain people of Upper Hunza rely heavily on forest to meet their energy need; as a result forest exploitations are increasing year by year. In such situation micro hydel (climate smart technology) is a best climate change adaptation and mitigation option to reduce their dependencies on forest area. In this way it will contribute to Clean Development mechanism. What it is and how it works?

Micro-hydropower is regarded as one of the viable and sustainable technological interventions in the mountainous regions of Hunza (Ishaq 2016). It typically produces electricity from 5 to 100kW. 30 kW micro hydel has been constructed in Gircha valley in 2014. The hydel power plant is providing electricity throughout the year to 60 households living in the village. The electricity that this plant generates is used for cooking, lighting and heating. The provision of electricity will discourage people from cutting trees and help conserving the natural habitat of wildlife in the Khunjerab National Park, which otherwise is under threat. In a span of one year, the station was constructed and the villagers actively took part in the construction activities. This hydro power station is now operational generating 25 KW and the villagers have 24/7 electricity available. The people are not using electricity from the Khyber hydro station and are delighted to use electricity generated in their own village. Each household is a paying 100 PKR each month as the fee of the station irrespective of their electricity usage. A person has been hired for the operation and maintenance of the station.

How does micro-hydro address climate risk and vulnerability?

Before the installation of this technology, the people of Gircha valley were dependent on forest, kerosene oil and LPG for their domestic energy needs. While in winter it was difficult for them to collect wood from forest due to harsh climatic conditions and heavy snow. Burning of plant biomass and coal in winter seasons has bad effect on their health. During winter flash floods have damaged the routes to main market areas. In such situation it was difficult for villagers to access the market for LPG and Kerosene oil to meet their energy demands. This micro-hydropower plant has fulfilled the rural demand for energy and also reduced pressure on forest; improved health condition, sanitation, indoor environmental conditions and also economic growth. This small hydro plant is under the management of the concerned village committee. This technology will promote Clean Development Mechanism (CDM), contributing to economic and social development by providing energy services and reducing energy crisis in small and climate vulnerable areas of Hunza River Basin.

Effectiveness, efficiency and sustainability of the practice

Effectiveness: During our Focus Group Discussion (FGD) with local community of Gircha valley they said that this project has made their livelihood easier. Mr Raza who is the chairman of Gojal Rural Support Organization (GRSO) said, this technology is more environmental friendly having zero carbon emission and economically feasible for small communities to develop as well as socially acceptable for every village in Upper Hunza.

Efficiency: A woman during our FGD said, "this technology has reduced our time and labor work in collecting the firewood and plant biomass for domestic energy need. Now we can easily use our energy appliances". It was found that, health issues due to house smoke because of burning of plant biomass has been decreased. Now Gircha community are active engage in other livelihood opportunities even in winter seasons.

Sustainability: Gojal Rural Support Organization (GRSO) is the apex organization in the village which monitors the community needs their issues and constrains and also identifies the way to cope with the issues. GRSO has pointed a small committee of 5 members who are responsible to monitor the micro hydel monthly based. This committee has further pointed a person who is responsible for bill collection in the village.

Limitation and Constraints:

The demand for high energy is proportional to increase in rural population. Frozen water in the springs in winter season is and additional challenge for community. Climate induced hydro meteorological hazards further add to the problems of village community. Due to active participation of community, it has been possible to cope with every climate extreme and adapt to changing environment.

Challenges:

- Proper Check and Balance
- Migration of technical human resource
- Local conflict among the management teams and local electrification committees and electricity bill

- Natural Disaster, (Flash flood, land sliding) may hinder the MPH
- Systematic monitoring and evaluation (monthly based)
- Long term maintenance problem
- Poor infrastructure

7.3. Solar Water Pumping in Soan Basin; A Climate Smart Technology

Context

Pakistan is facing severe water crisis and its water demand per capita is increasing day by day. Soan basin is a rain fed area and its irrigation practices are highly dependent on rainfall but due to environmental and climatic

Figure 3: showing solar water pumping in Soan

changes, the irrigation system is highly suffering and the cultivation pattern of communities is getting affected too. With the growing energy crisis, it will become much imperative to find alternative/renewable energy resources. Solar energy has been a viable option as an alternative energy resource. It has many advantages over the traditional energy sources. Solar energy has two main advantages over fossil fuels. The first is that it is renewable and never going to run out which makes it very cheap and secondly it is environmental friendly.

Although Pakistan has a very extensive canal irrigation system, yet it is facing water shortage problems on an enormous scale. To fulfill water shortage, approximately 0.8 million tube wells have been installed in which 90% operated with diesel while 10% are operated with electricity (GOP, 2008).The basic purpose of installing solar pump is to create awareness among the farmers to conserve the resources and to overcome hesitation in the adoption of new technologies which is beneficial for them. Conventional water pumping system powered by diesel and gasoline engines have been used for decades but it is very expensive in term of cost, transportation of fuel and engine maintenance. There is a natural match between need of water and availability of sunlight, besides for greater reliability and avoiding costly cum high maintenance components; the photovoltaic pumping system is being used without batteries. The solar photovoltaic pumping technology is the best option because of availability of solar radiations is more than wind even biogas or biomass in many places (Purohit and Michaelowa, 2008).

