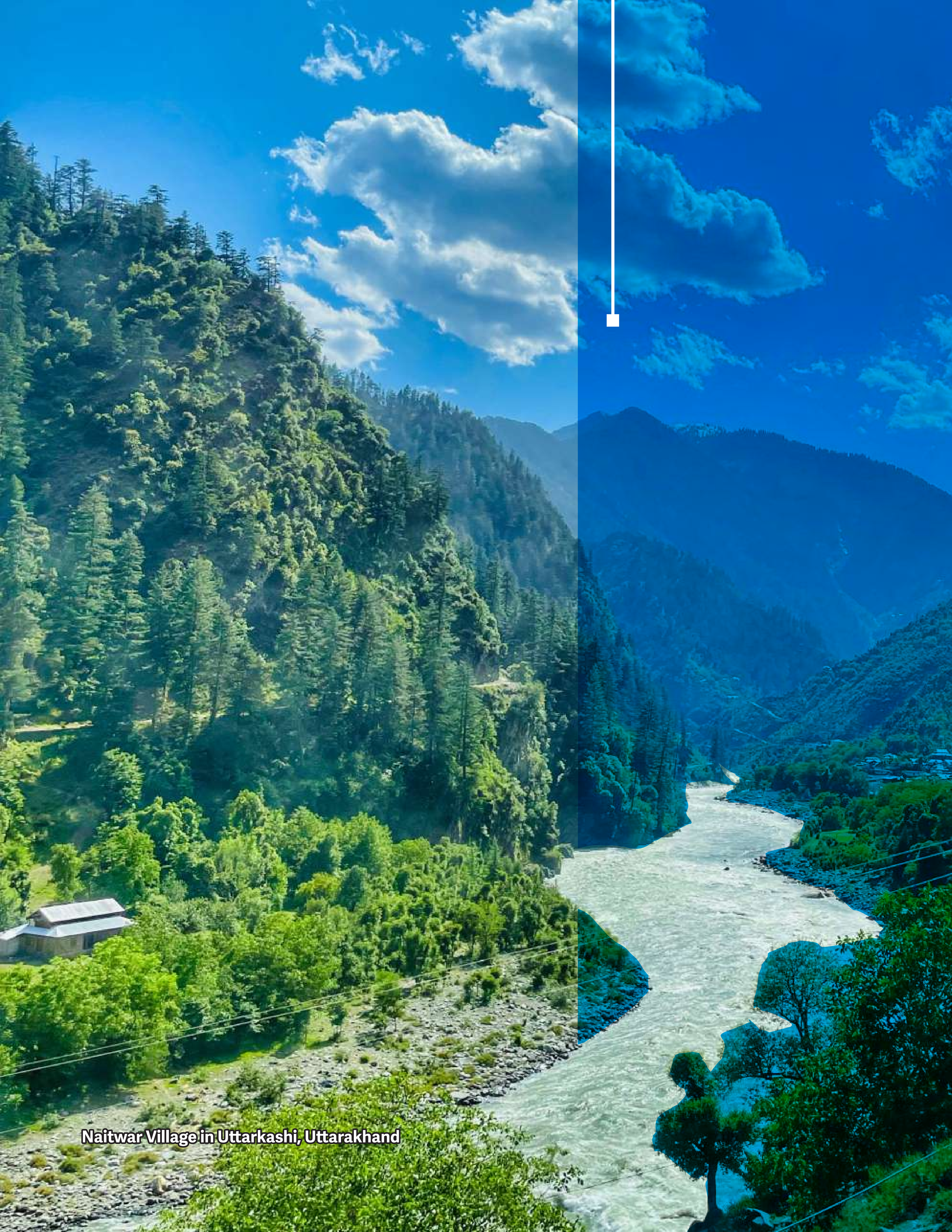
Micro-watershed for Sustainable Socio-economic Development in the Himalayas

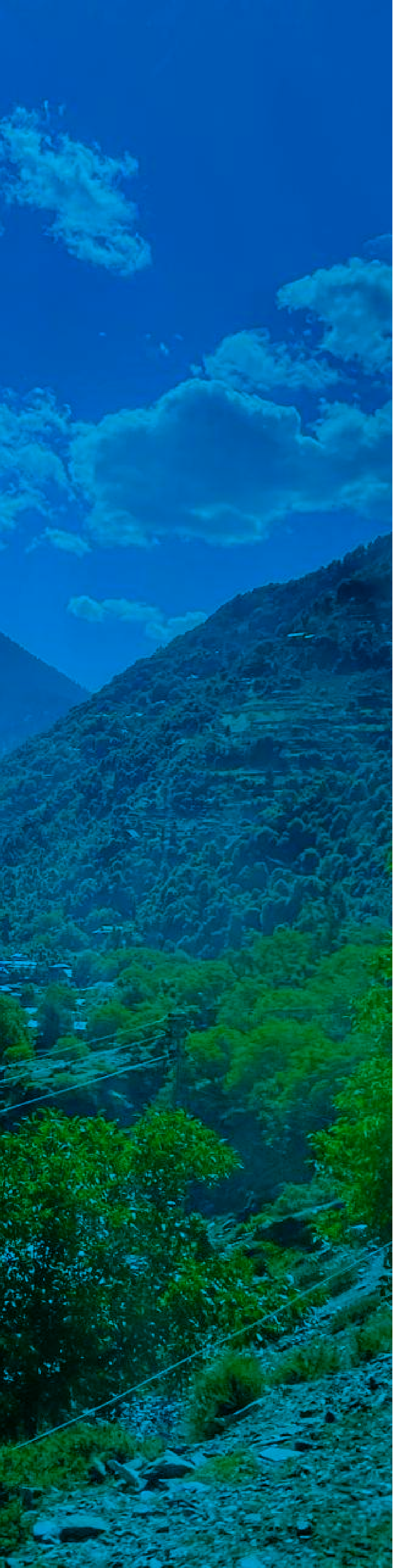
A Study of Uttarakhand Forest Resource Management Project

Sankala Foundation
Sankala Centre for Climate and Sustainability

2024



Naitwar Village in Uttarkashi, Uttarakhand



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Front Cover Photograph: Confluence of two rivers, Alaknanda and Bhagirathi, give rise to the holy river of Ganga, in Uttarakhand. Photograph by Vivek

Back inside cover photograph: Sankala Foundation research team at work

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Inspiration

Water conservation, nature conservation, these are part of India's cultural consciousness.

Shri Narendra Modi
Hon'ble Prime Minister of India

September 6, 2024 (At the launch of Jal Sanchay, Jan Bhagidari Initiative - Virtual meeting)

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Note on Study

Watershed management has been a critical component of India's development strategy for over three decades, initially conceived as a solution to water scarcity in rainfed and arid regions. Over time, its scope has expanded significantly, addressing not only water conservation but also flood mitigation, soil erosion control, forest cover restoration, and ecological balance. The need for integrated watershed management has grown increasingly urgent in light of climate-induced challenges such as erratic rainfall, prolonged dry spells, and an escalating frequency of extreme weather events.

In Uttarakhand, the challenges of water management and disaster risk mitigation are further amplified by the state's distinct topography and climatic vulnerabilities. As a Himalayan region, Uttarakhand hosts ecologically sensitive zones characterised by steep slopes, glacial rivers, and fragile soils.

The Uttarakhand Forest Resource Management Project (UFRMP), in collaboration with the Japan International Cooperation Agency (JICA), has adopted a micro-watershed (MWS) approach to address these challenges. This model emphasises ecological restoration through participatory and localised interventions. By selecting degraded forest areas for treatment and incorporating traditional water harvesting systems such as gadheras, naulas, chal-khal, and guls, the programme seeks to rejuvenate the region's water resources and improve the overall health of its ecosystems. This approach also directly addresses disaster risks by stabilizing slopes, reducing soil erosion, and restoring forest cover, which collectively enhance the region's resilience to landslides and other hazards.

The socio-economic benefits are equally significant and associated with the micro-watershed model. Uttarakhand's predominantly rural and agrarian communities rely heavily on natural resources for their livelihoods. Sustainable agricultural practices, including agroforestry, crop diversification, and the use of Non-Timber Forest Products (NTFPs), play a vital role in ensuring food security and economic well-being.

This report, prepared by the Sankala Foundation, evaluates the implementation and impact of the UFRMP-MWS programme, focusing on its ability to address ecological and socio-economic challenges in Uttarakhand. The research employs mixed methodologies, combining quantitative indicators with qualitative insights gathered from field observations, beneficiary surveys, and participatory approaches. The findings underscore the transformative potential of watershed management in restoring degraded ecosystems, enhancing water security, and supporting rural livelihoods. The report also highlights areas for improvement, including the need for sustained capacity-building, robust monitoring systems, and policy-level support for scaling these interventions.

Overall, this micro-watershed management approach documented in this report exemplifies a sustainable model for balancing ecological restoration with socio-economic development. As climate uncertainties and developmental pressures burdens the Himalayan region, scaling such initiatives will be crucial for ensuring the long-term sustainability of Uttarakhand's natural ecological systems. This report provides a comprehensive assessment of the programme and serves as a resource for policymakers, practitioners, and stakeholders invested in advancing watershed management in the region.

Amitabh Agnihotri
Distinguished Fellow

Executive Summary

This publication reviews the successes and challenges of the Micro-watershed (MWS) programme implemented by the Uttarakhand Forest Resource Management Project (UFRMP), in cooperation with the Japan International Cooperation Agency (JICA) in the state of Uttarakhand. The Sankala Foundation has compiled this research based on an assessment of the programme implementation and beneficiary interactions under the UFRMP-MWS model.

Watershed programmes in India were initiated about 35 years ago, primarily to address water availability for irrigation in arid and semi-arid zones. Gradually the concept has evolved to incorporate objectives such as improving soil moisture levels, groundwater recharge, water conservation, reducing soil erosion, and fostering sustainable forest management. The effects of climate change and changes in the predictability of our eco-climatic zones has increased water scarcity, even in areas with glaciers, snow-covered mountains, and multiple river systems.

The UFRMP has defined micro-watershed as the smallest unit of work for development projects in mountainous locations. The overall goal of the micro-watershed intervention is to contribute towards ecological restoration and the development of forest resources, which helps improve the livelihood and income generation activities of the forest-dependent communities.

The treatment area is selected based on the criticality of degraded forest (scrub, open forest, and moderately dense) that needs improvement and restoration, impacting the health and sustainability of the natural water resources considered part of the micro-watershed. The priority selection area is the forestland under the 13 forest divisions covering 37 priority Forest Ranges and the decentralised forest councils—the Van Panchayats (VPs).

State legislation empowers Van Panchayats in Uttarakhand to undertake planned forestry operations approved by the state's forest and revenue department. Accordingly, a portion of the VPs' income from Non-Timber Forest Products (NTFPs) and other fees is utilised for public utility projects and maintenance of the VPs' resources.

The UFRMP-MWS model capitalises on the central nerve of the issue, a participatory approach to decision-making at the community level. As the Division Monitoring Unit (DMU), the forest division and Van Panchayats are directly responsible for preparing the treatment plan for MWS. This approach leverages traditional and cultural water harvesting structures like gadheras, naulas, chal-khal, and guls. These structures are revived and rejuvenated so that they naturally become part of the restoration and forest ecosystem, requiring minimal maintenance from the communities.

Chapter 1 delves into the concept of micro-watershed, the ecology and hydrology of the state of Uttarakhand, and the role of local institutions like Van Panchayats. It also outlines the need for this study, its objectives, and the scope of the project. Chapter 2 explains the UFRMP institutional model, including its hierarchy and functionality. Additionally, it outlines the conceptual framework model of the UFRMP - MWS, including its project implementation and activities.

Chapter 3 provides the design of the study and methodology of the survey proposed by the Sankala team to observe, assess and understand the functionality at each layer of the project implementation. The study used a mixed research methodology of research to gain a deeper understanding of socio-economic ties and activities requiring water access. This study covered nine micro-watershed sites, 15 Van Panchayats and 247 beneficiary surveys during fieldwork.

Chapter 4 highlights the findings based on the quantitative indicators, while the qualitative analysis of each site is done using the Participator Rural Approach (PRA). Based on the implementation stage of the project, two model sites, three developed sites, and four developing sites were identified to assess the changes during a particular phase of the project.

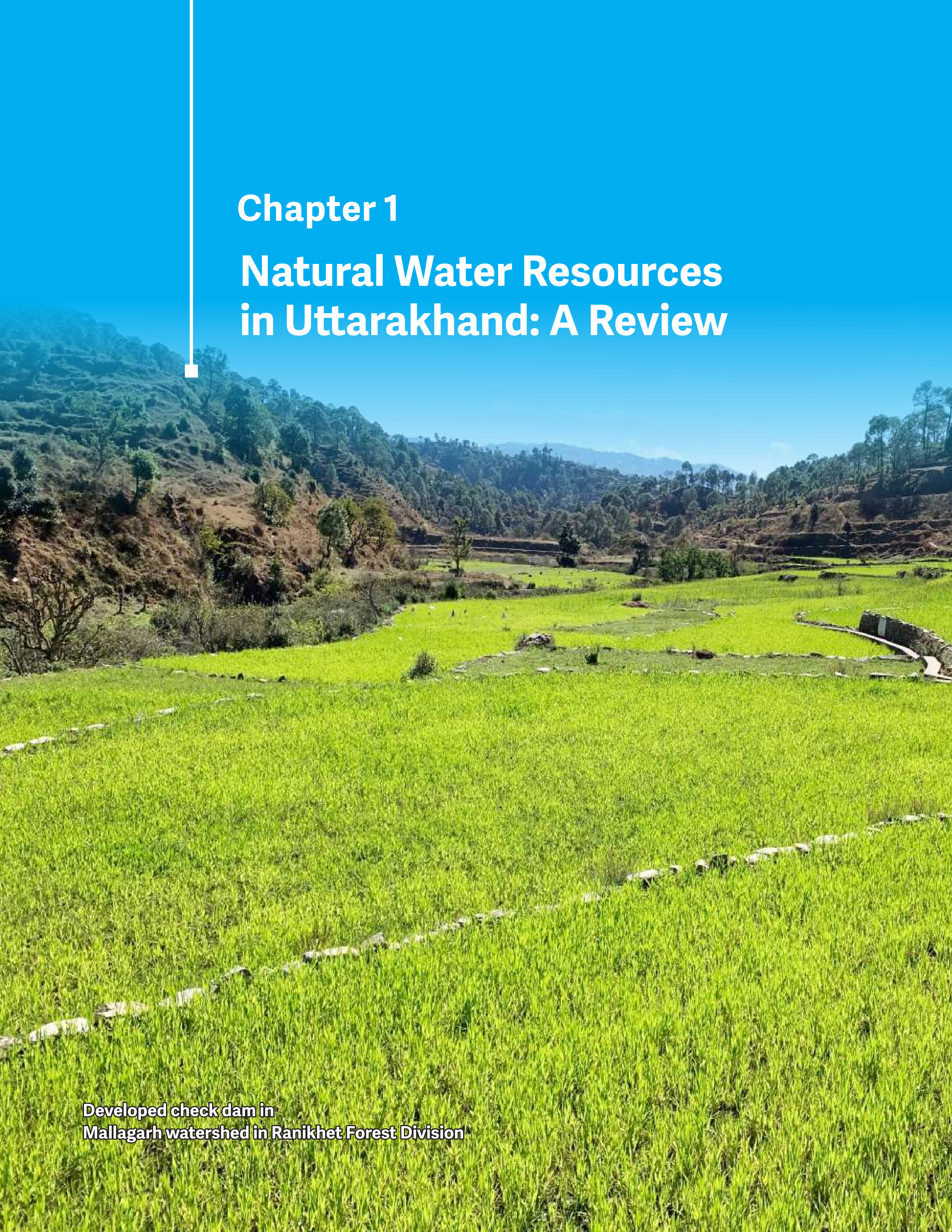
Chapter 5 emphasises the scalability aspect of the implementation structure and resource management for successful replication in Uttarakhand and other regions of the Himalayas spanning Southeast Asia. Additionally, this chapter provides case studies for each site under UFRMP-MWS and a detailed impact assessment based on the proposed model. It also highlights various indicators of change observed directly during the field. At the same time, it is also concerned about the challenges uncalculated in the model. Chapter 6 draws policy recommendations for the successful management of micro-watersheds for water security purposes at the state, national, and international levels based on the UFRMP model.

