Executive Summary

IWMI-TATA, under the Water Policy Research Program, offered a study titled "Sustainability of Water Interventions for Livelihoods' to CEDAR, Dehradun. This study was conducted by a team from P-Green Solution, Dehradun from September 2025 to February 2026. The objective of the study was to analyse the efficacy, effectiveness, efficiency, and impact of the selected water interventions in the Western Himalayan region, in the context of climate change, and to assess their potential for future scale. The focus of the study was on the following aspects:

- Different types of support irrigation interventions, such as Gravity-based, Lift-based (Solar-powered pumps, Petrol-powered pumps), and rainwater harvesting-based interventions.
- Storage tanks (e.g. UV-resistant plastic-lined tanks, ferro-cement tanks, RCC tanks, LDPE tanks, etc.) are being used for support irrigation.
- Water distribution systems for crop irrigation.

Selection of study villages: A total of 12 villages, including one unirrigated village for comparison were selected from 6 mountain districts (3 villages each in Pauri and Dehradun, 2 villages each in Tehri and Uttarkashi, 1 each from Nainital and Almora). Preference has been given to selecting those villages where interventions were carried out 3-5 years earlier, and the schemes had been handed over to the community for operation and management. Study sites were selected based on types of water intervention combinations under topographic and geographical scenarios. Different criteria considered for selection of study sites: (a) status of water source & water discharge at source, water storage structures, water distribution systems; (b) agricultural land characteristics, changes in land use pattern, crops grown and crop yield before and after interventions, etc.; and (c) investment incurred, status of community institutions, operation and management of the scheme, efficiency, effectiveness, and sustainability of interventions.

Action research methodology: A framework for data collection and analysis was designed. Secondary data were collected from various sources, including the compilation of Detailed Technical Reports (DPRs), drip and sprinkler manuals, case studies, progress reports, and rainfall data. Intensive field visits were undertaken in each study village to observe irrigation interventions, land use and cropping patterns, institutional structures, and O&M status. Household and village-level surveys and semi-structured interviews were conducted to capture field data. Verification of data / information was carried out in consultation with technical experts.

Chapter-wise key observations, results and recommendations are summarised as follows:

Water Ecosystem

i. The catchment area of water sources in study villages is broadly categorised in Reserved Forest, Van Panchayat, Civil-Soyam and private land. The water sources in Diusa, Kyara, Simoldi and Silla villages are either perennial streams or rivers. The catchment areas of these water sources are a large valley, and most of the land is under the Reserved Forest category, which is largely unprotected and unmanaged. The water sources in Pujargaon, Taliya, and Saabli are natural springs originating in the Van Panchayat Forest and are well-maintained by the community. In Monisakri village, the natural spring originates from Civil Soyam land, and in Rampur-Chaukhutia, the source is a marshy area within private agricultural land. Except for Saabli village, in other

villages, the spring recharge zone is neither identified nor treated. In Saabli village, the recharge zone has been identified, and a 4.75 ha catchment area has been treated and protected by the village community with Himmotthan support.

ii. A comparative analysis of average source discharge during the study was conducted, comparing with the average water discharge recorded during the site's technical feasibility assessment. The analysis reveals a 38.3% decrease in water source discharge in catchments within an unprotected Reserved Forest, and a 14.2% decrease in water discharge in catchments within a protected Van Panchayat. Only in Saabli village was a 38% increase observed, following the identification and treatment of a recharge zone in the catchment area. The Uttarakhand government has recently formed a unified agency known as Spring shed and River Rejuvenation (SARA) to work on the rejuvenation and conservation of Dhara, Naula, streams, and rivers in a collaborative manner. There is a need for collaboration with SARA to jointly identify recharge zones and their treatment and maintenance for the long-term sustainability of water sources.

iii. Most of the water sources, with potential for gravity-based schemes, have already been developed either for drinking water or irrigation purposes. However, in many cases, water sources beneath the settlement / agricultural land remain untapped. There is potential to tap such water sources through a solar-powered lift irrigation system. Lifting water from perennial streams / rivers using a surface pump is the most suitable option. However, the pump's proper operation and safety are a concern, as there is always a risk of flash flooding along the stream/river. The operating costs of petrol-driven pumps are higher than those of solar pumps. Therefore, solar pumps of different capacities should be designed and installed based on the mountain topography.

