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An Innovative Approach to Agricultural Water Management in the Upper Indus Basin: The Water-Energy-Food Nexus at the Local Level

Background

The Pakistani administrative territory of Gilgit Baltistan (GB), home to one of the highest mountain ranges in the Upper Indus Basin (UIB), spans 7.24 million hectares (ha). Tourism, agriculture, and livestock herding are the three major pillars that support the area's economy. However, only 2% of the territory's land is arable and small landholdings (<0.075 ha) that focus only on household food security dominate. Agricultural productivity is hence insufficient when it comes to feeding the rapidly growing population. Dwindling water supply for irrigation and seasonal shifts attributable to climate change create further problems. Additional challenges include labour shortages resulting from high male out-migration (41%), insufficient research and development and government subsidies, and poor market linkages.

The arable land in GB is spread along river banks but the steep incision and strong currents characteristic of the Hunza River and its tributaries means that water from the river is not used for irrigating surrounding land. There is also insufficient surface water for irrigation. Hence, 50% of the total arable land in GB remains uncultivated. On the land that is being cultivated, irrigation water comes from glacier melt channelized to agricultural land through irrigation canals cut through moraines and mountain slopes, constructed over the course of several generations. Farmers in GB have depended

on ice and glacier melt (>60%) for centuries. Additionally, water-related hazards and the lowering of glacier surface, both resulting from climate change, are causing reduced water availability for agricultural use. The kuhl traditional irrigation system, which comprises of a system of unlined water conveyance and distribution channels, has proven to be inefficient in the present context. Furthermore, poor on-farm-water management techniques directly contribute to water losses and lower yields.

A pilot project entitled "Agricultural Water, Energy, and Hazard Management for Improved Livelihood in the UIB, Pakistan" is being implemented in villages in Gojal, the largest sub-district in GB. The pilot aims to improve mountain livelihoods by enhancing adaptive capacities in relation to understanding, managing, and demonstrating state-of-the-art climate smart irrigation water, energy, and hazard management technological options in project areas.

Location

As part of the project, an innovative adaptation intervention for horticultural development has been successfully piloted in several villages in Gojal. Spread over 0.85 millon ha, Gojal sits at an elevation ranging from 2,340 metres (m) to 4,877 m above sea level. The temperature here ranges from -11 degrees Celsius (°C) to 29 °C, and the area receives 180 millimetres mm of rain on average in one year.

Agricultural irrigation water management demonstration sites have been established in Passu and Morkhun. Passu is home to 717 individuals – 358 male and 359 female, of whom only 15% practice farming. Similarly, Morkhun is home to 501 individuals – 253 male and 248 female, of whom only 13% practice farming. The agriculture practised is subsistence-based and male outmigration is prevalent in both villages. Because the literacy rate is high, communities in both villages are receptive to innovative ideas.

Technology Package

A survey showed that 95% of the population in these communities depends on glacier melt for irrigation water. However, accelerated glacier melt and the lowering of glacier surfaces have resulted in the disconnection of most channels that supply glacier melt. Furthermore, the water application methods currently being used are inefficient. The same survey also indicated about 42–80% farmers in the area have been using ridge and furrow irrigation methods and about 16% have been depending on flood irrigation. Only some farmers were found to be practising both methods in their orchards.

Figure 1: **Agricultural irrigation management demonstration site, Popdon-Passu, Gojal**