The report underscores the importance of social partnerships and community engagement in sustaining and scaling watershed programs. Early involvement of communities ensures alignment with local needs, fostering ownership and long-term support. Empowering local governance, especially VPs, through capacity building enhances their ability to manage resources effectively. Collaborative decision-making platforms encourage transparent communication and the integration of traditional and modern practices.

Watershed management should also align with sustainable livelihoods like agroforestry and non-timber forest product (NTFP) income generation, addressing both ecological and socio-economic priorities. Knowledge exchange and regular monitoring strengthen adaptive management and resilience to climate impacts. The UFRMP-MWS model serves as a replicable framework for other Himalayan regions, emphasising climate adaptation, community-driven initiatives, and the integration of traditional knowledge for sustainable outcomes.

Chapter 1

Natural Water Resources in Uttarakhand: A Review



Developed check dam in
Mallagarh watershed in Ranikhet Forest Division

The Indian state of Uttarakhand, situated on the southern slope of the Himalayas, is made largely of nearly 90% hilly terrain and topology. The state consists of snow-covered mountains, naturally forged valleys, perennial river systems like Ganga, Yamuna, etc. and steep slopes with an average elevation of 2,102 meters. Uttarakhand is further carved out into two administrative divisions, namely Kumaon and Garhwal.

The identity and culture of the two regions originate from the different dynastic rules in pre-modern times, but in the modern era, we have identified them in the following manner:

- The Garhwal region is located in the north-western part of the state, bordering Himachal Pradesh in the northwest, Uttar Pradesh in the south and the northern peak near China. It consists of 7 districts; namely Uttarkashi, Chamoli, Pauri, Rudraprayag, Tehri, Dehradun and Haridwar.

- The Kumaon region is located in the south-eastern part of the state, sharing the north-western peak with China and the south-western side with Nepal. It has six districts: Udham Singh Nagar, Nainital, Almora, Pithoragarh, Champawat, and Bageshwar.

The distinct identity of these regions holds significant relevance for various stakeholders, including research scientists, policymakers, geographers, and climate experts. Both Garhwal and Kumaon face common challenges, exacerbated by the fragile ecological nature of the Himalayas, which are among the youngest mountain ranges globally. Consequently, due to ongoing tectonic activities, these regions are highly vulnerable to natural disasters like earthquakes and landslides.

Uttarakhand's natural catchments are crucial in the broader context of water resource management. The intricate drainage systems within these catchments regulate the flow of water, impacting not only local ecosystems but also downstream regions reliant on these water sources. Thus, exploring strategies to enhance water availability and promote sustainable utilisation practices in rural catchments emerges as a pressing priority for stakeholders vested in the long-term well-being of Uttarakhand's communities and ecosystems.

This research also addresses the water challenges and water security issues faced by the state, highlighting the nuanced variations in the nature of these challenges across the Garhwal and Kumaon regions.

Water Resources in Uttarakhand

Uttarakhand has three major river systems, 19 rivers originating from the greater Himalayas with glacier reservoirs and mountain tops. Despite regular rainfall and snow, this region has been facing droughts frequently. This phenomenon requires an understanding of the hydrology of the state and a climatic or anthropogenic explanation.

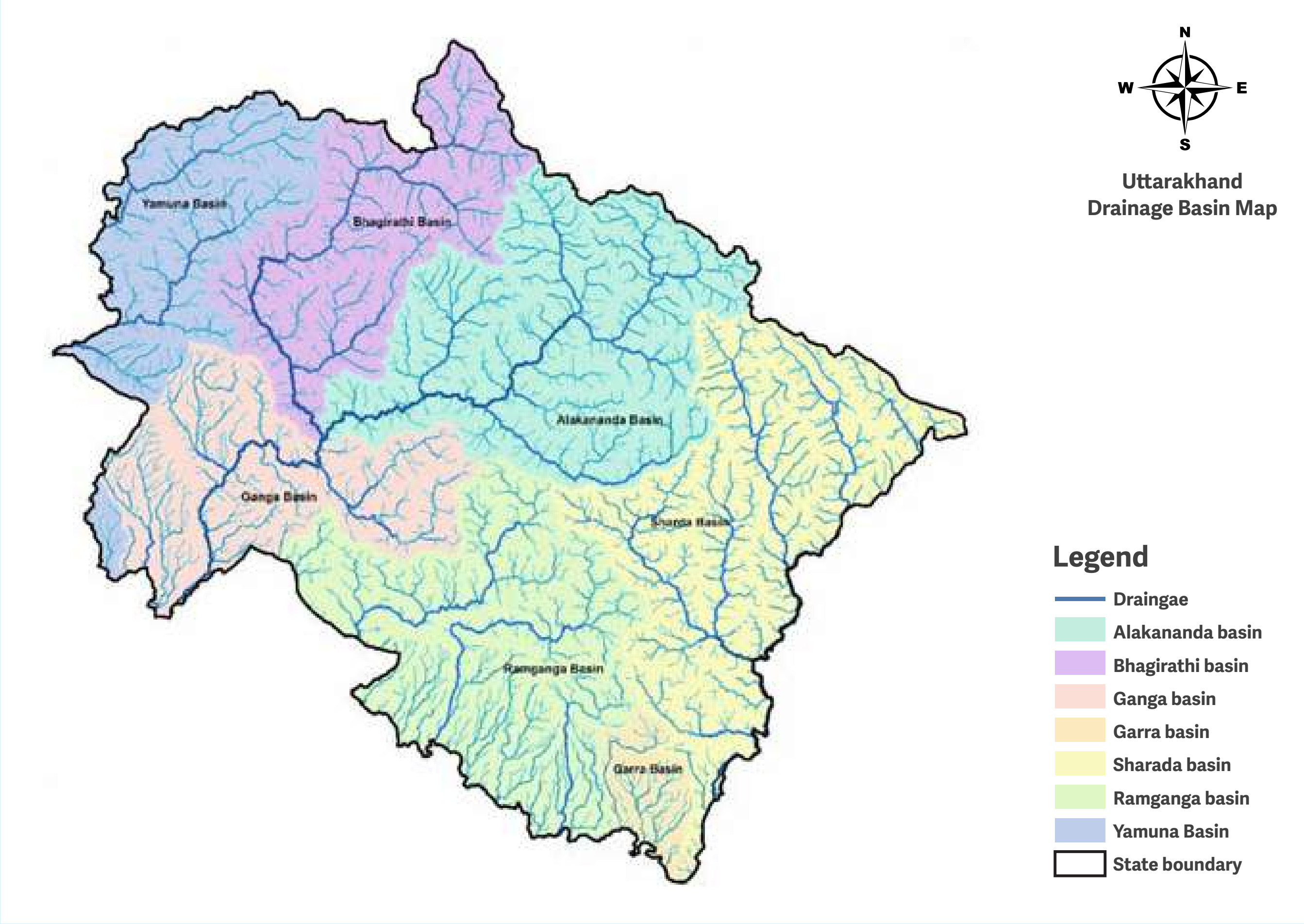
Central Himalayas – Mountain Hydrology and Drainage System

The mountainous hydrology and drainage system of Uttarakhand are characterised by a diverse array of water sources, including glaciers, snowmelt, rainfed rivers, and groundwater springs. Glacial melt from the Himalayan ranges contributes to the formation of major river systems like the Ganga, Yamuna, and Kali. The lower Himalayas and Shivalik ranges are drained by rainfed seasonal rivers. Map 1 provides the drainage basin map of Uttarakhand (Mani et.al, 2023). However, changing climatic conditions, such as decreasing snowfall and glacier retreat, are altering water availability patterns, affecting both the timing and volume of water flow.

Traditionally, communities in Uttarakhand have relied on various water harvesting structures and practices to meet their domestic and agricultural water needs. These include ponds, tanks, and other rainwater harvesting systems, often managed at the community level. However, government interventions aimed at providing water to remote villages have led to a decline in traditional water manage-

Map 1

Uttarakhand drainage basin map



Source: Chauhan, M. (2010). A perspective on watershed development in the central Himalayan state of Uttarakhand, *International Journal of Ecology and Environmental Science* ment systems, exacerbating water scarcity issues. Uttarakhand, despite being the site for origin of major rivers like the Ganga and Yamuna faces regular water shortages, as springs and streams have dried up (Chauhan, 2010).

The impact of anthropogenic activities on mountain hydrology is a subject of debate among experts, with arguments regarding scale and significance. It is important to note that local human activities can contribute to landslides and erosion, their effects may be overshadowed by larger-scale geophysical processes. However, studies suggest that land use practices, such as deforestation and agriculture, can influence water yield and flow patterns at different scales. Vegetation and land use changes have been shown to affect total water yield and stream flow timing, particularly in catchment areas of less than 500 km. Therefore, it is essential to understand the scale dynamics of hydrological processes for developing effective watershed management strategies in Uttarakhand.

Water Scarcity in Uttarakhand

Water scarcity is a relative concept and can be understood in terms of the balance between water demand and supply within a particular region. In Uttarakhand, water scarcity is typically assessed by comparing the total water available from various sources with the water consumed by people, wildlife, forests, and other ecological services.

Numerous factors contribute to the intensification of water scarcity in most countries, including the finite nature of freshwater sources, overpopulation, climate change, diminishing water reservoirs, and poorly managed water resources (UN Water, 2021). In an effort to comprehend this phenomenon, several studies have explored the situation in Uttarakhand.

One such study, 'Land use land cover change and climate change impact on water resources: A study of Uttarakhand state' (Mani et al., 2023), utilised remote sensing and GIS tools to analyse the impacts on forest cover, agricultural land, and water resources. The study presented land use and land cover (LULC) area change statistics for Uttarakhand from 2005-2006 to 2015-2016.

The findings of the study observed changes in the natural resources.

Some of these changes are:

- Agriculture, represented by crop land, witnessed a substantial increase of 2233.96 km², indicating intensified agricultural activities. Conversely, fallow land exhibited a significant decrease of 2935.21 km², suggesting a decline in land left uncultivated. Barren and unculturable areas saw shifts, with barren rocky areas decreasing by 611.81 km², while scrub land increased by 745.17 km², possibly due to changes in soil quality and vegetation cover.

- Built-up areas expanded notably, with rural and urban areas increasing by 8.83 km^2 and 278.4 km^2, respectively, indicating rapid urbanisation and infrastructure development.

- Forest areas, including deciduous and ever-green/semi-evergreen forests, experienced mixed trends, with deciduous forest cover decreasing by 1350.87 km^2, while evergreen/ semi-evergreen forests increased by 358.48 km^2. Grass/grazing lands expanded by 324.74 km^2, potentially due to changing land use practices. Notably, snow and glacier areas decreased by 203.1 km^2, indicating changes in climate patterns impacting high-altitude regions.

- Additionally, wetlands/ waterbodies, including rivers/ streams/ canals and reservoirs/ lakes/ ponds, witnessed moderate increases, highlighting changes in extending water bodies.

These findings on LULC area change statistics underscore the dynamic nature of land use patterns in Uttarakhand, influenced by various environmental, socio-economic, and climatic factors. They offer insights into the change in the demand for water resources and address the crisis of water scarcity in this mountain region.

A UNDP investigation, 'Drill down vulnerability risk assessment' conducted in 2017, highlighted the intricate factors driving water stress in Uttarakhand, focusing on the Tehri Garhwal region. Key findings revealed that deforestation, driven by infrastructure projects and local subsistence needs, has resulted in over a 50% decrease in water flow from critical sources like springs and streams, severely threatening potable water accessibility. Climate change has exacerbated this issue by increasing the risk of spring extinction due to climate variability and changes in land use and water source characteristics. Water scarcity has been identified as a significant driver of migration, particularly in the Pauri Garhwal district, where villages face severe water crises, and the acidic quality of available water necessitates arduous efforts to procure it.

Additionally, remote sensing data has shown increased susceptibility to forest fires in Tehri Garhwal, Pauri Garhwal, and Dehradun, as reduced moisture levels in the forest floor and water scarcity contribute to this risk, posing further challenges for water resource management and ecosystem preservation. The research underscores the urgent need for comprehensive strategies, sustainable forest management, and climate action initiatives to address water stress in Uttarakhand.

While intensity of the water scarcity remains challenging to quantify, several solutions have been employed to improve water resource management practices in Uttarakhand, including rainwater harvesting, watershed management, water recycling, greywater treatment, and groundwater recharge (Das, 2023). Initially targeted as drought-prone and rain-deficient areas, these solutions are now imperative globally as water resource management becomes increasingly crucial.

Micro-watershed Programme

Micro-watershed (MWS) delineates a specific geographic area within a larger watershed, typically ranging between 100 to 1,000 Ha. It represents the smallest hydrological unit where water flows into a common outlet, often serving as the fundamental unit for water resource management and conservation efforts. Traditionally, MWSs have played crucial roles in regulating water flow, mitigating soil erosion, and sustaining local ecosystems.

Within the context of Uttarakhand, MWS are integral components of the region's intricate hydrological network, particularly in the hilly terrain characterised by steep slopes and diverse vegetation. These micro watersheds contribute to the replenishment of groundwater, regulate surface water flow, and support agricultural activities through natural irrigation processes. Additionally, MWSs serve as habitats for diverse flora and fauna, enhancing biodiversity and ecological resilience.

Need of MWS in Uttarakhand

The need for Micro Watershed Management (MWS) in hilly areas, particularly in regions like Uttarakhand, is paramount due to several critical factors related to water security and natural resource management. These are:

a. **Source Water Availability:** Firstly, the geography of hilly areas poses unique challenges to water availability and distribution. With a substantial portion of freshwater stored in glaciers and underground aquifers, hilly regions often face water scarcity issues, especially during dry seasons. Effective MWS practices can help conserve water resources by promoting rainwater harvesting, groundwater recharge, and soil moisture retention, thus ensuring water security for local communities.

b. **Developmental Challenges:** The rapid urbanisation, agricultural expansion, and industrialisation occurring in hilly areas contribute to environmental degradation and water pollution. Runoff from impermeable surfaces and agricultural fields can introduce pollutants into water bodies, posing risks to both human health and ecosystem integrity. MWS initiatives focus on pollution mitigation, erosion control, and watershed protection measures to safeguard water quality and quantity.

c. **Himalayan Ecology:** In Uttarakhand, where biodiversity and ecological fragility are pronounced, MWS becomes even more crucial. The state's diverse terrain, ranging from high alpine areas to tropical regions, harbours rich biodiversity and serves as a vital watershed for numerous rivers and streams. Sustainable management of these watersheds is essential for preserving biodiversity, regulating water flow, and supporting ecosystem services vital for human well-being.