iv. Water storage tank capacity to be designed based on water availability at source, and the type of schemes (i.e., gravity, solar lift, etc.) to be constructed. However, in many places (such as Diusa and Saabli), storage decisions have been made based on preliminary data assessments. Farmers generally prefer low-cost, durable, and moderate-sized (20KL-30KL capacity) underground ferro-cement tanks and/or RCC tanks that can be easily constructed in their terraced fields with minimal maintenance. However, further piloting is required to identify the best-suited storage tanks in mountain conditions.

v. In the mountain region, farmers have fragmented land holdings. Agriculture practices are carried out in terraced fields. In such topography (as already demonstrated in Taliya village), a decentralised water storage tank and an individual-level irrigation system need to be developed. The main tank is to be connected to the designated water supply storage tanks. A proper water distribution system is in place, and individual farmers are allowed to irrigate fields as needed, based on their suitability and the crop’s requirements.

vi. Villages situated in uplands are mostly devoid of any water source in nearby areas. These villages are entirely dependent on rainfed agriculture. Further action research is required on potential rainwater-harvesting options, their storage capacity, and water distribution systems for critical crop irrigation.

vii. So far, the focus of supplementary irrigation schemes is mainly on the supply side; limited work has been done on an efficient water distribution system for crop irrigation. Farmers have limited awareness about the optimum use of water for crop production. Farmers are mainly using pipes for crop irrigation and are comfortable with flood irrigation. Water-use efficiency can be increased by promoting proper water distribution systems and irrigation in line with crop requirements. Further work is required to optimise the efficient water distribution system (drip, sprinklers, etc.)

for maximum water utilisation in crop production. Furthermore, around 20-40% transmission loss was observed. Optimising water use needs to become a key focus going forward.

Cropping Pattern and Crop Production

i. In high altitude temperate areas, vegetable cultivation provides a better income option to farmers than cultivating traditional crops, i.e. cereals and pulses. In Pujargaon and Chopriyalgaon, farmers have begun intercropping vegetables with high-density apple orchards. A drip irrigation system is used to irrigate the apple orchard, while critical irrigation via pipe-spray is practised in vegetable crops. Farmers are now also beginning to benefit from fruit production, and their annual household income has increased considerably. Therefore, given the challenges in crop production, such as reduced workforce and limited resources, farmers should be encouraged to intercrop temperate orchards with off-season vegetables to reduce input costs and increase profit margins.

ii. In study villages like Diusa, Kyara, Monisakri, and Taliya, farmers started cultivating off-season vegetables and spices with the availability of irrigation facilities. Except for Kyara village, other study villages (Monisakri, Taliya) were cultivating cereals and mixed crops before irrigation interventions. In Diusa village, the agricultural land was fallow prior to the intervention. Overall, there is a considerable increase in gross area under cash crop production and crop productivity increased around 2 to 2.5 times after irrigation intervention. Per household, farm income was highest in Kyara, followed by Diusa, Monisakri, and Taliya. There is around 5-10 times increase in income in the study villages after the installation of supplementary irrigation facilities.

iii. In those villages, like Kyara, where land is consolidated, the area under cash crop production is more, compared to villages (like Monisakri) where land is fragmented. In Diusa village, women groups started group farming on fragmented landholdings and are getting a good return from farm production. Hence, in fragmented landholdings, farmers should be encouraged to practice 'Group Farming' to cultivate selective cash crops across the entire agricultural patch. Additionally, farmers have small landholdings in the mountain region; therefore, along with irrigation facilities, efforts should also be made to increase gross crop area under production by promoting off-season short-duration vegetables and spices, such as coriander leaves, radish, pea, beans, etc.

iv. Three study villages, i.e., Rampur, Saabli, and Simoldi, are still engaged in cereals-dominated mixed cropping. In these villages, on average, per-household landholding is approximately 5 Nali, which is highly fragmented. Comparing crop production with rainfed conditions, there is around a 1.5 to 2 times increase in crop production with the availability of water for irrigation. Irrigation has substantially increased crop yield, thereby increasing farmers' income. However, other crop production issues, such as wildlife damage, cluster-based bulk production, and limited marketing facilities, hinder farmers from adopting cash crop cultivation. Therefore, in addition to irrigation, these issues should be addressed to maximise output.