PARC solar power pumping system for tube wells at Talagang

The HI-AWARE team of CAEWERI (PARC) introduced AC submersible pumping system by solar power at Talagang in December 2015. DC solar pumping system was not economical where more discharge is required from depth of more than 200 ft. Therefore, it became a leading challenge to design and integrate solar power with available inverters and AC pumps through state of art technologies to address the issues in an affordable cost.

How this system works?

Solar panels of 8.5 KW were integrated with 7.5 KW of inverter to run 0.2 AC submersible pumps. The first pump with 5 liter per second (lps) discharge was installed at a depth of 260ft to lift water and store in reservoir of 47268 ft3 capacity. The second pump with 7 lps discharge was installed in the reservoir to irrigate field crops through 50 psi rain gun. Both pumps are using single source of power with change over switch (From 1 to 2 and 2 to 1) on alternate day. The total cost of the system is Rs. 1.3 million which is only 50% compared to solar powered DC pumping system of same size.

Effectiveness, efficiency and sustainability of the practice

Effectiveness: During our discussion with the farmer at Talagang site where this solar based drip is functional, we came to know that the provision has really helped this man improve his livelihood. Better supply of water with drip has really given good fodder yield and thus the number of livestock has increased up to 50 now. The effectiveness of the system is further depicted in table 8 briefing the number of pumps installed by private companies and Government institutions.

Table 8: showing solar water pumps installed both Government and Private Companies

Govt. Institutions / Agencies	No. Of Installed Pumps	Private Companies / Authorized Dealers	No. Of Installed Pumps
ABAD	70	Pak Agro. Tech.	100
		Nizam Energy.	52
		Green Line Technologies.	38
PARC	07	MAK Pumps.	25
		ATS Engineering.	25
		Catkin Engg. Sales & Services.	13
PCRWR	03	Authorized dealers of Catkin.	50
		Mansha Brother	20
		Solar Well.	08
PCRET	02	ZEUS Energy Pvt. Limited.	06
		A.R. Brother.	05
		Sharif International.	04
BARI	01	Solar Sigma Ltd.	03
		Miscellaneous.	25
Total Installed Pumps	83	Total Installed Pumps	374

Source: Authors

Solar water pumping is an important climate smart technology used for water management and for irrigation purposes. It is important to strengthen the rural livelihoods so that people can cope with the pressures and vulnerabilities they are facing while continuing to support sustainable development (ICIMOD, 2015).

The above findings show that 457 pumps have been installed in Soan basin and the area still requires more systems to be deployed. Solar pumps will reduce the dependency on diesel pumps and are cost effective to adapt. These pumps are environmental friendly, socially acceptable and economically viable for poor communities relying on rain water to meet irrigation needs.

Efficiency: The intervention has provided economical solution to the farmers having deep water source. Now, large farming communities will be able to provide supplement irrigation after successful implementation of this system especially in Baluchistan where majority of Tube wells are more than 200 ft deep.

Sustainability: The agricultural scientists of water sector have been trying their best to solve the farmer's hardships due to shortage of water. The high efficient irrigation systems integrated with solar pumping developed and tested by CAEWRI/NARC will contribute in improvement of livelihoods of poor farmers. The number of companies that are designing solar panels is growing day by day that will ultimately ensure the uptake and sustenance of this technology within agricultural sector.

Barriers and constraints

- Some of the barriers that cause hindrance for farmers in the uptake of this technology include
- Initial installation cost which is very high than the operational cost
- Secondly, since system will remain open in the field its safety is another important concern.
- Lack of a technical person is another restricting factor because in case of any problem or system failure, farmers do not have skills to manipulate the situation.
- Up till now, there are limited Government policies / projects on solar irrigation pumping systems installation.

7.4. Drip Irrigation system, a water conservation technology in Chaj Doab

Context

Chaj Doab is located in the northern part of West Pakistan and comprises an area an area of 5,000 square miles of the Indus Plain. It stretches about 170 miles in length and 40 miles in width with the long axis trending southwest. The topographic slope is also to the southwest and ranges from more than 2 feet per mile in the northern part to less than a foot per mile on the south end with an average slope of the Doab of 1.5 feet per mile. The low relief of the plain and terrace is, however, broken by a few scattered bedrock hills known as Kiranas.

