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ISSUE BRIEF

Climate-smart agriculture interventions in Gilgit–Baltistan

KEY MESSAGES

Over 90 per cent of the population in Gilgit–Baltistan is primarily dependent on agriculture, and the impacts of climate change are increasingly putting irrigation water supplies at risk. In this ever-changing context, it is crucial to develop and implement agricultural water management interventions that are adaptive and resilient.

The limited amount of cultivable land (due to the complex mountainous terrain) can potentially be utilized for high-value agricultural practices by employing innovative water-lifting technologies.

The learnings from energy-efficient interventions such as the introduction of hydraulic ram pumps and solar pumps should be incorporated into decision-making processes so that their effectiveness in relevant areas of the country may be tested.

The capacities of local stakeholders need to be strengthened and their understanding regarding energy-efficient technologies enhanced to enable the wider implementation of such adaptation measures and to transform traditional agricultural practices. Therefore, it is important that government authorities at different levels, national and international organizations, and local communities work together in fostering capacity-building, knowledge enhancement, and the implementation of climate-smart technologies.

1. Introduction

Mountain agriculture in the Upper Indus Basin (UIB) relies heavily on glacial meltwater supplied by gravity-based irrigation systems via lined or unlined channels called 'khuls' in Gilgit–Baltistan – where 90 per cent of the population is agrarian – 95 per cent of the cultivated area depends on irrigation water supplied by khuls.[1,3,7] However, during recent years, the mountain farming community in the UIB has been facing challenges related to climate change and its varied impacts. Across the Hindu Kush Himalaya (HKH), temperatures have been rising at a rate higher than the global average. This has accelerated glacial melting in the HKH, resulting in the general shrinkage of glaciers across the region, with only some glaciers in the Karakoram Range being the exception.[2]

Unlike in other parts of the HKH, where irrigation intakes are further downstream from the termini of glaciers, in Gilgit-Baltistan these intakes are located at the side of glaciers, upstream from their termini. However, the shrinkage and associated lowering of glaciers has in many cases made the irrigation intakes higher than the glacier's surface; consequently, the meltwater cannot flow into the intake to the khuls any longer, rendering the irrigation system dysfunctional. Moreover, increased glacial downwasting, with a substantial contribution from torrential rainfall, has resulted in frequent and devastating water-related hazards such as flash floods and glacial floods, which have damaged irrigation infrastructure in Gilgit–Baltistan. Under these prevailing conditions, irrigation water shortages have been observed in Gilgit–Baltistan.[10, 11] Water shortages, in an area where subsistence agriculture is practised, have adversely impacted the livelihoods of the people.

These irrigation water shortages are surfacing in a region that is already facing grave socio-economic challenges. The population of Gilgit–Baltistan has increased by 72 per cent during the last three decades but its cultivable area has remained the same, resulting in increased pressure on the agricultural system in the region.[5, 8] As it is, crop yields in Pakistan are low; the subsistence farming in Gilgit–Baltistan has even lower yields. For instance, the average wheat productivity in the region is 2.6 million tonnes per hectare (Mt/ha) compared to the national average of 2.9 Mt/ha and the global average of 3.5 Mt/ha in 2019. Similarly, maize productivity in Gilgit–Baltistan is 2.3 Mt/ha, which compares unfavourably with both the national average of 4.7 Mt/ha and the global average of 5.9 Mt/ha in 2019.[5, 9]

The government of Gilgit–Baltistan has been trying to increase crop yields and expand the area under agriculture in the region to ensure food security. A number of schemes have been launched to expand the cultivated area by irrigating currently barren areas with glacial meltwater. A study by the Directorate of Water Management, Gilgit–Baltistan identified 43 such glacial meltwater sources but stated that these could only irrigate 22 per cent of the potential arable land.[4] It is very likely that these sources and khuls will be vulnerable to the lowering of glacial surfaces discussed above. And the remaining 78 per cent of the land, mainly spread along river banks at higher elevations, will remain barren; hence it requires river water to be lifted to provide a sustainable irrigation water supply in order to expand the agricultural base in the region.