MWS Programmes in India

Grassroots organisations spearheaded watershed management programmes about 35 years back in India, initially targeting drought-prone regions. These initiatives, originally aimed at mitigating drought, later expanded to encompass broader livelihood enhancement objectives, spurred by the visible success of early projects in reviving water

Figure 1
A sample of MWS model in India created with the help of AI

bodies and increasing agricultural productivity in arid environments.

As a result, watershed management evolved into a popular poverty alleviation approach, with conservation efforts often leading to higher local productivity (Hardaha, 2001). The concept of watershed management involves complex inter-relationships between productivity, conservation, and poverty alleviation, particularly in the context of natural resource utilisation (Chauhan, 2010). However, challenges persist in directly linking poverty reduction to conservation efforts, with benefits often disproportionately favouring wealthier downstream communities.

The watersheds are classified depending upon the size, drainage, shape and land use pattern and there are five categories found in India: Macro-watershed (> 50,000 Ha), Sub-watershed (10,000 to 50,000 Ha), Milli-watershed (1000 to 10,000 Ha), Micro-watershed (100 to 1000 Ha) and Mini watershed (1-100 Ha). Following are some notable watershed programmes of the central and state governments in India:

a. **The National Watershed Development Project for Rainfed Areas (NWDPRA)** was initiated during the 9th five-year plan in 1990-91 across 25 states and two union territories. It was founded on integrated watershed management principles and sustainable farming systems. In 2000-2001, NWDPRA was absorbed into the Scheme for Macro Management of Agriculture (MMA) (Shukla, 2001). The NWDPRA adopts a community-driven approach, involving local stakeholders in planning, implementation, and management of watershed development activities(Hardaha, 2001).

b. **Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)** was launched as a social welfare programme that guarantees the right to employment for rural households, with a focus on creating sustainable livelihood opportunities and enhancing rural infrastructure. The primary objective is to enhance the income and livelihood security of rural households by providing them with employment opportunities while creating productive assets for sustainable development. Watershed development activity was identified under MGNREGA as part of its demand-driven approach, allowing rural households to demand employment for specific public works projects, including soil and water conservation measures (MGNREGA, 2005).

c. **The Integrated Watershed Management Programme (IWMP)** was launched by the Department of Land Resources, Ministry of Rural Development in 2009-10. Its objective was to cover 55 million hectares of rainfed land by 2027. The programme was designed to restore ecological balance by harnessing, conserving, and developing degraded natural resources like soil, vegetative cover, and water through watershed management initiatives. The IWMP is financed by both central and state governments in a 90:10 ratio and implemented nationwide. Its outcomes include preventing soil run-off, regenerating natural vegetation, and harvesting rainwater to recharge the groundwater table. These initiatives enable multi-cropping and the introduction of diverse agro-based activities, ensuring sustainable livelihoods for people in the watershed area.

d. **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)** is a flagship programme of the Government of India aimed at enhancing the efficiency of water use in agriculture and improving water security through various interventions. In 2015, IWMP, along with the On-Farm Water Management (OFWM) scheme and Accelerated Irrigation Benefit Programme (AIBP), became part of the *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) (Integrated watershed management for the promotion of dry land farming, 2011). It is implemented across all states in India, focusing on increasing irrigation coverage, improving water use efficiency, and promoting sustainable water management practices. The PMKSY adopts a comprehensive approach, integrating various water management initiatives, including watershed development, groundwater recharge, and water conservation measures, to achieve water security and sustainable agriculture.

The IWMP and the MGNREGA are significant initiatives in India aimed at watershed development. These programmes emphasise holistic approaches to watershed management, including afforestation, soil conservation, and water harvesting, to address water-related challenges effectively.

Lessons from MWS in India

International organisations like the World Bank (WB) and Asian Development Bank (ADB) have also supported watershed management projects in Himachal Pradesh, Uttarakhand, and Karnataka. They serve as exemplary models for integrated watershed management, offering valuable lessons for countries worldwide facing similar challenges. These projects employ participatory micro-watershed planning coupled with broader livelihood support programmes, with forests playing a significant role. Approximately 30% of the total project budgets are allocated to forestry-related programmes, emphasising the importance of environmental conservation and sustainable resource management (World Bank in India, 2017).

a) **A well-equipped Project Monitoring Unit** (PMU) staffed with trained personnel is required for effective project management. The optimum tenure for project staff is identified as at least three years to ensure familiarity with the project and effective field performance, while the MWS should be planned for a duration of five to seven years to build sufficient social capital and develop vibrant local institutions crucial for post-project asset maintenance.

b) **Capacity-building** emerges as a crucial component for sustainable outcomes, involving comprehensive training for all stakeholders. Performance-based payment systems must be designed collaboratively, ensuring fairness, transparency, and accountability among all parties involved. Besides, establishing conflict resolution mechanisms at various levels is imperative to address disputes effectively and maintain harmonious community relations.

c) **Leveraging community participation** for these projects underscore the importance of respectful and transparent interactions between agency personnel and the community, emphasising mutual respect, cooperation, and integrity. Moreover, for smooth project implementation and social cohesion, transparency and public accountability are identified as key factors.

d) **Socio-economic factors** like empowerment, and mainstreaming of women, the poor, and vulnerable groups in decision-making processes are essential for project sustainability. Networking and collaboration with local developmental agencies facilitate value addition and resource access in the post-project period.

In India, projects involving multiple agencies benefit from institutional arrangements that leverage each partner's comparative advantages. Engaging NGOs with technical and managerial expertise can enhance project efficiency and accountability, allowing project authorities to focus on monitoring and overall management. These lessons offer valuable insights for designing and implementing watershed management programmes worldwide, fostering sustainable development and environmental conservation.

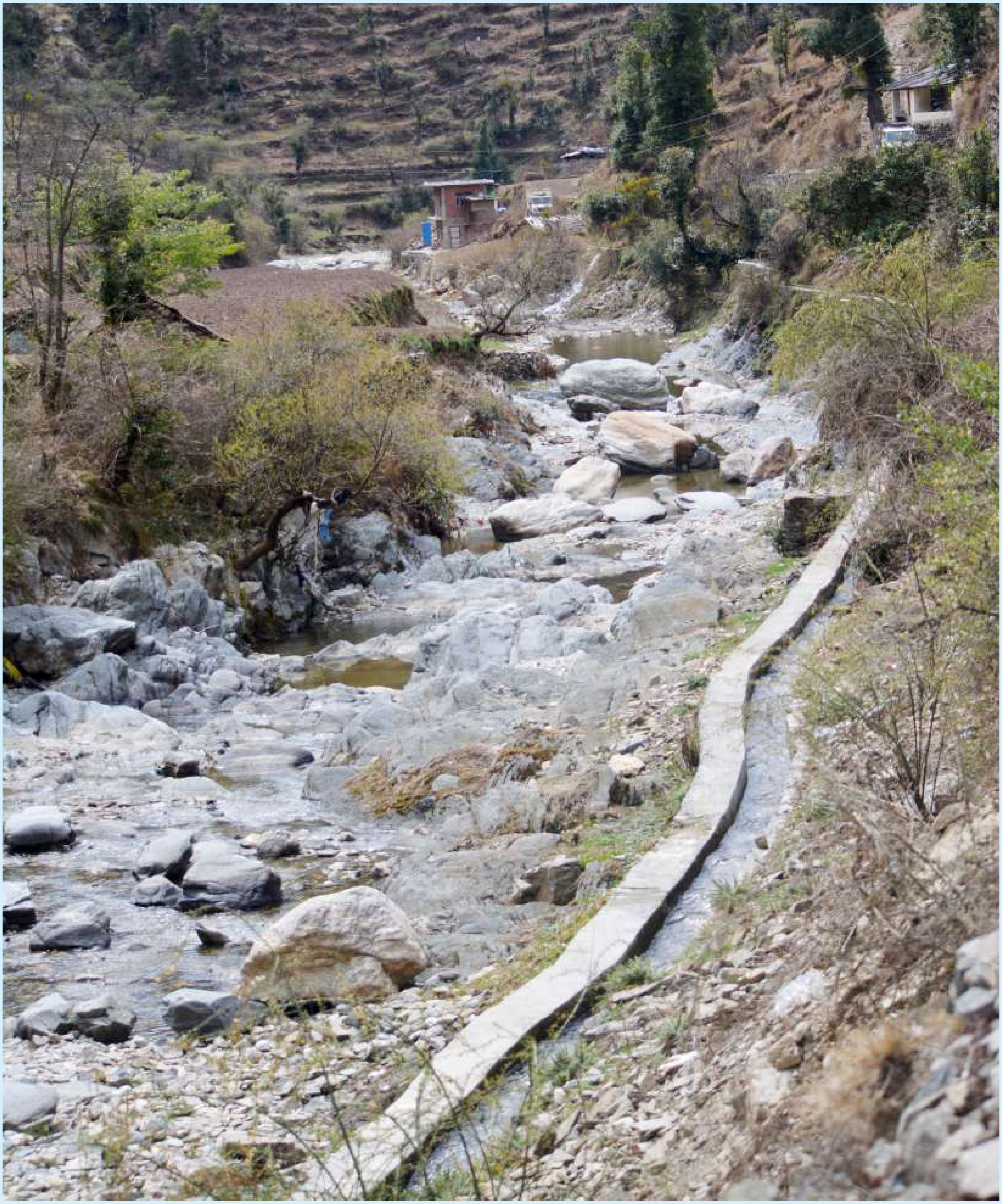
Innovative Practice in Himalayan Region

To illustrate the importance of MWS and showcase innovative practices, various case studies from international and South Asian regions with similar ecological characteristics to the Himalayas can provide valuable insights (see Table 1, p. 13). These case studies highlight successful watershed management initiatives that have revitalised degraded areas, enhanced income opportunities, and promoted sustainable livelihoods while ensuring ecological balance and equitable distribution of benefits.

Role of Van Panchayats

Van Panchayats, or forest councils, are local community-based forest management institutions in Uttarakhand, India. These institutions have been traditionally established to manage and govern forest resources at the grassroots level, making them one of the earliest examples of co-management in the region. Van Panchayats play a significant role in forest conservation, afforestation, and sustainable resource management practices.

The origins of Van Panchayats trace back to early 20th century when communities in Uttarakhand recognised the need to collectively manage forest resources to ensure their sustainability. Over time, these institutions have evolved and are now formally



↑ Developed irrigation infrastructure in a micro-watershed project

Table 1

Innovation in Micro-watershed Models in Himalayan Region

Innovation in Micro WLocation	Practice	Innovative Practice	Benefits
Nepal (Dolpa region)	Fog harvesting (BBC, 2016)	Nets capture moisture from passing clouds, providing a valuable water source in arid regions.	Increased water availability in dry areas.
Nepal	Community-Managed Irrigation Systems (CMIS) (Khadka, 2017)	Local communities manage and maintain irrigation canals, fostering ownership and efficient water use.	Improved water management in agriculture, reduced waste.
Bhutan	Bio-engineering for slope stabilisation	Techniques like planting vegetation on slopes control erosion and protect water sources in mountain ecosystems.	Reduced soil erosion, improved water quality and availability.
Uttarakhand (India)	Check dams, gully plugs and drip irrigation	Check dams and gully plugs: small structures in streams and ravines slow water flow, reduce erosion and promote rainwater infiltration. Drip irrigation: Water-efficient systems deliver water directly to plant roots, minimising waste in agriculture.	Reduced soil erosion, improved groundwater recharge. Reduced water consumption in agriculture, increased crop yields.

recognised under various forest management policies and laws.

The role and responsibilities of Van Panchayats include:

a) Conservation of forest resources: VPs work diligently to protect and preserve forest ecosystems, including flora and fauna, to ensure their sustainability for future generations.

b) Sustainable resource utilisation: They regulate the use of forest resources such as timber, fuelwood, and non-timber forest products to prevent overexploitation and promote sustainable harvesting practices.

c) Afforestation and reforestation: VPs actively engage in tree planting activities to increase forest cover and combat deforestation and land degradation, contributing to the overall health of the ecosystem.

d) Community empowerment: These institutions empower local communities by involving them in decision-making processes related to forest management. By fostering a sense of ownership and responsibility towards forest resources, VPs contribute to the sustainable development of the region.

The functioning of VPs in Uttarakhand, particularly in forest conservation and natural resource management, reflects a unique blend of community ownership and state oversight. The VPs operate within a regulatory framework established by the Van Panchayat Act of 1931, which mandates that these community-managed forests cannot engage in clear-cutting or impose high fines. However, within these constraints, VPs have the autonomy to devise their own rules of management, monitoring, and enforcement. This decentralised approach allows for democratic decision-making procedures at the local level, ensuring that forest management strategies align with the needs and priorities of local communities.

Despite their significance, VPs represent only 11% of the total forest area in Uttarakhand and are mostly localised in certain pockets, such as the Almora and Pithoragarh districts. While there are over 12,000 VPs in the state, some are merely notional entities on paper, lacking active community engagement and meaningful participation in forest management.

Therefore, the emergence of VPs was accelerated during the mid-1990s, partly driven by a state policy aimed at improving forest status through participatory governance. However, the local response to these initiatives has been mixed, with many communities viewing them as temporary sources of casual employment rather than vehicles for sustainable forest management. Additionally, bureaucratic controls on the incomes generated by VPs have raised concerns about democratic decision-making processes at the local level.

Over time, the Van Panchayat Act has undergone amendments to address issues of control and accountability. However, critics argue that bureaucratic interventions threaten the autonomy and effectiveness of VPs in achieving their objectives. Nevertheless, empirical evidence suggests that the challenges faced by VPs stem from broader socio-economic variables rather than just regulatory frameworks. Factors such as changes in land use patterns, economic incentives, and community dynamics also influence the functioning of VPs on the ground.

In this study, the VPs of Uttarakhand have been considered crucial for forest conservation and natural resource management, leveraging community participation and local knowledge to safeguard forest ecosystems. However, their effectiveness is contingent upon addressing challenges related to bureaucratic interventions, community engagement, and sustainable funding mechanisms.

Project Rationale

The rationale for focusing on watershed management in Uttarakhand stems from the region's ecological significance and the pressing need for sustainable resource management. The India State of Forest Report for 2021 highlights the importance of forest cover, with approximately 3,800 hectares designated as forest land. However, concerns arise from moderately dense forest cover reduction, driven partly by developmental activities.

Under the National Forest Policy of 1988, the hill districts are assessed separately to monitor a minimum of two-thirds of forest coverage. This policy ensures the fragile ecosystem of the hilly areas, reduces land degradation, and controls soil erosion. Furthermore, Uttarakhand's intricate river systems, freshwater sources, and natural aquifers underscore the critical importance of watershed management for water catchment, absorption, and soil sustainability.