Food and livelihood security for growing populations is one of the essential global challenges (Seckler et al., 1998). Food security, droughts, energy crisis and water scarcity are the major problems also faced by many communities in Pakistan. In reaction to the water, energy, food security and other climate related impact, different Resource Conservation Technologies (RCTs) are being developed and supported by national and international organizations, especially for rice and wheat which together make up to 90 percent of the country's total food grain production (Ahmad et al., 2007). These technologies comprise of zero tillage, bed/furrow planting, high efficiency irrigation systems (HEIS), laser land leveling and improvement of irrigation schem es (PARC-RWC 2003).Among the technologies, zero tillage, HEIS and laser land leveling are so far most widely adopted in Pakistan, with use centered in Punjab and other rice-wheat cropping systems (Hobbs and Gupta 2003).Water saving technologies can play an important role in saving water, viable use of water and increasing productivity.

Figure 4: showing drip irrigation system and components in Chaj Doab

Technology Effectiveness, Efficiency and Sustainability

Effectiveness: High efficiency irrigation system i.e. drip irrigation system has yielded fruitful results in Chaj Doab. The effectiveness of this technology is also evident from the status of water conservation practices (HEIS, Laser Land Leveling, Improvement of Water courses and irrigation schemes) in Chaj doab through PIPIP and other government projects (Planned Adaptation) as is given in table below.

Table 9: Status of water conservation practices in Chaj Doab

Districts of Chaj Doab	High Efficiency Irrigation Systems (HEIS)		Irrigation schemes Improvement	Water Courses Lining/ Improvement	Laser Land Levelers
	No of Sites	No of Acres	No of Sites	No of Sites	No of Units
Sargodha	90	953	32	194	74
Gujrat	90	782	44	16	34
Mandi-Bahuddin	81	791	31	97	76

Source: On Farm Water Management Government of Punjab

Efficiency and sustainability: The provision of drip based irrigation system has facilitated efficient utilization of water while cutting down water losses. The crops are supplied with the exact quantity of moisture that is according to the current growth stage. Subsidies on drip and other HEIS are encouraging farmers to uptake this technology and increase their capacity to mitigate effects of climate change.

In Chaj Doab many government and non-government organizations have been working on water conservation technologies. Punjab Irrigated Agriculture Productivity Improvement Project (PIPIP) has aimed to provide technical guidance for improvement of water productivity i.e. producing more crops per drop by providing High Efficiency Irrigation System (HEIS), Laser Land Levelers and improvement of water courses and Irrigation schemes at subsidized rates.

Barriers and constraints

Some of the barriers that farmers might face include

- Installation cost
- Lack of a technical expertise to install the system
- Difficulties in land preparation
- Lack of interest

Conclusion

Communities residing in Upper Indus are facing climate extremes and climate induced hazard. Most people of the UIB believe that climate induced hazards have been occurring severely since from last few decades, and their impacts are not limited only to the natural resources but also effects their socio-economic condition. The climate induced hazards are a mounting threat for vulnerable communities in UIB. People in UIB seem to trust on community based climate change adaptation ideals to minimize the impacts which were identified during community consultative and orientation sessions with all stakeholders and target community.

This HI-AWARE working paper was meant to find out the adaptation practices prevalent across the geographical domains of Indus Basin i.e. High Mountains (Hunza Basin), Mid Hill (Soan Basin) and Flood plains (Chaj Doab). Both autonomous and planned adaptations have been documented and their value addition plus constraints have been discussed as well. It has been noted that intervention of climate smart technologies and climate smart agricultural practices have a vital role to play and push development towards attaining a sustainable livelihood in the area of Upper Indus Basin. The case study of Micro-hydel at Upper Hunza in Gircha valley brought to light that micro-hydel is a valuable renewable energy technology that needs to be promoted all across the high mountains to meet the energy crisis. At downstream (both mid hills and flood plains) people need supplemental irrigation to equip their crops with adequate amount of moisture, thus solar water pumping and rainwater harvesting are the most feasible technologies in both regimes.

The results of this working papers shows that, people in Upper Indus Basin are mostly focusing on autonomous adaptation measures and are adapting shot term coping strategies. In the foremost remote areas of UIB like Gircha, Shimshal, Hoper, and Misger where external support and planned adaptations are inadequate, autonomous adaptation are considered very much imperative for communities to cope with weather variability and short-term climate change extremes. As these areas are located around 3500 m high from mean sea level, and climatic conditions remain harsh throughout the year. In such climatic conditions autonomous adaptation and short term coping strategies remain not effective and sometime failed to reduce their vulnerabilities. This alarming situation demands for planned and systematic adaptation measures in terms of community based as well as ecosystem based adaptation.

There is need to identify, categorize, test and scale up the climate smart adaptation measures and strategies in order to reduce the adverse impacts of climate change. It has been concluded that flexible farming systems, with a variety of farming products are essential for achieving food security in mountain areas under climate change. Climate Polices must focus on flexibility, integrated water resource management, value chain development, livelihood diversifications and improving indigenous and local based food production.

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