This issue brief focuses on adaptation strategies to address these challenges of water scarcity in a region seeking to cope with a changing climate. It is based on the findings of a pilot project implemented by ICIMOD, the World Wide Fund for Nature Pakistan (WWF–Pakistan), and the Pakistan Council of Research in Water Resources (PCRWR). The project was implemented over a five-year period: Phase I (September 2015–August 2017) and Phase II (June 2017–April 2020). Two specific water lifting technologies – the hydraulic ram pump and the solar pump – are proposed as the most apt climate smart interventions for the region.

2. Adapting to water scarcity: Climate-smart agricultural interventions

2.1 SITUATIONAL FIELD ANALYSIS

A team of experts from ICIMOD, WWF–Pakistan, the Pakistan Water and Power Development Authority (WAPDA), and the PCRWR visited Gilgit–Baltistan in 2014 (prior to the implementation of the pilot project) to observe and understand climate change impacts in the region, and to identify relevant strategies for adaptation and building resilience. The team noticed that the arable land is spread at a higher altitude than the main river and that the steep terrain made it difficult for local farmers to transport water from the river to their agricultural land. Instead, irrigation water is sourced directly from glaciers through canals. However, as has been stated, the lowering of the glacier surfaces, occurring due to climate change, had in many cases disconnected the canal intakes from the glacier and had rendered irrigation systems dysfunctional. Such impacts called for alternative irrigation methods. Energy-efficient technologies such as hydraulic ram pumps and solar pumps were recognised as the most apt and feasible considering the terrain and proximity to the water source. In addition, the team noted that many of the existing irrigation channels, such as in Khyber village, were being damaged on a regular basis by flash floods, debris flows, and landslides.

Different villages were identified for the pilot project based on their need (for water lifting technology) and the appropriateness of the technology to be introduced. The Hunza River flows along a narrow path and with high velocity, making it suitable for the installation of hydraulic ram pumps. Khyber village was chosen. The villages of Passu and Morkhun were found more suitable for the solar pumps as they are in locations where the shadows of mountains do not block the sunlight.

2.2 APPROPRIATE TECHNOLOGIES

Hydraulic ram pumps

The hydraulic ram pump is a self-actuating pump that lifts water from a position near the water source to a higher location. It runs on the kinetic energy of the flowing water itself and hence does not require any other source of energy or fuel. It is particularly suited to Gilgit–Baltistan, where swathes of land are left unirrigated precisely because water sources are downhill. It is paired with an intake pipe from the source and a delivery pipe to the storage. The diameter of these pipes need to be of a certain specification as illustrated in Figure 1.

Solar pumps

Another technology, the solar pump, operates primarily through solar energy and is hence a climate-smart method of promoting low-carbon irrigated agriculture. The equipment includes solar panels, a motor, and