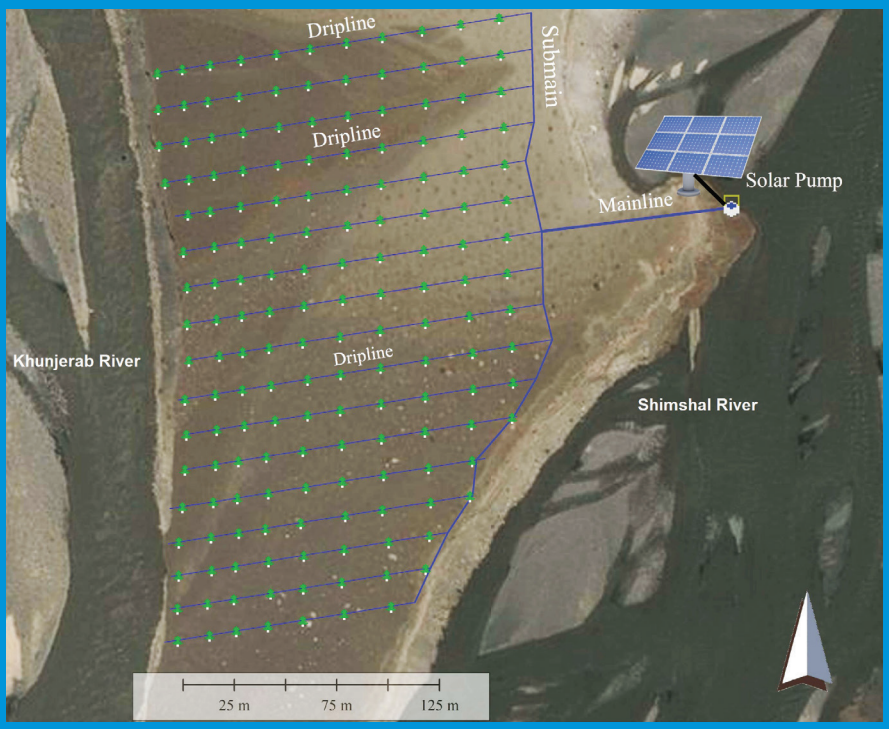

Figure 2: **Agricultural irrigation management demonstration site, Morkhun, Sost**

Figure 3: **UIB project: Innovative Approach for Irrigation Water Management**

To address water scarcity, the project came up with an innovative alternate to irrigation channels made dysfunctional by the lowering of glacier surface. In what is the first known use of a solar water pump in the high mountains of the Hindu Kush Himalaya (HKH), water from the Khunjerab River is being pumped to irrigate community land that has so far remained uncultivated. Several technological innovations in solar pumping system were required to make this possible as most solar powered irrigation technologies are designed for use in plain areas where clean water is lifted either from ponds or from bore wells. Pioneering a solar powered water pumping system in Gojal was a challenge given the heavy concentration of suspended sediments as well as salts in river water. The challenges were overcome after multiple attempts, particularly after installing direct current pumps capable of working in spite of heavy sediment.

Currently, water lifted from the Khunjerab River is evenly distributed through a highly efficient (90%) drip irrigation system to irrigate high value orchards. Furthermore, mulching has been demonstrated to conserve valuable soil moisture and avoid weed growth. By applying this integrated approach, two demonstration sites have been developed in Gojal. One is a 2.5 hectare apple and cherry orchard in Passu and another a 2.5 hectare Fuji apple orchard in Morkhun. About 3,200 apple saplings have been planted, 100% of which survived. The fruiting is expected in 2017, with the pilot se to be an example of the water-energy-food nexus a local level.

The expected outcomes of this intervention are: 1) adaption and upscaling by the government and local communities; 2) enhanced livelihoods for marginalized farmers; 3) adaption of the technology by local enterprises for its upscaling, leading to more livelihood opportunities for educated youth; and 4) involvement of youth in smart and high value farming.

Implementation and Partnership Approach

The project follows the resilient mountain village (RMV) approach and introduces measures to adapt to the changing climate through agricultural, water, energy, and hazard management for improved livelihood in GB. This requires a multidisciplinary, multi-sectoral approach, which is why the project is adopted a local level consortium of parters.

The GB office of the World Wide Fund for Nature (WWF) is a lead partner responsible for overall coordination, social mobilization, and monitoring of the agricultural water and hazard management component. Several other partnering organizations are actively involved in the project through WWF. The following table represents the partnership approach at the implementation level.

Partner	Partnership Responsibility
Karakoram International University (KIU)	Provide information and analysis related to water, energy, hazards management, and use of technology for climate smart agriculture in pilot areas.
Pakistan Council of Research in Water Resources (PCRWR)	Introduce contextually relevant climate smart energy technologies (solar pump) and micro irrigation systems for better livelihood options.
Gilgit Baltistan Forest, Wildlife and Environment Department (GB-FWED)	Introduce contextually relevant climate smart technologies ie, bio-engineering measures for better risk reduction from water-induced hazards.
Gilgit Baltistan Disaster Management Authority (GB-DMA) and Aga Khan Agency for Habitat	Introduce contextually relevant climate smart technologies ie, early warning systems for water-induced hazard risk management.
Worldwide Fund for Nature–Gilgit-Baltistan (WWF) and Pakistan Agricultural Research Council (PARC)	Enhance institutional as well as individual capacity of relevant public/private institutions and pilot communities for better management and utilization of water, energy and hazards management, and climate smart agriculture

Lessons learnt

The agricultural resource base in Gilgit Baltistan is under visible threat of climate change. However, there is great scope to expand the innovation introduced by the consortium along the river banks where currently no water under gravity flow is available. Solar pumps combined with an efficient drip irrigation system are a highly appropriate solution for addressing agricultural water management issues and increasing the area of cultivated land in Gilgit Baltistan. However, implementing solar lifting systems in cases where river waters contain salts and mountainous sediments requires certain modifications.