v. In the unirrigated Nald village, per-household annual income from crop production was recorded at Rs. 18,300/-, which is very low compared with villages with irrigation facilities for crop production. With the expansion of supplementary irrigation facilities in the study villages, farmers' income from farm production has increased significantly. The highest household annual income of Rs 3,29,770/HH was observed in Chopriyalgaon, where intercropping of orchards with vegetables is practised. This was followed by Kyara village, where vegetables and spices are grown, and the annual family income was observed to be Rs. 2,59,430/HH. In the cereal-dominated mixed-cropping village of Rampur, the annual family income was observed to be Rs. 65,660/HH.

vi. In villages where farmers are growing vegetables and spices commercially, the production costs have increased significantly, due to greater reliance on the purchase of seeds, fertiliser, insecticides, etc. from the market. The doses of fertilisers and pesticides are increasing day by day due to a lack of proper knowledge of the package of practices. Even in villages where farmers cultivate mixed cereals and pulses, organic manure application is decreasing due to a decline in livestock population and composting practices. In addition to crop damage by wild animals, there is also an increased risk of damage from climate change, such as hailstorms and untimely rains. Often, farmers suffer heavy crop losses due to natural disasters. There is a limited support system from the government and other agencies to protect farmers from such calamities.

Investments, Institutions, Efficiency and Sustainability of Interventions

i. The investments in supplementary irrigation are being financed by external agencies. There is a limited stake of rural communities in such intervention, as their contribution is very small. In Himmotthan intervention areas, around 90% of the cost was borne by the program, while the community contributed only 10%. Even the schemes implemented by state government, line departments provide substantial subsidies to farmers. Seeing the impact of supplementary irrigation on crop production, farmers are now convinced to increase their contribution to such interventions. Therefore, there is a need to increase community contribution to enhance their accountability and ownership, which is crucial for the long-term sustainability of interventions.

ii. In those villages where land is consolidated, the individual/ group of individuals are responsible for the Operation & Management (O&M) of the irrigation system. In such cases, there are fewer operational and management issues. In fragmented landholdings, the beneficiary farmers formed a Water Users Group (WUG) to operate and manage the irrigation system. Farmers have also collected funds among themselves for maintenance. However, differences of opinion among members often lead to conflicts. Therefore, regular members' meetings are essential to implement changes to rules and regulations, as and when required.

iii. In villages like Diusa and Taliya, women have a stronghold in the WUG and are also responsible for the selection of cash crops and marketing of produce. In such villages, women play a larger role in families' financial matters and decision-making, whereas in villages like Kyara and Saabli, women's role is limited in WUG decision-making and the marketing of farm produce. In such villages, women's role ends at crop cultivation. There is also a need to expand the role & responsibilities of WUG by involving them in agronomic planning and management, such as protecting agricultural land, selecting cash crops, and marketing farm produce.

iv. Presently, there is a provision of monthly O&M collection by WUG. It was observed that the members were reluctant to deposit the tariff on a monthly basis, especially during the months when irrigation is not in practice. Therefore, crop-season-wise tariff collection based on crop production should be introduced. WUG, in consultation with members, can decide the seasonal tariff based on the farm income.

v. Creating support irrigation infrastructure is a cost-effective intervention. It involves a series of interventions, including catchment area treatment, source protection, installation of an irrigation system, a water storage structure, and a water distribution and crop production system. It is difficult to secure funding from a single source/ project for such interventions. Therefore, the work should be planned in a phased manner or in a plan-convergence approach with line departments for different works.

Limitations of the study: The study was initiated during the monsoon season. Farmers generally do not irrigate their fields from July to December because of ample soil moisture and the harvesting of Kharif crops. Missing out on the peak cropping season (March to November) and the crop irrigation season (March-June). Consequently, primary data collection should be undertaken from March to November 2026. Current findings are mainly through recall data and detailed discussions with farmers. However, this study has identified key gaps that require further action research to collect primary field data. Therefore, a concurrent Phase for the study is essential. From these Phase II exercises, field tested recommendations would emerge, which would have the potential to influence more effective and appropriate implementation and help influence policy.

The Phase II needs to focus on the action research and physically piloting in the following areas: (i) harvesting rainwater, storage structures and water distribution system to retain soil moisture in rainfed conditions; (ii) piloting on different types and capacity solar lift pumps, create appropriate structure for storage, water distribution & O&M; and (iii) promoting appropriate water distribution system to reduce water loses, optimise water use efficiency in mountain conditions and ensuring adoption of improved agronomic practices to reduce cost of production, while maintaining biodiversity along with maximizing income at farmer level.