FIGURE 1 OPERATIONAL MECHANISM OF A HYDRAULIC RAM PUMP

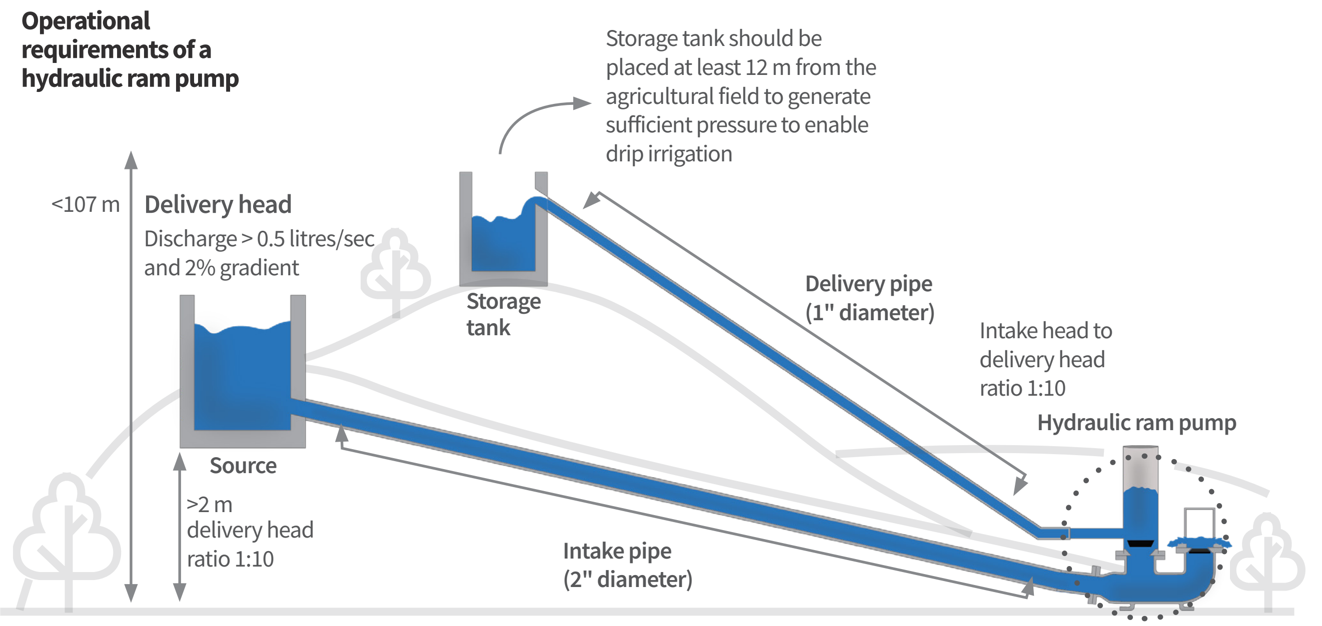

FIGURE 2 OPERATIONAL MECHANISM OF A SOLAR PUMP

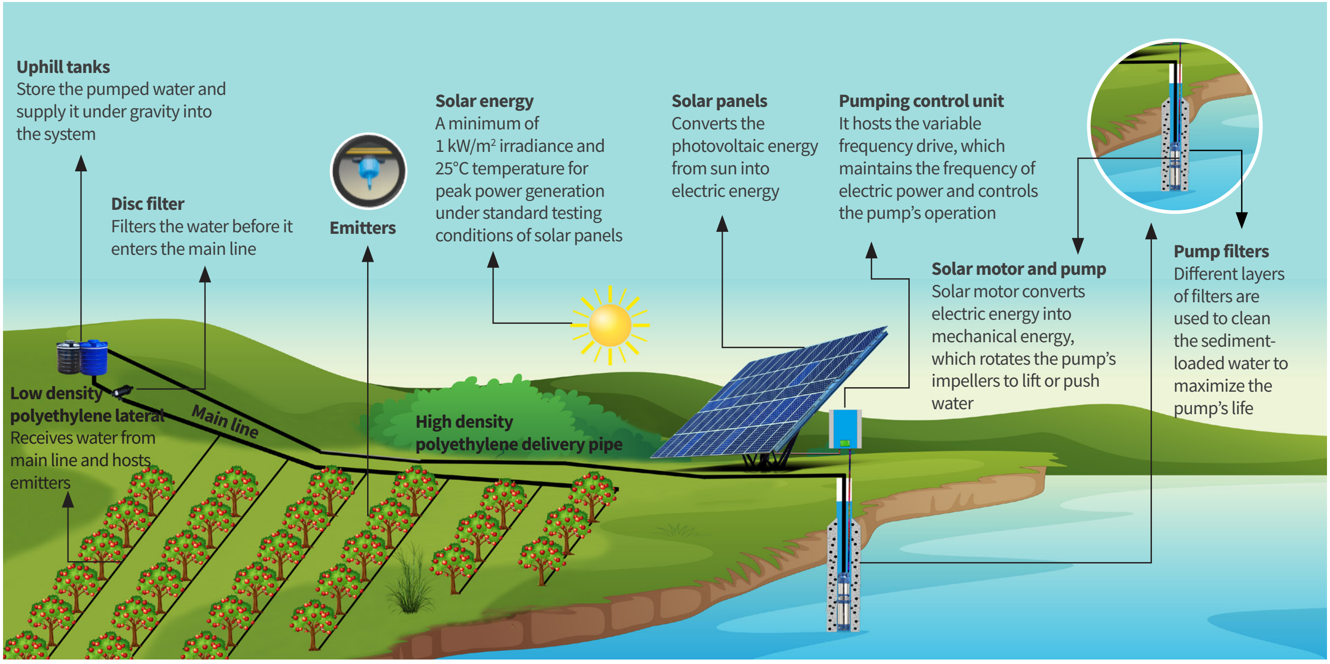

Illustration: Muhammad Mudassar Maqsood

a pump to lift water to a higher altitude, from where the water is supplied to the fields using gravity. Its operational mechanism is described in Figure 2.

2.3 LIFTING WATER FOR ENHANCED AGRICULTURAL PRODUCTIVITY: EXPERIENCES FROM THE FIELD

Hydraulic ram pumps and drip irrigation in Khyber village

Khyber village is located in the Upper Indus Basin region of Gilgit–Baltistan. Existing water supply practices to individual plots of lands are governed by traditional modes of flood irrigation that have existed for centuries, guided by customary norms. However, these conventional practices trigger soil instability and result in increased labour costs and lower yields and returns.

The introduction of climate-smart technologies, using a combination of a hydraulic ram pump and drip irrigation, has provided a less expensive way of lifting and distributing water for irrigation in Khyber. This pump is operational 24 hours a day, with minimal


Photo: Karen Conniff/ICIMOD

operational costs. This is in contrast to solar-powered pumps, which can only operate when the sun is shining. These pumps supply water through low-head drip lines to a 19.77-kanal (one hectare) apple orchard. Using drip irrigation technology has reduced the adverse effects of flood irrigation on soil nutrients and reduced labour costs. In addition, it enables a more efficient use of the limited water lifted through the hydraulic ram pumps.