Moreover, Uttarakhand's susceptibility to natural disasters such as heavy rains, flash floods, earthquakes, and landslides emphasises the need for effective watershed management to preserve water conservation and soil stability. Constructing water reservoirs within natural structures can help mitigate these risks and enhance water resource resilience.

The region needs to improve watershed management in Uttarakhand, as it is essential for sustaining water quality, quantity, and overall ecosystem integrity. We can safeguard habitats and ensure the availability of clean water for human consumption and other essential needs by implementing cooperative and comprehensive measures focused on pollution mitigation, erosion control, and water resource preservation.

Objectives

Below are the overarching objectives of this study.

a) Understanding the UFRMP Model of Micro Watershed, its core principles, institutional structure, project approach, and innovative strategies for addressing water scarcity in the project area.

b) Develop a survey to assess the interventions in natural drainage systems, evaluate water conservation efforts, and gauge beneficiary reach.

c) Evaluate planned treatment works in the project area, including progress, phases, outputs, and encountered challenges through surveys and field observation.

d) Document user benefits, such as changes in farming practices, livelihood activities, community ownership of structures, and water availability.

e) Based on feedback and case studies, assess the UFRMP model for its impact on addressing water scarcity challenges and recommend its replicability, scalability, and sustainability.

Scope of the Study

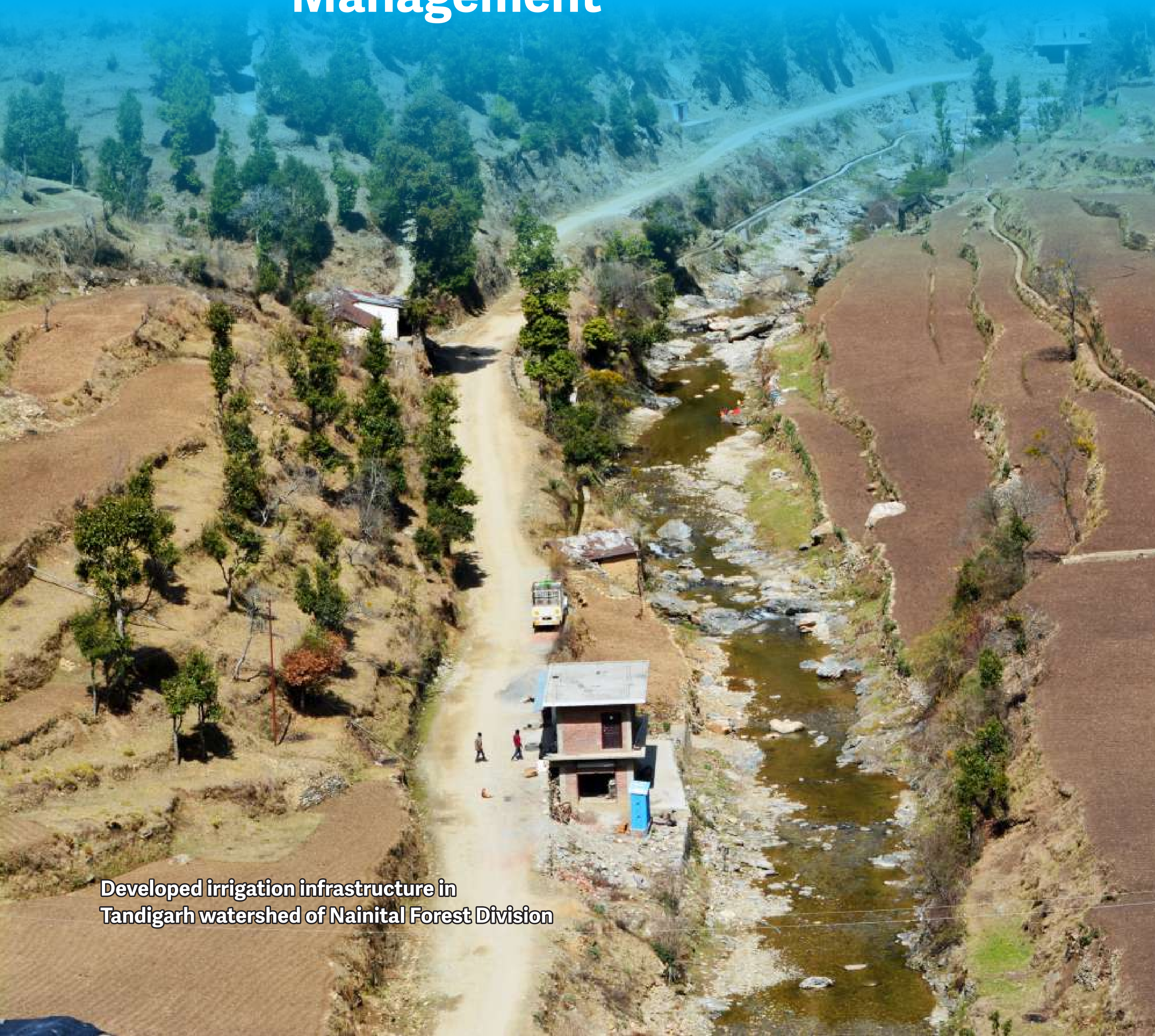
The scope of research under this project encompasses a comprehensive exploration of watershed management practices, decentralised forest governance, and the imperative to address water scarcity in the Himalayan region of Uttarakhand, India. The research will delve into the intricate dynamics of MWS, examining their relevance, effectiveness, and challenges within Uttarakhand's diverse ecological landscape.

This study reviewed the literature, and employed qualitative and quantitative methodologies to collect data, that included stakeholder interviews and field surveys to understand the complex interplay between ecological, socio-economic, and institutional factors shaping watershed management outcomes in Uttarakhand. The study attempted to examine the institutional mechanism that ensures working with VPs across the region and addresses their uniquely different challenges related to water resource management.

This research aimed to provide valuable insights and recommendations for policymakers, practitioners, and stakeholders in promoting sustainable development, environmental conservation, and water security in the Himalayan region. By bridging the gap between research and practice, the findings of this research endeavoured to inform evidence-based decision-making and facilitate the implementation of targeted interventions for the holistic well-being of Uttarakhand's communities and ecosystems.

Chapter 2

UFRMP Model of Micro-watershed Management



Developed irrigation infrastructure in Tandigarh watershed of Nainital Forest Division

The Uttarakhand Forest Resource Management Project (UFRMP) is a collaborative effort between the Government of Uttarakhand and the Japan International Cooperation Agency (JICA) to tackle forest degradation. The Japan International Cooperation Agency coordinates international development assistance. The UFRMP is implemented through the Uttarakhand Forest Resource Management Society (UFRMS), a registered entity under the Society Registration Act 1860, focused on restoring degraded forests and improving livelihoods in Uttarakhand.

The objectives of the Uttarakhand Forest Resource Management Project are:

UFRMP project aims at addressing the problem of forest degradation in the identified forest fringe areas of the state. The project aims at controlling forest degradation, improvement of livelihood options and income generating activities of the people living in the target area, thereby reducing their dependence on forests.

The project is implemented by Van Panchayats (VPs), which are community-based organisations in forestry sector, ensuring their capacity development in the process.

According to the original project timeline, this collaboration was planned for eight years, starting from 2014-15 to 2021-22, which was later extended for two more years due to COVID-19 (Nippon Koei Co., 2014). The project comprises several components aimed at achieving its objectives:

a) **Eco-restoration:** This component focuses on rehabilitating degraded forests, promoting non-timber forest produce (NTFP)-based livelihoods, conserving biodiversity, managing wildlife, and undertaking other eco-restoration activities. The UFRMP Eco-Restoration progress so far has achieved significant milestones, including securing and preparing 20,006.89 hectares of land, which was classified as partially degraded. For the land classified as degraded and completely degraded have successfully facilitated the plantation of 12,450.8 trees across 16,536.3 hectares, with a variety of species such as Baanj, Deodar, and Amla, demonstrating a comprehensive approach to ecological restoration.

b) **Livelihood Improvement and Community Development:** This component involves community mobilisation and micro-planning, entry point activities (EPA) for improving basic human needs, NTFP enterprise development, livelihood enhancement through community-based eco-tourism, and improvement of non-NTFP-based livelihoods.

c) **Other Support Activities:** These include preparatory works such as logistic support to project management units (PMU), district management units (DMU), forest management units (FMU), village panchayats (VPs), and geographic information system (GIS). Additionally, capacity building of executing agencies and village-level institutions, applied research, publicity, monitoring, and evaluation are undertaken.

d) **Erosion Control and Sediment Disaster Mitigation:** This component focuses on slope stabilisation, river training, emergency shelter construction, and overseas disaster management training.

Institutional Setup of UFRMP

The Uttarakhand Forest Resource Management Project is a registered society, constituted to function as Project Management Unit (PMU). This autonomous body functions parallel to the state government counterparts. Chief Project Director (CPD), who is in the rank of CCF or above heads the UFRMP and is supported by Deputy Project Director and Joint Project Director for day-to-day operations. The office of UFRMP is located at the IT Park, Dehradun, to maintain close proximity to the state department.

For all the project areas, the macro-planning, design, research, consultation and deliberation take place at the PMU. A Project Management Committee constituted and helped set up ongoing projects at the initial stage of the project deliberation and planning. Additionally, a dedicated team is onboarded at the Dehradun office through open market sourcing, consisting of experts, policy practitioners, consultants and technical personnel to provide guidance, hand-holding, monitoring and evaluation of the project progress.

Furthermore, the UFRMP's structure encompasses collaboration at various levels:

a) **State-level Federation:** The state-level federation is a prominent association overseeing forestry, conservation, and environmental operations at the state level. Apart from collaborating closely with government agencies, NGOs, and local communities, its responsibilities include policy advocacy, resource mobilisation, capacity building, and fostering collaboration among stakeholders.

b) **Forest Divisions**: Forest divisions represent executive units responsible for managing timber resources within specific geographical areas. In Uttarakhand, where timber cover is extensive, forest divisions play a crucial role in biodiversity conservation, watershed management, and sustainable utilisation of timber resources. Their tasks include afforestation, timber protection, wildlife conservation, ecotourism development, and community engagement. Forest divisions work closely with local communities, timber-dependent industries, and government agencies to ensure the ecological integrity of forest ecosystems while addressing socio-economic needs.

c) **Van Panchayats**: Under UFRMP model, Van Panchayats are recognised as direct beneficiaries and are provided with technical and financial support from state-level agencies in partnership with developmental and environmental organisations. This support aims to strengthen the capacity of Van Panchayats in forest conservation and management practices.

In its formation stage, the UFRMP envisioned integrating remote sensing technology to plan, develop, implement, and monitor the project. GIS and MIS professionals are housed at the Project Management Unit office in Dehradun to facilitate effective project implementation and monitoring. This technological support enhances the efficiency and effectiveness of Van Panchayats in fulfilling their roles in forest conservation and natural resource management.

UFRMP Micro-watershed Model

The Micro-watershed Model under the UFRMP is developed within the broader framework of ecological restoration, focusing on soil and water conservation to enhance local livelihoods. This model aims to optimise the utilisation of perennial water sources and revive dormant irrigation channels, thereby augmenting agricultural activities and improving the socio-economic conditions of the local communities.

Objectives of MWS Model

a) **Optimum Utilisation of Perennial Water Sources**: The primary objective is to maximise the utilisation of water flowing in drains or water bodies throughout the year (Perennial Drains) within selected micro watersheds. These water sources, which may currently be underutilised, will be harnessed to meet various needs, including agricultural irrigation, thus contributing to enhanced water security and livelihood improvement.

b) **Soil Erosion Control:** Another objective is to mitigate soil erosion within the area by implementing measures to treat the catchment area of selected drains. By implementing soil conservation techniques and recharging water sources, the aim is to increase the flow of water in these drains, thereby reducing soil erosion and preserving soil fertility for sustainable agriculture.

c) **Revival of Dormant Irrigation Channels:** The model seeks to revive previously constructed irrigation channels known as *guls* in the villages located within the catchment area of the drains. These channels, which are currently unused due to water scarcity, will be revitalised to ensure the availability of water for agricultural purposes, thereby revitalising agricultural activities and improving local livelihoods.

d) **Enhancement of Soil Moisture Regime**: The model aims to enhance the soil moisture regime of the area by reducing runoff in the catchment area and increasing percolation. By implementing measures to reduce surface water runoff, such as contour trenching, bunding, and afforestation, the goal is to facilitate greater infiltration and groundwater recharge, ultimately leading to improved soil moisture retention and agricultural productivity.

1) MWS Planning and Implementation

Establishing a Micro-watershed Management Plan within the UFRMP framework involves a systematic approach encompassing various steps to ensure effective water resource conservation and management. Here's an overview of the top-down approach of planning and implementation process under this project:

a) **Survey and Mapping**: The initial step involves conducting a comprehensive survey and mapping of the area to identify natural topographic features such as ridges, valleys, and watercourses. This helps in delineating the boundaries of the micro-watershed and understanding the flow of water within the area.

b) **Stakeholder Engagement**: Support and cooperation of the local communities, village leaders, and other stakeholders is essential under this project. Especially, to gather information about water-related challenges, traditional practices, and community needs. This participatory approach ensures that the management plan is inclusive and addresses local realities effectively.

c) **Assessment of Water Resources:** Quantifying and assessing the quantity and quality of water resources within the micro-watershed is crucial to understanding its current status and potential challenges. This involves analysing factors such as rainfall patterns, surface water flow, groundwater availability, and water quality parameters.

d) **Identification of Priority Areas**: Based on the survey and assessment, priority areas for intervention are identified. These may include sites prone to erosion, degraded lands, waterlogging areas, or locations with inadequate water access. The impact on the daily activities of nearby communities is considered to ensure that interventions align with local livelihoods.

e) **Treatment Plan Development:** Once priority areas are identified, a treatment plan is developed in consultation with stakeholders. This plan outlines specific activities and measures to address water-related issues and improve water management within the micro-watershed. Examples of activities include water and soil conservation measures, construction of water harvest structures, sustainable agricultural practices, and public campaigns for awareness and education.

f) **Monitoring and Evaluation:** Regular monitoring and evaluation are essential to assess the effectiveness of the management plan and make necessary adjustments. This involves measuring changes in water quality, soil erosion rates, vegetation cover, and community engagement levels. Monitoring ensures that the treatment plans are on track and meeting the desired outcomes.

Conceptual Framework of MWS

Based on the understanding of the UFRMP-MWS model, select areas and the interventions methodologies, this report adopts this model from a similar study conducted by Chavan, Ekal, & Salokhe in 2021, which evaluated the integrated watershed impact assessment of Jalyukt Shivar Abhiyan in Maharashtra.

This conceptual framework was proposed based on the project parameters and key indicators for assessing the impact, which are water harvesting structures, ecosystem restoration, soil erosion control, agricultural productivity, and socio-economic impact.