The local level consortium responsible for the implementation of the project found that successfully achieving desired project outputs and outcomes was a good model. The same model should be followed when implementing future projects in Gilgit Baltistan.

Impact

The intervention is seen as an effective climate change adaptation option. About 1,300 people—including 600 are women—in the pilot villages are expected benefit after the trees start bearing fruit. The foreseen impacts of these interventions have motivated partner organizations to contribute their own resources to piloting RMVs. PARC has introduced Angora rabbit farming in the highlands of GB and provided training to several communities with special focus on women. It has also supplied new, highly productive varieties of wheat seeds to the Gilgit Baltistan Agriculture Research Department for testing and multiplication purposes. Similarly, PCRWR, using its own resources, has piloted the hydro-ram pump for round-the-clock irrigation water supply. Similarly, the GB Forest Department has provided farmers irrigation pipes for sea buckthorn plantation along the Hunza River and barbed wire to protect social agro-forestry in Morkhun.

Imtiaz Ahmad, General Secretary, Passu Development Organization (PDO)

"An apple orchard has now been successfully established in the area. In the near future, it will contribute to nearly 50% of the additional income of the Passu community. These initiatives are environmentally friendly and are effective adaptation measures in the context of climate change. The introduction of solar-powered water lifting and drip irrigation is the first of its kind in the Upper Indus Basin. The system is simple and anyone once trained can operate it. Large swathes of barren area can be cultivated in this manner. Moreover, sea buckthorn plantations act as breaks to stop soil erosion, which has destroyed a lot of land in Passu Valley. This will be an example for other communities."

Meeraj Bibi, school teacher and social worker from Passu

"Solar water lifting is beneficial. In Passu, it transformed barren lands into productive agricultural lands. The area will develop socioeconomically because of the intervention and tourism will grow. Women are often most involved in agricultural activities and this intervention has provided them relief by making it possible for them to work nearer to their valley. Moreover, once the trees bear fruit, women will be able to sell them to generate income. The drip irrigation system introduced is simple to operate and requires less effort when compared to other means of irrigation."

Muhammad Ashraf, PCRWR

"Gilgit Baltistan is the source of all the water resources in the Indus Basin of Pakistan. It sustains one of the largest irrigation systems in the world. However, this source is subject to a number of issues, including declining in water quantity and quality and impact of climate change. Limited livelihood options are also an issue. Our experience shows that growing fruits plants with solar-powered low head drip irrigation systems can provide the local community a better livelihood without compromising on the environment."

The success of this initiative has also appealed to national organizations, encouraging them to give more importance to research and development in GB. After the implementation of this project, PCRWR approved the upgradation of a Gilgit water quality lab to a regional research centre for GB-specific research. The GB Forest Department has selected the same communities to upscale these interventions under an International Fund for Agricultural Development (IFAD) funded project to conserve the community members' livelihood base and promote social agroforestry along Karakoram Highway.

Way Forward

The International Centre for Integrated Mountain Development (ICIMOD) will continue to promote RMVs as models in Gilgit Baltistan to be upscaled through policy support. It is also continue to encourage investment by the provincial government and the private sector. These pilot RMVs will serve as excellent demonstration fields for policy makers seeking successful interventions for climate change adaptation and sustainable mountain development. The project will document the quantitative impact of the interventions with an end-line survey. This will help advocacy at the highest political levels to attract support for enabling policies for mountains and their people. The data and impact of RMVs can be translated into policy feeds to be used in upcoming provincial climate change policies in Pakistan. For this purpose, the project will be working very closely with the Government of Gilgit Baltistan and other concerned partners through a consultative process.

The Upper Indus Basin Network (UIBN) of national and international organizations and institutions actively working in UIB regularly shares state-of-the-art knowledge generated in UIB through a virtual knowledge platform (http://www.icimod.org/uib). This network has been active in informing decision makers of Pakistan about the knowledge gained in the field by various national and international network partners. Lessons learnt from the pilot projects under the model of RMVs in high altitudes will be shared through the UIBN knowledge platform.

For further information contact

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