The technology has also promoted community ownership, particularly through the involvement of the Women's Organization in Khyber in managing the agricultural site. Women from the village also take the lead in coordinating the sale of their agricultural produce in the local market.

Solar pumps in Passu and Morkhun

The villages of Passu and Morkhun were provided with solar pumps integrated with drip irrigation equipment, mini dams, and irrigation ponds on selected communal barren lands. A 49.42-kanal (2.5 hectares) apple orchard was established in Passu village and a 49.42-kanal (2.5 hectares) Fuji apple orchard in Morkhun. Additionally, vegetables were also cultivated in pits. The overall average survival rate of these plantations was around 70 per cent, which is a major success on hitherto barren land.

Learnings from the interventions

1. A comprehensive understanding of technology and context is crucial during site selection

While selecting a site and identifying the relevant technologies for specific sites, it is critical to understand the limitations of, or challenges faced by, each technology. For example, as was observed during the high silting season in Passu village, the drip nozzle gets blocked by sediment, hampering the functioning of the solar motor. With the hydraulic ram pump, it was found that the pump lifts silt-laden water that requires multiple filtering steps at the storage tank. Therefore, research about the local context and identifying suitable technological modifications are important to minimize the technical challenges during scaling out and scaling up. In addition, other aspects like soil quality, the crops being planted, and site conditions should be considered in detail to estimate the amount of water needed, which in turn will determine the feasibility of the intervention.