Figure 2 helps evaluate the impact of UFRMP model of micro-watershed project in the state of Uttarakhand in following manner:

1) UFRMP - MWS Model

This model comprises two primary processes: project implementation and impact assessment, with a focus on beneficiary response and ecological restoration work. The UFRMP-MWS Micro Watershed (MWS) model was conceptualised within the framework of an eco-restoration model, aiming to facilitate the rehabilitation of forest land. The following section provides a detailed understanding of this model

i) **Project Implementation:** The implementation of the MWS project follows a top-down approach, where project planning, site selection, and treatment area assessment occur at the PMU level, while the DMU and Van Panchayats are part of implementation, maintenance and evaluations of the project.

a) **Project Monitoring Unit (PMU):** Target areas for the MWS project are chosen based on spatial analysis of forest cover near Van Panchayats or clusters of Van Panchayats. GIS analysis identifies degraded forest areas for eco-restoration efforts. Catchment areas are delineated, and forest ranges, source rivers, watersheds, and micro-watershed sites are mapped. A web-based Monitoring and Information System tracks physical and financial activities from the Divisional Monitoring Unit (DMU) and Field Monitoring Unit (FMU).

b) **Divisional Monitoring Unit (DMU):** Ground truthing of selected project areas is conducted at the DMU level, supplemented by a population census of Van Panchayats. This data includes potential beneficiaries, livestock population, occupations, agricultural activities, and reliance on forest products. The respective forest division oversees the implementation of treatment plans, MWS structure construction, and plantation activities.

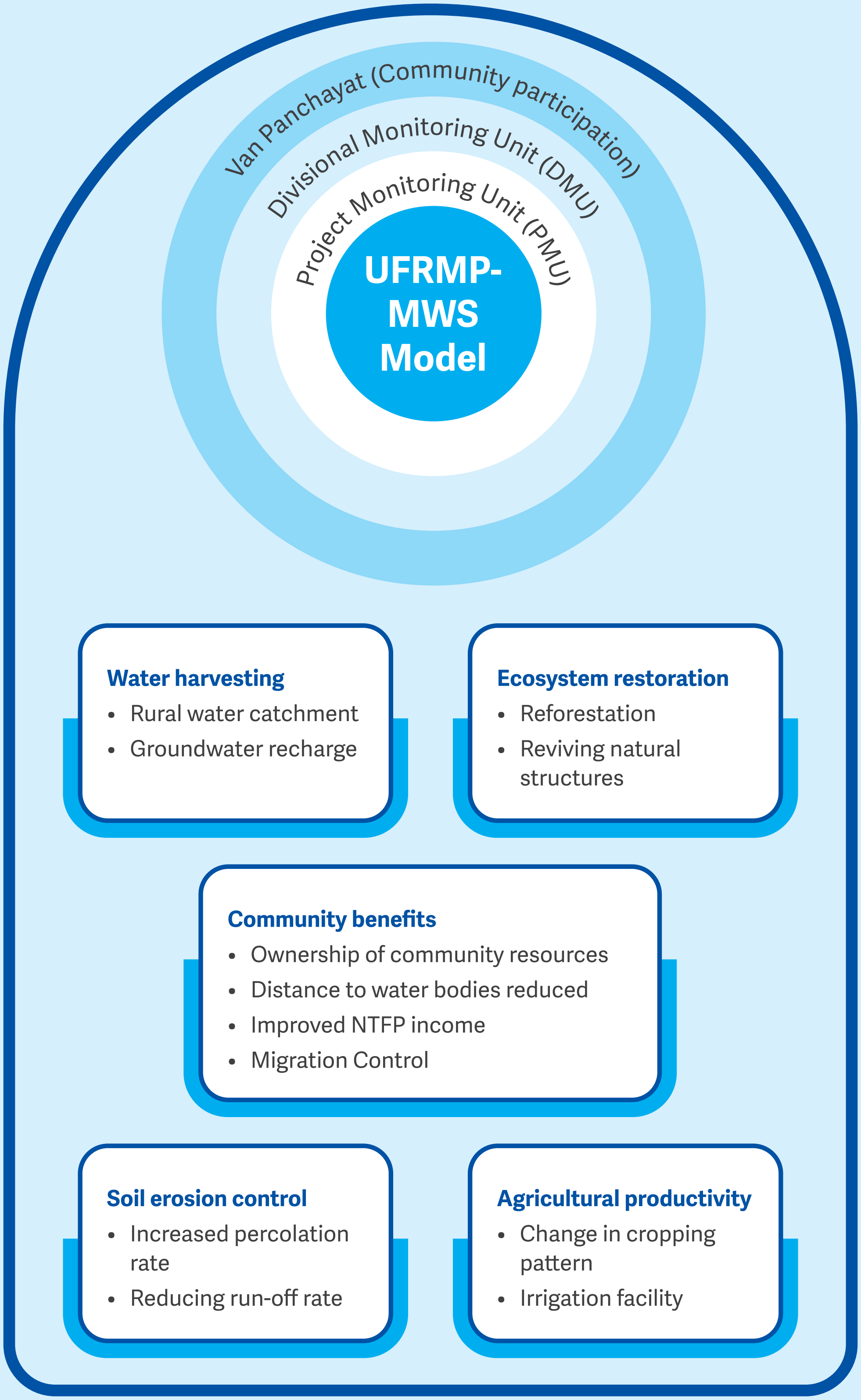
c) **Community Participation at Van Panchayat:** Van Panchayats develop comprehensive micro-plans through the Participatory Planning Approach (PPA) and Participatory Rural Appraisal (PRA). They implement treatment plans, engage in conservation activities, and identify traditional and natural water sources for revival. Roof water harvesting is proposed at Van Panchayats to recharge groundwater levels, alongside constructing collection tanks at households and community-owned buildings. Community participation and ownership of MWS structures are pivotal for model sustainability. The maintenance of smaller structures like guls and chal-khals is the responsibility of the community, while the forest divisions manage larger structures such as check dams and ponds (jalkunds).

ii) **Project Activities**

a) **Water Harvesting:** Water harvesting and conservation are central to MWS structure sustainability and eco-restoration efforts. Various water harvesting structures are revived or built, as detailed in Table 2. to achieve targeted objectives and benefits. Each MWS site creates specific structures in the project area to address water scarcity issues and improve ecological resilience.

Figure 2

Conceptual Framework of MWS Implementation and Impact Assessment



Source: This model has been prepared by Sankala Team based on the MWS structure

Table 2

Water harvesting structures under MWS

Name	Structure description	Usage	Benefits
Ponds / Jalkund	The size of the jalkund can vary depending on needs, but a typical size is 5 meters x 4 meters x 1.5 meters (holds around 30,000 litres). It is ideally built on hilltops where advantage of natural slope helps disperse water and its Inner walls are lined with non-porous material to prevent leaks.	Jalkund is a small, man-made pond used to collect rainwater in hilly areas. It's a simple and cheap way to store water during the rainfall (May-September/ The structure conserves the water for usage for dry season (October-April) when water is scarce.	Jalkund acts as a natural reservoir for irrigation, sustaining agricultural activities. It also supports livestock and facilitates fish farming.
Gully Plug / RR Dry Check Dam	It a small, temporary or permanent dam- like structure constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows. It is made out of stones walls in the curvature of downward stream to control the flow of the water.	Temporarily promotes the establishment of permanent soil cover while trapping sediments to conserve soil and water.	It improves soil moisture retention and groundwater table recharge. It can boost agricultural productivity and prevent soil erosion. It also offers a certain design range of storm events and to conserve soil moisture.
Check Dams	Wire crate/gabion check dams are used for retention of debris in the main nallas and are constructed by filling of stones in wire mesh cage. The size of the wire mesh is generally kept 15cm x 15 cm and the wire used for these cages is galvanised iron wire of 8 - 7 gauge (4 - 4.5 mm).	These structures are widely adopted for the treatment of drainage lines because they are flexible (bend without breaking), porous (water can seep through them) and are economical as compared to masonry structures.	Economical and easy to construct, aiding in erosion control and debris management. It is cost-effective in comparison to big dams and easy to construct. These structures installed to lower flow velocity in drainage ditches or water channels, preventing runoff.
Chal-khal (Contour trenches)	Chal-khals are small man-made ditches act as pond on middle slops of the mountain. These are used to collect rainwater from the upper slopes.	Traditional recharge pits designed for water and soil conservation.	Mitigates water and soil erosion, promoting sustainable land use. Increases percolation rates and groundwater recharge, benefiting river systems.

Table 2 continued

Name	Structure description	Usage	Benefits
Roof Water Harvesting Tanks	These structures are made to collect rainfall on roofs of houses and other buildings through a system of pipes and semi-circular channels of galvanized iron or PVC and stored in tanks suitably located on the ground or underground.	It is used to collect rainwater from roofs for direct consumption or to recharge the groundwater source.	It can help alleviate water scarcity issues by recharging the groundwater or conserving water for irrigation.
Contour Bunding	Stone barriers built along the contour of sloping fields to reduce runoff and increase water filtration.	This is part of the sustainable land management practice of hilly/mountain region (Taman, 2020). It helps to control soil erosion, promote water retention, and increase crop production.	Reduces soil erosion and nutrient loss by retaining runoff water in the watershed. Ideal for hilly terrain and areas prone to erosion.
Naulas	A small temple-like structure made with stones. It is basically a water tank which catches dripping water from springs and streams.	Traditional water harvesting structure in the hilly region. They are considered sacred therefore culturally significant.	Alleviates water scarcity issues, particularly in areas lacking surface water sources. Provides source for drinking water.

- Rural Water Catchment: Uttarakhand, despite its abundant river systems and Himalayan connection, grapples with water scarcity issues, especially in rural areas. Factors contributing to this challenge range from mountainous terrain to anthropogenic influences, but the state's hydrology primarily revolves around water conservation. Deforestation and reliance solely on rainwater exacerbate soil erosion, emphasising the importance of rural water catchment initiatives.

- Groundwater Recharge: Traditional methods like chal-khal and contour bunding enhance soil moisture retention and water filtration, which are crucial for eco-restoration and forest preservation. Modern approaches like roof water harvesting bolster groundwater recharge, facilitating irrigation and elevating water table levels in targeted areas.

b) **Ecosystem Restoration:** The mountain communities of Uttarakhand have traditionally depended on the forests for livelihood, fuel, grazing for animals, sustenance and medicinal needs. These forests have significant cultural impact on their lifestyle. By ensuring the sustainability of forests, the safety of these communities can be assured as it can help reduce the rate of migration and threats to wildlife and bio-diversity in these regions. Under this project, site selection for the treatment work is centered around addressing these challenges and improving the forest land in these areas, being one of the parameters for impact assessment.

- Reforestation: The ecosystem restoration as the name suggests is the treatment of the damaged and degraded forest land with help of retaining soil moisture level and improving the soil health in a manner that the ecology can survive on its own (Khudsar, 2023). The reforestation on the other hand is the plantation of the native species in the historically identified forest lands. The new plantation undertaken for this project can be identified as such.

- Reviving Natural Structure: This MWS model, in an attempt to maintain the historic way of preservation and conservation of the forest has focused more on leveraging the traditional structures of water conservation. These structures while operating without technical interventions are functional and most efficient in improving the eco-restoration process. *Guls*, *chal-khals* and *naulas* have been part of the mountain ecology for hundreds of years and provided water security therefore sustaining the biome without any external intervention. Improving the soil moisture level and groundwater recharge can also lead to reduction in forest fire and improved agricultural production.

c) **Community Benefits:** The forest-dwelling communities are survived by the richness of the forest and natural produce while they are also the guardian of the forest as they help conserve and propagate the resources and control forest fires. Under this model, the Van Panchayats are considered the direct beneficiary of the improved ecosystem services in following manner.

- Ownership of Community Resources: This model is building water harvesting and water conservation structures within the forest areas and community land of Van Panchayat. As per their institutional role, these resources are the assets built in the communities, which can last generation and benefit in the harsh climatic conditions of drought or heatwaves. Although, these structures as seen benefiting the community requires proper management and repairment from these communities in timely manner.

- Distance to Water Bodies Reduced: Despite having three major river systems and 19 rivers originating from the greater Himalayas, the residents of Uttarakhand face difficulty accessing water sources. One of the major reasons is lack of sub-rivers and water source systems due to the hilly terrain. The Watershed and Micro Watershed Systems are built to bridge this gap. Under this model, the priority was to improve rural water catchment area and improve the capability to store rainwater and recharge the groundwater level resulting in eco-restoration and reducing the distance to water bodies.

- Improved NTFP Income: These forest communities depend on non-timber forest products not just for sustenance for livelihood as well. Products like fruits, vegetables, nuts, resin, rubber, medicinal plants, natural oils, herbs and bamboo are found naturally in the forest, which helps these communities improve their income, conditional only on the health and sustainability of the forest cover. This is a mutually beneficial relation and under this model, this goal can be measured not only by income improvement but to reduce the rate of migration.

d) **Agricultural Productivity:** It is expected that the intervention shall augment the overall agriculture. Increased irrigation facility enables farmers to take cash crops, and multiple crops, which eventually leads to an increase in agricultural income of the farmers. Moreover, there is a potential for significant improvement in soil moisture and groundwater levels, which further encourages farmers to diversify their crops, including cash crops, thereby boosting their income. Evaluating the effectiveness of the intervention is crucial, necessitating the provision of irrigation facilities alongside rainfed agriculture.

- Change in Cropping Patterns: Improvements in soil health and the availability of irrigation water are pivotal in bolstering agricultural productivity. This approach enables farmers to adapt their cropping patterns, allowing for the cultivation of multiple crops throughout the year. By diversifying their crops, farmers can enhance their livelihoods and income streams, thereby reducing dependency on single-crop farming practices. This shift in cropping patterns underscores the transformative impact of improved soil health and irrigation infrastructure on agricultural sustainability and economic prosperity.

- Irrigation Facility: The provision of irrigation facilities plays a pivotal role in enhancing agricultural productivity and sustainability. By ensuring consistent access to water resources, farmers can mitigate the risks associated with rainfed agriculture and cultivate crops throughout the year. Adequate irrigation infrastructure supports crop growth, improves yield quality, and reduces the vulnerability of agricultural systems to climate variability. Therefore, investing in irrigation facilities is essential for promoting agricultural resilience, increasing food security, and fostering rural development.

e) **Soil Erosion Control**: Soil plays an important role in the process of improving the degraded forest areas, reviving the natural structure and fostering the eco-restoration. Water harvesting structures like MWS can improve the soil health and vegetation growth.

- Increased Percolation Rate: The implementation of water harvesting structures like the MWS model fosters improved soil moisture retention and vegetation growth. This, in turn, enhances the rate of percolation and mitigates soil erosion. By arresting soil erosion, the model aids in preserving soil integrity and fostering sustainable land use practices.

- Reducing Run-off Rate: Over time, the MWS model contributes to the restoration of degraded land by minimising the runoff rate. By limiting runoff, the model prevents further land degradation and facilitates the rejuvenation of ecosystems. This process is essential for restoring ecological balance and promoting long-term environmental sustainability.

Evolution of MWS under UFRMP: Phase-wise Development

The evolution of Micro Watershed Management under the UFRMP has progressed through distinct phases, marked by strategic planning and on-ground implementation. Initiated in 2019-20, the project embarked on its first phase by identifying 32 micro-watershed areas spread across the Tehri - Garhwal and Kumaon regions of Uttarakhand (See Table 3).

Out of these 32, 22 MWS sites have been selected from the Kumaon region, while only 10 from the Gharwal region. This distinctively indicates the water source availability in the Kumaon region, while the water stressed Garhwal region lacking behind in sustaining the natural water structures. Table 3 gives a classification of the Soil Conservation (SC) and Forest Divisions (FD) and the phase-wise implementation of the MWS project under UFRMP.

In a comprehensive GIS analysis, various drainage networks within the project area were delineated. Priority was given to MWS areas housing perennial water sources, laying the foundation for subsequent interventions. Particularly, attention was directed towards existing perennial *nalas* (streams) within these MWS especially those with defunct diversion channels (*guls* or *nehars*). The revival of these channels was deemed critical alongside broader micro - watershed treatment endeavours.

Under this model, each proposed structure is tailored to address the unique hydrological characteristics of the micro - watershed regions, aiming to optimise water conservation and management efforts. Through these targeted interventions, the UFRMP aims to foster sustainable resource utilisation, enhance agricultural productivity, and uplift the socio-economic well-being of local communities across Uttarakhand's diverse landscape.

Table 3

Evolution of MWS under UFRMP: Phase-wise development

32 Sites of MWS under UFRMP

Forest Division	2018-2019		2019-2020	
	MWS	Nala Selected	MWS	Nala Selected
Addl. SC FD Ramnagar	Mandal Nadi	1	Badangarh	1
			Devgarh	1
C&S FD Pauri	–	–	Dhaijuli	1
			Edgarh	1
SC FD Alaknanda	–	–	Aatagarh	1
			Kandai	1
			Baramgarh	1
SC FD Lansdowne	–	–	Lansdowne	1
			Gairoli	1
SC FD Nainital	–	–	Ghatgad	1
SC FD Ranikhet	–	–	Mallgad	2
Bageshwar FD	–	–	–	–
Mussoorie FD	–	–	–	–
Narendranagar FD	–	–	–	–
Tehri Dam-1	–	–	–	–

Table 3 continued

2020-2021		2021-2022		2022-2023	
MWS	**Nala Selected**	**MWS**	**Nala Selected**	**MWS**	**Nala Selected**
Katora Raula	1	Haldu Gadhera	2	Kali Nadi	1
–	–	–	–	Tarpalisain	1
Naunagad	1	–	–	Choptagad	1
Gwaldam	1				
–	–	–	–	–	–
Dhouna	1	–	–	Logada Khal	1
Tandigad	1				
Muthugad	2	Muthugad	1	Maiger Nadi	1
Joshigaon	1	Dharamgad	3	Gaganigad	2
		Bilkhet	1		
Chipaldi	1	–	–	–	–
Dubra	1				
Song	1	–	–	–	–
–	–	–	–	Jakhnoli	1

Source: UFRMP official website www.jicauttarakhand.org

Chapter 3

Study Design and Methodology

Developed check dam infrastructure in Tandigarh watershed of Nainital Forest Division

This chapter provides a brief understanding of the methodology employed to comprehend the UFRMP model from the planning stage to the implementation strategy, including the use of technology and the beneficiary survey conducted by the Sankala team.

The Sankala research team relied on both qualitative and quantitative methods of evaluation. The three stages of project design and implementation are outlined below.

The site selection for this study was based on a proportional sampling method, reflective of the total project size and regional distribution of the MWS sites. As detailed in Table 3, the project has developed 32 MWS sites in Uttarakhand since 2019, with two-thirds (22 sites) located in the Kumaon region and the remaining 10 sites in the Garhwal region. To maintain proportionality, approximately 28% of the total sites (9 sites) were selected for this study from six forest divisions.

The particular site was selected after a discussion with the PMU based on the project stage.

The sampling was conducted in a 1:2 ratio between Tehri-Garhwal and Kumaon sites. Specifically, as shown in Table 4, three sites from the Garhwal region are located in the Pauri and Alaknanda Forest Divisions, while the six sites from the Kumaon region are situated in the Ramnagar, Nainital, Ranikhet, and Bageshwar Forest Divisions. Additionally, the table categorises the MWS sites into three phases based on the project implementation stage, providing a basis for future analysis to identify and compare progress across different stages.

The three phases for understanding the stage of implementation are as follows:

i) Phase 1: These are model sites developed in the initial stage of the project during 2019-20 in the Kumaon region. Both of these sites are connected with perennial river sources and collect rainwater for annual use predating the project. The implementation and development of these sites were during pre-COVID, which is significant for comparative analysis.

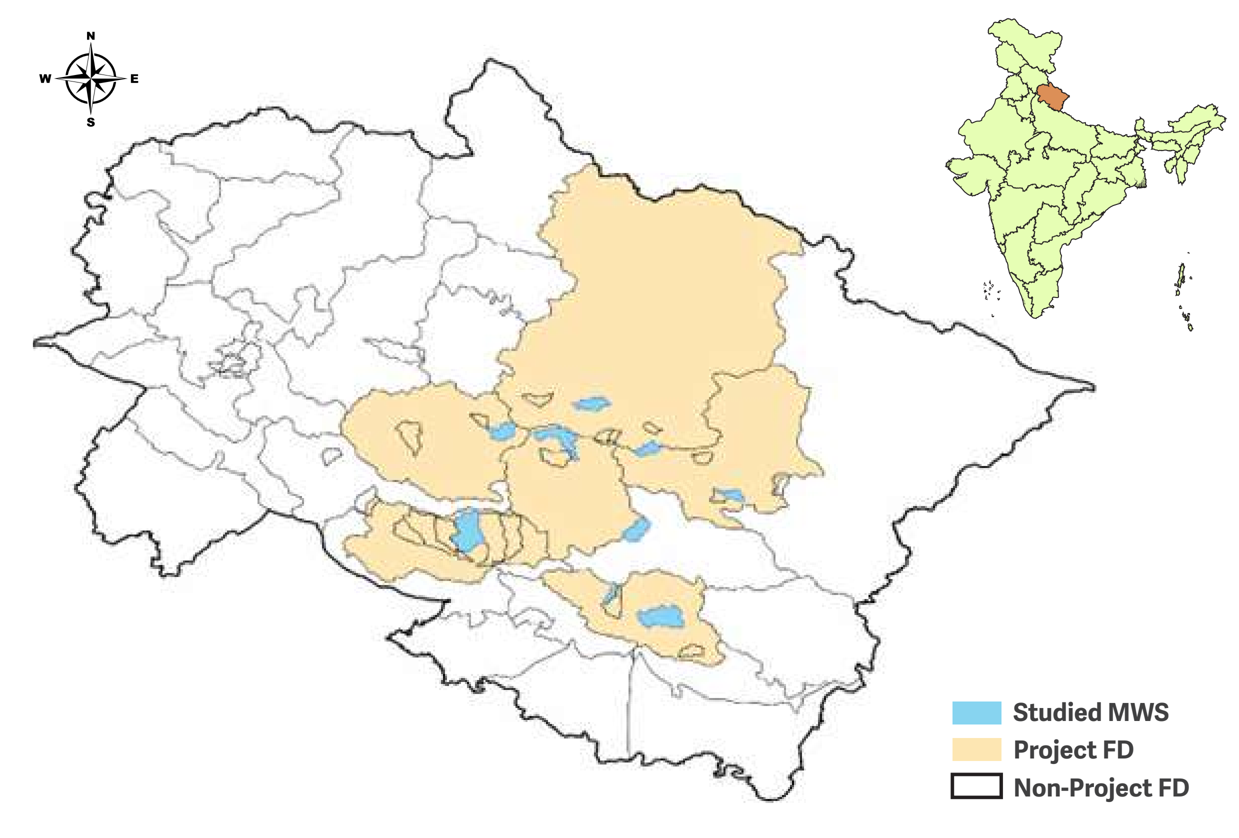
ii) Phase 2: Developed in 2020-21, these three sites are in the completion stage of the project implementation but have faced challenges due to COVID-19 restrictions on public gatherings during the development process. Two of these sites are in the Kumaon region, while one is located in Garhwal.

Table 4

Micro-watershed Under Study Design				
Region	Forest Division	Model Sites	Developed Sites	Developing Sites
		Phase 1: 2019-20	Phase 2: 2020-21	Phase 3: 2021-23
Tehri-Garhwal	**Pauri (SC & FD)**			Tripalisain
	Alaknanda (SC & FD)		Gwaldam	Choptagad
Kumaon	**Ramnagar (SC & FD)**			Kali *Nadi*
	Nainital (SC & FD)	Ghatgad	Tandigad	
	Ranikhet (SC & FD)	Mallgad	Muthugad	
	Bageshwar (SC & FD)			Bilkhet

Map 2

Selected Sites for Study under Micro-watershed



Map prepared by Ravina Yadav of Sankala Foundation

iii) Phase 3: The four sites selected are developed between 2021-23 and are the most recent sites. While the physical infrastructure has been built, the benefits yielded and progress on its original objectives are on a slow mend. Out of four, two sites are built in the water-stressed Garhwal region, leading to some innovation and interesting strategies in water resource management.

Baseline Indicators Identification

In the next stage, the research team engaged with the PMU to understand the project objectives and the assessment mechanism developed by the team. This engagement provided a detailed understanding of the treatment plans, activities undertaken, and stages of project implementation. During this time, the team also familiarised themselves with the GIS functionality developed by the PMU for project scope and site selection. The MIS provided data on project monitoring at various levels. At this stage, the team gained an understanding of the size and scale of the project, as displayed in Map 2, which provides a GIS-based understanding of the project undertaken for this study report.

Individual reports of the MWS sites were shared by the PMU, outlining the project from inception and planning to implementation based on the needs survey conducted by the DMU. These reports helped identify and curate a list of basic indicators and types of structures proposed under each MWS site, along with their financial implications.

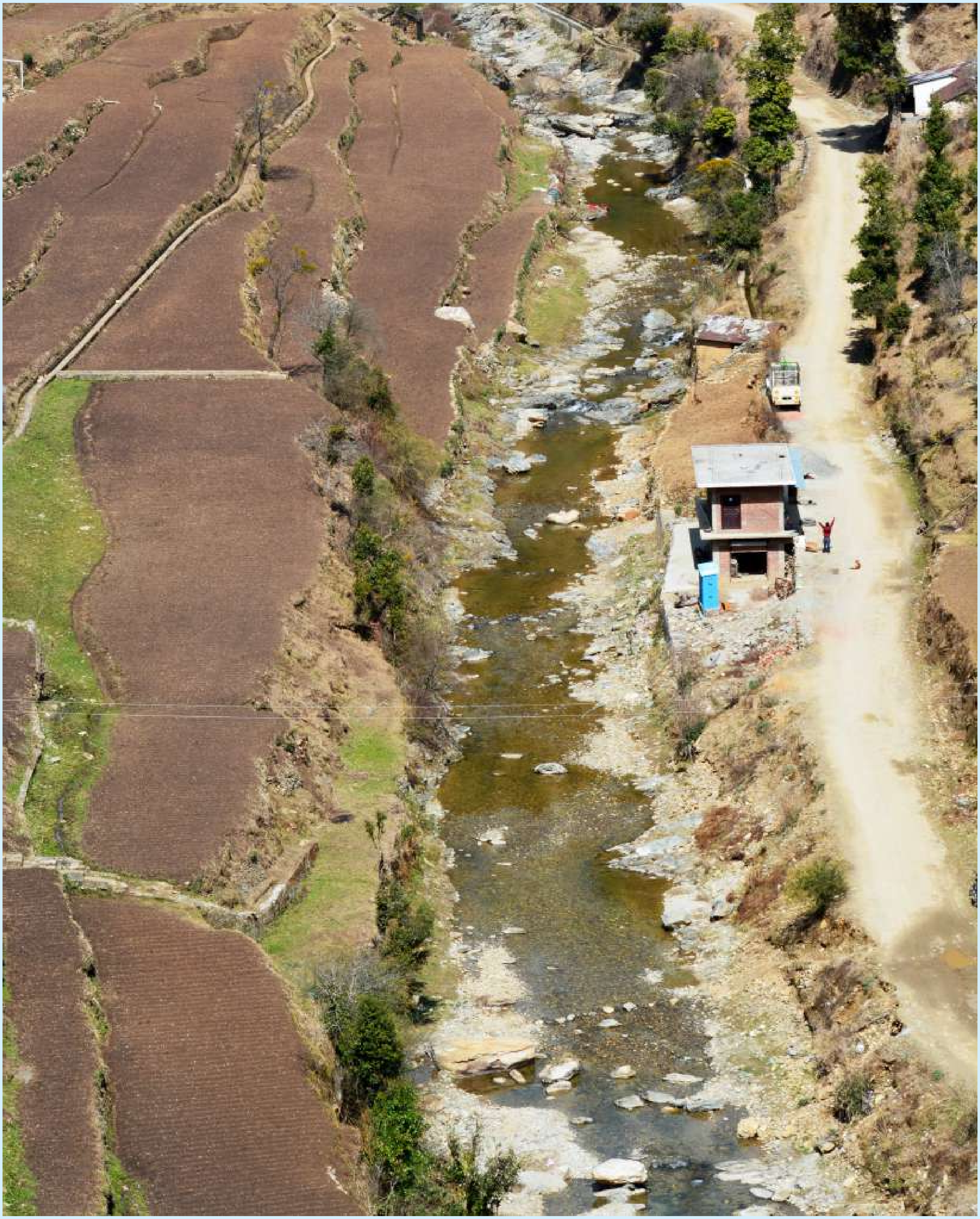
Table 5 displays the number of MWS structures identified from the reports in each of the selected sites, which allowed the team to verify the information on the field.

Table 5

List of Water Harvest Structures Built Under the Selected MWS Sites

Forest Division	Micro Watershed Name	Total Ponds	Total Gully Plugs	Total RR Dry Check Dam	Total Chal-khal	Total Crate Wire Check Dam	Roof water Harvesting Tanks
Nainital	Ghatgad	3	-	-	110	6	2
Ranikhet	Mallgad	3	-	-	56	9	15
Ranikhet	Muthugad	3	42	48	50	10	20
Nainital	Tandigad	3	15	22	40	13	6
Alaknanda	Gwaldam	3	35	35	30	10	-
Bageshwar	Bilkhet	4	38	-	55	12	-
Ramnagar	Kali Nadi	2	39	24	50	7	-
Alaknanda	Choptagad	3	26	28	26	10	-
Pauri	Tripalisain	3	50	30	25	7	-

Developed irrigation infrastructure in Tandigarh watershed of Nainital Forest Division



Survey Design for Data Collection

The team undertook secondary research and developed a literature review to compare various models of MWS programmes with their features. This helped build a comparative understanding of MWS models in India, especially the ones employed by the central and state governments. Special attention was paid to various national and international techniques used in MWS, particularly in the Himalayan areas.

Based on the research, we decided to employ a mixed-method survey of quantitative and qualitative approaches to supplement the information collected by the reports.

1) Quantitative Survey

A survey questionnaire is an ideal tool for collecting quantitative data, which has been developed under this project. A snowball sampling method was carried out at the ground level for the survey questionnaire. Upon reaching the project sites, some households were randomly selected, and beneficiaries were requested to participate.

These questions were divided into main classifications: Question 2 focused on collecting socio-economic data of the household (HH); Question 3 aimed at identifying the primary water resource used by the family and its distance; Question 4 aimed to find out the benefits from the MWS and its impact on agriculture, if any; and Question 5 focused on identifying the change in water availability. A detailed question list for this exercise is attached in Annex - I.

The questionnaire designed was uploaded on an application-based platform named Clappia for easy survey filling, which collected data on the backend, including verification of GIS location of assessor for full transparency.