Regarding the feasibility of different areas, many factors had to be taken into consideration while looking for the most suitable pilot sites. For instance, the project team observed that most of the barren areas along river banks are made of moraines. The layers of topsoil are infertile and have a pea gravel texture. Such conditions do not favour plantation, and land preparation is essential. In the case of solar pumping sites, sufficient sunlight was necessary, and areas under the shadow of the mountains had to be avoided to ensure day-long operation of the pumps. Prerequisite conditions for the successful operation of the hydraulic ram pump – the channel discharge, which produces the desired water hammer effect and the intake head, which ensures the potential energy required to lift the spill valve – were similarly considered.

Although the barren lands brought into cultivation through the pilot are relatively safe from water-borne hazards (they are located at altitudes higher than the river they draw irrigation water from and typically do not experience intense rainfall), precautions were taken to sustain the operation of the installed systems. Dug wells or water sumps with drainage galleries were built in areas where solar pumps were installed. In the case of the hydraulic ram pump, stone gabions were constructed whenever a pump was installed within a stream or on one bank. Additionally, crop cultivation and orchard plantation were carried out across the slope to reduce runoff-induced erosion.

2. Community knowledge and ownership are essential for the sustainability of interventions

Placing community knowledge and ownership at the core of an intervention is key to its sustainability. The knowledge and experiences of community members ought to be incorporated at all stages of the planning, implementation, and evaluation of the technology deployed. Community ownership of the technology, especially from key beneficiaries such as women, is pivotal for the sustainability of the intervention. In Khyber village, for instance, the Women's Organization, through the mobilization of its members, continues to not only ensure the safety of the technology but also proactively tries to increase and manage the agricultural yields.

3. Better market linkages (for the sale of the agricultural output) are important to ensure scalable and long-term benefits from climate-smart technologies

The lack of competitive value chains in fruit and vegetable selling and processing has hampered the possibilities of farming profitably, denying individual farmers sufficient returns from agriculture. Better market linkages would encourage farmers to plant high-value crops, aided by energy-efficient technologies.

4. A cost-benefit analysis indicates that these technologies have monetary and social benefits

Installing climate-smart, high-efficiency irrigation systems on barren lands through community participation offers insights into the successful turnaround of agricultural practices at both the individual and community levels. These technologies have propelled the community to be more proactive and work together in monitoring the pilot sites, such as in TuPopdan Passu and Morkhun villages, and encouraged women to step forward in managing the pilot sites, as in Khyber. This can help contribute to greater harmony within the community and strengthen the leadership roles of women.

The cost–benefit ratios for the solar pump and hydraulic ram pump packages – at 4.96 and 2 respectively – show that the technologies are economically viable. Seeing the potential of these new methods of irrigation, villagers have already identified multiple plots of barren land to set up such technologies, and plan to pay half the cost for the equipment if any donor or government agency is willing to support the other half.

2.4 SCALING UP AND SCALING OUT INITIATIVES: OPPORTUNITIES FOR CROSS-LEARNING

The piloting of the energy-efficient technologies in Gilgit–Baltistan has captured the interest of institutions such as the United Nations Development Programme (UNDP). In partnership with WWF–Pakistan, UNDP has further scaled out 30 hydraulic ram pumps and 30 solar pumps to additional sites in Gilgit–Baltistan. Such initiatives not only open up possibilities for cross-learning but also help strengthen the evidence regarding the effectiveness of such climate-smart technologies, which would help the Government of Pakistan to potentially scale up such interventions in other areas of the country.

The federal government decided to scale up such water-lifting initiatives with financial support from the Ministry of National Food Security and Research (MoNFSR). The government plans to scale up 50 hydraulic ram pumps to 10 districts and 150 solar-powered pumps to 10 districts with drip irrigation systems, which would bring approximately 3,000 acres of arable land under cultivation. Such commitment from government bodies in deploying energy-efficient technologies not only contributes to strengthening agricultural water management mechanisms but also enables the implementation of best practices in areas with similar geographical contexts.

At the local level, village development organizations could play a vital role in the adoption of both technological packages given that the technology concerned is effectively demonstrated to local farming communities. For example, the Shahi Khyber Imamabad Development Organization of Khyber village has developed a plan to extend its agriculture base using a hydraulic ram pump package. To actualize the plan, the organization has used its own funds to purchase a hydraulic ram pump. It would be advisable for government or private sector development agencies to include demonstration components in their projects to increase locals' interest and trust in technologies.

2.5 THE WAY FORWARD: SOME POLICY SUGGESTIONS

1. Policy support is crucial for the scaling out and scaling up of climate-friendly technologies

The government of Gilgit–Baltistan ought to prioritize passing the agricultural policy for Gilgit–Baltistan, which has been awaiting cabinet approval since 2019. Policy actions included in the agricultural policy – such as strengthening research, the development of technologies for the mitigation of climate change and adaptation to its impacts, and the adoption of water-efficiency packages fit to context – should be implemented with priority.

The government's initiation of the Prime Minister Agriculture Emergency Programme has been a positive step towards boosting agricultural production and improving the lives of farmers. However, areas like Gilgit–Baltistan, where around half the arable land is still underutilized, require further attention. With the arable land being at a higher level than river banks, piloted technologies such as the hydraulic ram pump and solar pump would help bring new lands under cultivation for high-value and organic crops.

In addition, relevant government bodies such as the Department of Agriculture ought to identify the barren lands that have no access to water along with existing agricultural lands for which technological solutions can be adopted. As noted above, prior research is essential for the success of these technologies and for scaling out and scaling up these technologies into other parts of Pakistan and beyond.

2. Building awareness and providing support to local farmers is crucial for greater impact

The government should create awareness among farmers about the potential benefits of climate-smart technologies in irrigation, including enhanced returns. The government can also promote natural farming practices among farmers to complement the benefits of climate-smart technologies in agriculture.

However, greater awareness, while necessary, is not sufficient. The lack of proper market linkages acts as a huge hindrance in farmers fetching sufficient returns from agriculture. Hence, policy makers should pay greater attention to facilitating the process of production, processing, and marketing of agricultural products and linking farmers to profitable markets.

3. Other initiatives to aid the adoption of climate-smart technologies should be introduced

The government could work with banks or small and medium enterprises to design soft loans or interest-free loan products for both farmers' collectives and individuals to be able to deploy climate-smart technologies in their agricultural practices.

In addition, the technological packages could be made affordable so that a wide range of communities across the country are able to access and benefit from them. Private sector engagement in manufacturing the technology locally would also help farmers access it and enable their easy repair and maintenance. In addition, donor agencies ought to address capacity constraints in technical know-how across relevant departments and communities. Since the technology has been shown to have monetary and social benefits, policy makers could promote these benefits in order to generate more interest among private sector entities and donor agencies.

4. Strengthening research and development for easy adaptation of technologies

The existing research and development facilities could be enhanced both in terms of human capacities and infrastructure for testing the technologies under local conditions, followed by their customization. This would lead to a better adoption of water resource management technologies in mountainous areas.

5. Promoting value chain inclusive development for monetary and social benefits to the farming community

The government may include creating value chains as an inclusive component of any development in the agricultural sector to enable agricultural produce to reach its consumers and thereby reduce post-harvest losses for the farming community.

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This issue brief has been authored by Muhammad Mudassar Maqsood[1], Ajaz Ali[1], Madhav Prasad Dhakal[1], Sharmila Dhungana[1], and Arun Bhakta Shrestha[1] with inputs from Ghulam Abbas[2]

[1] International Centre for Integrated Mountain Development
[2] WWF-Pakistan

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International Centre for Integrated Mountain Development
T +977 1 5275222 | **E** info@icimod.org | **www.icimod.org**