2) Qualitative Survey

This study adopted the Participatory Rural Appraisal (PRA). This approach provides an opportunity for community development, participation, and understanding of the project firsthand. With the help of open-ended questions and focused group discussions led by the field team, this method can uncover the motivations, strengths, opportunities, and challenges that surround the implementation process. It provides opportunities for analysing the resource base, problems, and developmental opportunities by incorporating the rich experience of primary stakeholders and expertise of technical experts (service providers) in joint meetings. Triangulation further provides opportunities to improve in the initial development plan and create interest among primary stakeholders (Jhakhar et. al., 2010).

While the beneficiaries are directly engaged, it can also provide perspective to understand their lives, traditions, beliefs, and goals on one hand, while it can open up detailed intervention of their needs, demands, unique challenges, and feedback on the other hand.

To evaluate the VPs, the decentralised forest councils for this MWS project, PRA became a natural, cost-effective, and informative method, which can fetch information from a broad spectrum. Some basic questions were prepared and asked to prompt the feedback on matters like water availability in the region, any support or programmes for water supply, forest products for sustenance, routine lifestyle, and traditional practices undertaken to manage community water bodies. With the help of DMU and forest division officials, meetings were set up with beneficiaries at VP level for the PRA. A detailed question list for this exercise is attached in Annex I under question 6, 7, and 8.

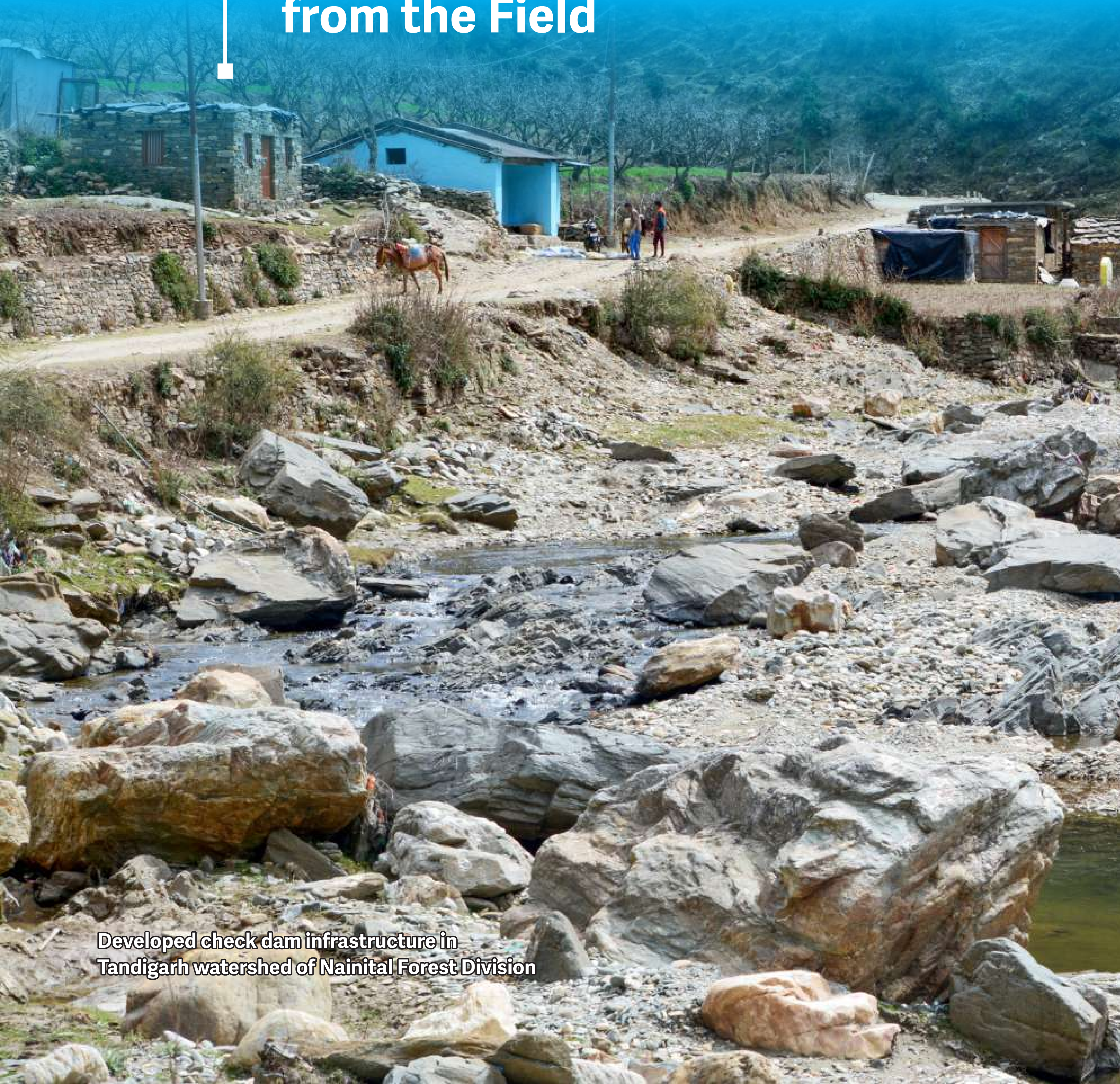
Project Limitations

During the fieldwork for the survey, the team encountered several challenges. Firstly, there was limited access to recent data, which hindered the ability to make informed decisions and accurately assess current conditions. Additionally, the seasonal scarcity of water in water bodies complicated the evaluation of water resources and their management. A lack of awareness among field rangers and some beneficiaries further impeded effective data collection and engagement with local communities.

Lastly, accessibility to various structures within the survey area posed logistical difficulties, making it challenging to comprehensively cover and assess all relevant sites. These limitations collectively impacted the survey's scope and accuracy, underscoring the need for enhanced data availability, community awareness, and logistical planning in future efforts.

Chapter 4

Findings and Observations from the Field



Developed check dam infrastructure in Tandigarh watershed of Nainital Forest Division

This chapter represents the findings from the field surveys, which were conducted to understand the community's demographic profile, need for water, sources of water conservation, and natural resource management under this model. It also highlights the observations and findings collected with qualitative methods.

Summary of the Findings

Out of the nine MWS sites, six sites are from Kumaon region while three from the Tehri-Garhwal region. During the fieldwork, a total of 247 beneficiary surveys were conducted from 14 Van Panchayats, which are mentioned in Table 6. Out of these 247 surveys, 58 beneficiary surveys were conducted under Phase 1 sites, 127 beneficiaries were surveyed under Phase 2 sites and 62 beneficiaries were surveyed under Phase 3 sites. There 247 beneficiaries were interviewed under 14 PRAs conducted across 9 MWS Sites.

For the discussion of the quantitative parameters of the survey, the study has eliminated the Tripalisian site of Phase 3 from the Garhwal region. The treatment plan discussed under this MWS site was in progress. Therefore, the potential beneficiaries could not respond to the survey questionnaire. However, the team on the field conducted a PRA in Gheravaram Van Panchayat to understand the water-related challenges of the area and the community participation in the primary discussion with the forest department and DMU.

This study will interpret the data collected based on the questionnaire in four sections. The sections are as follows: 1) Demographic profile of the respondent household and beneficiaries 2) Source water for use by households and agriculture 3) Major agricultural products and cropping patterns and 4) Water availability before and after the MWS project implementation.

1) Demographic Profile

The quantitative questionnaire begins with the collection of unique data by recording each respondent with his/her name, age, gender and literacy level. Additionally, to capture the socio-economic profile of the beneficiary household, data is collected on family size, community, economic activity, crops undertaken, livestock, family members migrated, land holdings etc. This profile helps identify the traits of the rural household under study. For example, the primary occupation and literacy level can point towards the potential of livelihood options. Additionally, the agricultural land and the livestock population are related to the economic well-being of the family.

Graph 1

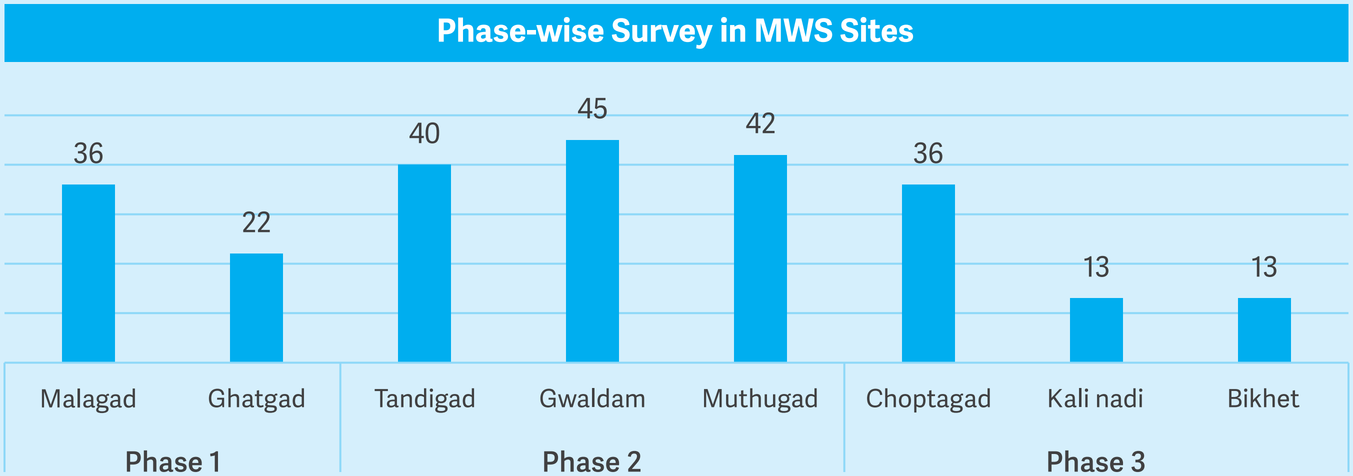


Table 6

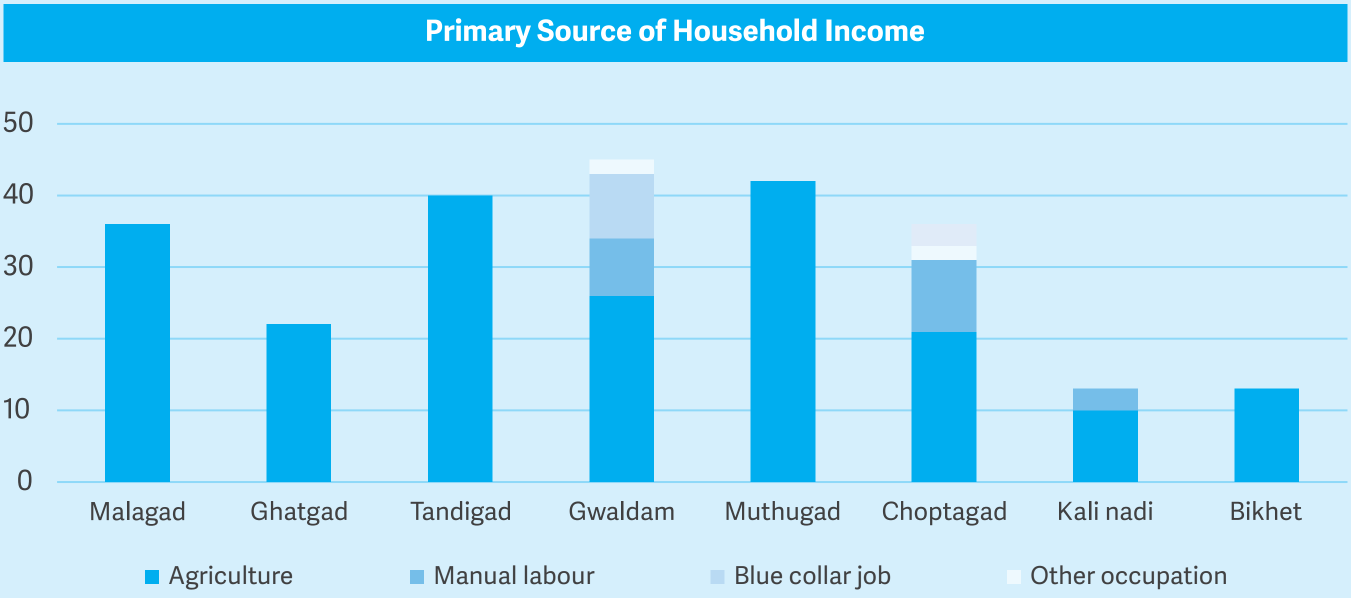
Van Panchayats Covered Under Survey

Project Phase	MWS	Van Panchayat	Total
Phase 1	Mallgad	Aina	31
	Mallgad	Bhitarkot	5
	Ghatgad	Seam	22
Phase 2	Tandigad	Majedha	7
	Tandigad	Malla Ladfoda	33
	Gwaldam	Chidinga Malla	44
	Muthugad	Salyana	37
	Muthugad	Kalimati	5
Phase 3	Choptagad	Rains	17
	Choptagad	Lodla	6
	Choptagad	Tuneda	14
	Kali Nadi	Mandav	13
	Bilkhet	Khuna Van Panchayat	6
	Bilkhet	Bilkhet	7
TOTAL		**14**	**247**

Table 7

Demographic Indicators of Respondents and Households Under Survey		
Socio-Economic Parameters	**Count**	**% of sample**
Selected Project Area		
Total MWS	8	
Total VP	14	
Total Household Survey	247	
Respondents by Gender		
Total Male	94	38.06%
Total Female	153	61.94%
Respondents by Age		
Average Age	46.27	
Minimum Age	20	
Maximum Age	92	
Respondents by education		
Primary	93	37.65%
Secondary or Higher Secondary	98	39.68%
Graduate	16	6.48%
Postgraduate	11	4.45%
No Formal Education	29	11.74%
Avg. Household Size	5-6 members	
HH Social Profile		
General	207	83.80%
OBC	2	0.80%
SC/ST	38	15.40%
HH Engaged in Agriculture	235	95.14 %
HH Migration Rate	68	27.53 %
HH with Livestock	214	86.63%
Primary Source of Income for HH		
Agriculture	211	85.43 %
Manual Labour	19	7.69 %
Regular Job	12	4.86 %

Graph 2



The demographic data clearly conveys the high dependency of the communities on agriculture and livestock rearing. Therefore, the majority of their livelihood depends on the sustainable source of water as well as the need to improve the current conditions in the state. The chief reason for the high rate of migration are linked to work or livelihood opportunities, which are directly related to the availability of water and other natural resources.

Graph 2 indicates the primary source of household income for each of the MWS sites surveyed. Conclusively, agriculture and related activities are the major sources of livelihood and income in most households. Therefore, the UFRMP - MWS model is fundamentally built around the premise to improve not just sustainable forest and natural resource management but also help the livelihood opportunities for these forest communities.

2) Water Resources for Household Use

At the household level, the utilisation of water resources emphasises the regional water stress and reliance on traditional sources for household usage. This analysis reveals variations in household profiles across MWS sites. For example, in MWS areas such as Muthugad, Ghatgad, and Mallgad, early-phase sites in the Kumaon region rely solely on tap connections, indicating a relatively stable and accessible water supply infrastructure in these areas. Conversely, Kali *Nadi* stands out as the only region necessitating water tanker services, suggesting potential challenges in water accessibility or infrastructure.

According to Table 8, the Tandigad MWS region shows heavy dependence on traditional water resources like *naulas* or *gadheras* for daily water needs. Gwaldam and Choptagad, two regions from Garhwal, also show a lack of tap water connections and reliance on external resources for daily household needs. Out of 247 households, 180 have tap connections, signifying the available infrastructure to cater to drinking and household needs. However, the remaining 67 households present a complicated picture of these rural communities, especially owing to water security for these communities linked directly with water resource availability as a result of the MWS project.

Table 9 shows the availability of water sources and the distance from households. This indicator can also be linked to socio-economic aspects, as primary water managers are often women in these communities. In harsh climatic conditions and hilly terrain, a greater distance from the water source can reflect

Table 8

Water Source for Household Use					
MWS Sites	**Gadhera or Naula**	**Pipeline Connected with Check Dam**	**Tap Connected with Spring Water Source**	**Tap Connection**	**Water Tanker Service**
Mallgad	-	-	-	36	-
Ghatgad	-	-	-	22	-
Tandigad	22	-	-	18	-
Gwaldam	1	-	17	27	-
Muthugad	-	-	-	42	-
Choptagad	3	2	7	24	-
Kali Nadi	5	1	-	5	2
Bilkhet	1	1	-	11	-
Grand Total	**28**	**4**	**25**	**180**	**2**

Table 9

Distance Covered to Access Water Source				
MWS Sites	**0 - 100 meters**	**100 - 200 meters**	**200 - 500 meters**	**500 meters and above**
Mallgad	36	-	-	-
Ghatgad	12	10	-	-
Tandigad	-	-	7	33
Gwaldam	1	-	14	30
Muthugad	42	-	-	-
Choptagad	4	1	13	18
Kali Nadi	-	5	4	4
Bilkhet	7	1	2	3
Grand Total	**102**	**14**	**39**	**84**

Table 10

Cropping pattern of the beneficiary HH

Agricultural Cropping Pattern			
MWS Sites	**Kharif**	**Rabi**	**Zaid**
Mallgad	36	36	36
Ghatgad	22	22	22
Tandigad	40	40	40
Gwaldam	45	29	6
Muthugad	42	42	42
Choptagad	36	1	-
Kali Nadi	13	8	6
Bilkhet	13	4	-
Grand Total	**247**	**182**	**152**

the drudgery experienced by women as well as indicate a discrepancy in water availability at the community level.

3) Change in the Cropping and Irrigation Pattern

The two indicators, agricultural benefit and change in irrigation source can observe the direct benefits of water availability for the communities. Based on the questions asked during the field study, Table 10 showcases the change in cropping and agriculture activities in each of the sites. We can see the maximum impact at the model sites, while the developing sites have yet to experience the full extent of the MWS benefits.

Table 11 provides data on irrigation water sources for the agriculture activities in each site, indicating a similar trend to the previous table. The model sites have benefitted the most from the guls and pipelines directly connected to each farm, while the developing sites receive a limited amount of water in the planned structures under MWS. The developing sites have yet to receive farm-to-farm water availability.

Table 11

Irrigation method used by HH in MWS sites

Irrigation Water Source for Agriculture					
MWS Sites	**Gadhera**	**Hydro Pump**	**Pipeline Connected to Gul**	**Rain Water Harvesting Tank**	**Rainwater**
Mallgad	-	-	36	-	-
Ghatgad	-	9	13	-	-
Tandigad	1	19	19	1	-
Gwaldam	43	-	-	-	2
Muthugad	-	-	42	-	-
Choptagad	30	1	1	-	4
Kali Nadi	13	-	-	-	-
Bilkhet	9	-	-	-	4

Table 12

Water availability before MWS in the select areas

MWS Sites	Water Availability Before Micro Watershed					
	November			May		
	Bad	Good	I Don't Know	Bad	Good	I Don't Know
Mallgad	-	36	-	36	-	-
Ghatgad	-	22	-	22	-	-
Tandigad	3	37	-	38	3	-
Gwaldam	13	32	-	11	23	11
Muthugad	-	42	-	41	-	-
Choptagad	15	16	5	12	13	11
Kali Nadi	-	10	3	7	-	6
Bilkhet	-	8	5	13	-	-
Grand Total	**31**	**203**	**13**	**180**	**39**	**28**

Table 13

Water availability after MWS in the select areas

MWS Site	Water Availability After Micro Watershed					
	November			May		
	Bad	Improved	No Change	Bad	Improved	No Change
Mallgad	-	36	-	-	36	-
Ghatgad	-	28	-	-	22	-
Tandigad	-	23	17	-	37	3
Gwaldam	-	41	4	-	39	5
Muthugad	-	42	-	-	42	-
Choptagad	1	-	7	1	24	11
Kali Nadi	-	11	2	1	7	5
Bilkhet	-	13	-	-	6	7
Grand Total	**1**	**194**	**30**	**2**	**213**	**31**

4) Water Availability Throughout the Year

The study further addressed the question of water availability to support agricultural and household needs during the year. November is taken as the highest water-available month due to the end of the monsoon approaching the winter harvest, while in May, the water sources are considerably lower due to the mid-summer period. The beneficiaries were asked to rate the change in water availability for these two months.

The tables 12 and 13 help identify the water availability in the area, before the implementation and after the implementation of MWS, respectively. In Table 12, we can see the lack of water availability before MWS in the respective areas.

Table 13 displays a improving picture of water availability even in the month of May with 213 respondents saying the water availability improved in their areas as the project moves ahead in phases.

Overall, the level of water availability throughout the year has improved significantly, which is one of the basic goals of developing MWS.

Phase-wise Observations of MWS Projects

This study further has collected the data on the post-project implementation stage of MWS by conducting 14 of PRAs with the beneficiaries at nine watersheds. The interaction with each beneficiary group has been conducted at the Van Panchayat level.

The initial phase of the micro-watershed projects have reached a project adjustment stage, where the changes in the ecological balance were visible around them and improved water harvesting in the area. Table 14 provides observations and discussion points noted during the visit. The model sites were proposed before the COVID-19, which had a comparative advantage over other sites of advance participation from the community stakeholders. Each model site is from Kumaon region and connectivity of the perennial river source has given them the advantage over Garhwal region sites.

The model sites having completed over five years of the projects, are facing some challenges of maintenance, which is the leading cause of reduced effi-

Developed check dam infrastructure in Mallagarh watershed of Ranikhet Forest Division

Table 14

Observations from the Model Sites	
Strengths	**Weaknesses**
Water Availability: Both Mallgad and Ghatgad demonstrate successful ecosystem restoration efforts through the development of the check dams and guls. These interventions effectively reduce soil erosion and replenish groundwater levels, supporting sustainable agriculture practices and biodiversity conservation.	**Infrastructure Maintenance Neglect:** Neglecting infrastructure maintenance undermines the efficiency and lifespan of water management infrastructure in both Mallgad and Ghatgad. This lack of maintenance compromises water availability and security efforts and ultimately the benefits noted by the users shall start disappearing.
Water Harvesting Restoration: Mallgad and Ghatgad both prioritise the restoration of traditional water management systems, such as chal-khal, naula and dhara, preserving cultural heritage and indigenous knowledge. This ensures the sustainability of water management practices and enhances water availability for various purposes.	**Limited Community Involvement:** Limited community engagement diminishes ownership and responsibility for water management, hindering collective efforts for effective water resource utilisation and sustainable development in both Mallgad and Ghatgad.
Community Empowerment and Engagement: Villagers in both Mallgad and Ghatgad actively participate in decision-making processes and watershed management activities. This engagement has fostered a sense of ownership and responsibility towards sustainable water practices, showcasing a strong commitment to community empowerment.	**Lack of Technical Knowledge:** Mallgad and Ghatgad both exhibit a heavy reliance on external support for operation and maintenance of the water resource, indicating a lack of skilling and knowledge for sustainable water management practices. Additionally, the absence of plantation initiatives overlooks potential solutions for mitigating environmental degradation and enhancing ecosystem resilience.

ciency of these structures. Many respondents have complained that the *guls* at higher altitudes closer to the water source are not maintained properly leading to contaminated water flowing in their farms. The major point of improvement observed of the model sites that was significant is their lack of capacity building and initiative to operate and manage these structures on annual basis before the rainfall.

Furthermore, the vulnerability of infrastructure to natural disasters remains one of the biggest challenges. The landslides in the valley areas and cloudburst underscore the urgent need for enhanced resilience measures to withstand future events. There have been evident economic and environmental impacts, with disruptions in water-related activities and tourism, as well as environmental degradation affecting biodiversity and ecosystem health.

The developed site on the other hand is most disadvantageous among all as the treatment work began under the social distance phase which had eliminated the open participation form the community. The respondents from these sites are still not aware of the full functionality and benefits of the project due to lack of awareness. In terms of the efficiency of the water harvesting structures, these sites are in better state but require proper planning and user guidance.

Table 15

Observations from the Developed Sites	
Strengths	**Weaknesses**
Community Empowerment and Participation: Across all sites, there is a notable emphasis on empowering local communities, fostering collective action, and instilling responsibility towards water resources. Initiatives like fair watermill operation in Tandigad and effective check dams in Muthugad showcase successful community involvement.	**Infrastructure Neglect and Planning Deficiencies:** Infrastructure neglect, incomplete construction, and planning deficiencies are prevalent issues, compromising water management efforts. Lack of effective planning is observed in Tandigad and Gwaldam.
Resilient Sustainable Development: Techniques like rainwater harvesting and percolation tanks contribute to establishing a resilient framework for sustainable development, benefiting both present and future generations. This aspect is particularly evident in Tandigad and Muthugad.	**Limited Inclusivity in Decision Making:** Heavy reliance on external funding from partners like JICA signifies a lack of local initiative and self-sufficiency, perpetuating socio-economic disparities. Limited inclusivity in decision-making processes hampers effective watershed management, as seen in Tandigad and Gwaldam.
Environmental Conservation Opportunities: Diversifying funding sources and engaging communities in decision-making processes amplify conservation efforts, such as tree planting and native plantation, combating environmental degradation and promoting biodiversity.	**Environmental Risks and Sustainability Challenges:** Challenges such as inadequate infrastructure planning, environmental degradation, and susceptibility to natural disasters pose significant risks to sustainability. These issues require comprehensive solutions for programme resilience and effectiveness, affecting all sites but particularly evident in Muthugad.
-	**Community Reluctance and Lack of Awareness:** Community reluctance to adopt sustainable practices, combined with a lack of awareness about land degradation and water pollution, complicates efforts to address pressing environmental concerns and promote ecosystem conservation.

The structures built for eco-restoration are performing well in Kumaon region, but the team observed that due to insufficient rainfall in the last year or two, the forest division in the Garhwal region recorded plantation failure. The picture below shows one of the nurseries under the UFRMP-JICA programme in Garhwal region, showcasing the plantation option in the region along MWS work.

The observation from the developing sites can be divided in two parts. The sites from Kumaon region, Kali *Nadi* and Bilkhet both saw a serious migration challenge in the region. Although the beneficiaries were satisfied with the MWS project and the benefits, the community engaged in manual labour and aside from agriculture in winter season as the income was not sufficient from NTFPs and farming.

Plantation nursery under UFRMP-JICA in Garhwal region

Table 16

Summary of observations from the developed sites	
Strengths	**Weaknesses**
Effective Water Management Infrastructure: Several sites demonstrate effective water management infrastructure, including check dams and channels, ensuring reliable water access for various purposes such as irrigation, livestock, and domestic use. This infrastructure supports sustainable agricultural practices and enhances livelihoods.	**Environmental Degradation and Soil Erosion:** Environmental degradation and soil erosion present persistent challenges in certain areas, threatening ecosystem, health, and community livelihoods. Overreliance on temporary measures like check dams may not effectively address these issues, highlighting the need for comprehensive and sustainable solutions.
Innovative Construction Techniques: Innovative construction methods, like rocks encased in wire netting, contribute to superior check dam construction, enhancing stability and durability. These techniques optimise water resource utilisation and resilience, showcasing adaptive approaches to watershed management.	**Water Scarcity and Reliance on Rainfall:** Heavy reliance on rainfall as the primary source of irrigation poses significant challenges to sustainable water resource management. Insufficient water channelisation exacerbates water scarcity issues, impacting agricultural productivity and livelihoods, particularly during periods of drought or erratic rainfall patterns.
Community Involvement and Commitment in Decision Making: Strong community involvement and commitment to watershed management efforts are evident across multiple sites. Collaborative decision-making processes foster a sense of ownership and responsibility, ensuring the sustainability of initiatives and promoting resilience in the face of environmental challenges.	**Limited Local Participation and Coordination for Maintenance:** Some sites struggle with limited local participation in construction and maintenance processes, leading to a disconnect between the community and crucial infrastructure. Inadequate communication and coordination hinder effective micro-watershed management, diminishing community engagement and ownership.
Infrastructure Development and Maintenance: Proactive efforts in infrastructure development and maintenance, such as protective walls and repair of check dams, enhance watershed resilience and protect agricultural lands from erosion and floods. Year-round water availability and crop diversification further contribute to economic stability and food security.	**Socio-Economic Pressures and Migration:** Socio-economic pressures, including migration and inter-community conflicts, contribute to dwindling local populations and uneven distribution of benefits. These challenges exacerbate existing vulnerabilities and hinder collaborative efforts towards sustainable water resource management.

Drinking water tank developed by UFRM in Tandigarh watershed of Nainital Forest Division

On the other hand, Choptagad and Tripalisain in Garhwal faced significant water scarcity, but the beneficiaries were strong proponent of NTFP activities for income generation. Of the two sites, Tripalisain was yet to receive the benefits of MWS but the respondents displayed their desire to get back to farming for survival.

Despite the water disparity in Garhwal and Kumaon region, the Garhwal region showed more promise towards maintenance of the MWS while the Kumaon sites had more to learn to share the community resources and develop the capability to improve the efficiency of these structures. Comparatively, these developing sites had better understanding of the MWS programme and attempted to make the process of maintenance democratic and regular under the guidance of forest division.

Chapter 5

Model Analysis

A landscape view of Tandigarh watershed of Nainital Forest Division

This chapter explores parameters for assessing the model's success based on the framework presented in Chapter 2. This study assesses the impact of each MWS across all parameters. The case studies prepared based on this assessment and field observations aim to provide insights into understanding the functionality of the MWS model.

Based on the conceptual framework of the MWS model presented in Figure 2, below are the parameters and indicators for impact evaluation of each site. These indicators are linked to the structures created under MWS, socio-economic parameters, soil-moisture regime, plantation, and agricultural activities.

This study sought to understand the model functionality of the project sites on three of the five indicators, namely, water harvesting, community benefits, and agricultural productivity, as per Figure 2. Other two parameters were referenced from the reports produced from the UFRMP-JICA based on its availability. However, further study can be conducted based on this model to evaluate the impact of the UFRMP - JICA efforts on eco-restoration for the 32 sites after a minimum of three years of maturity of the project.

Best Practices Under UFRMP

This section underlines a deeper understanding of the MWS model by presenting case studies that highlight successful aspects of the model across all three phases of the project undertaken in this study. These case studies will focus on the positive outcomes observed in each site, based on beneficiary responses and the functionality of the model as observed by the field team.

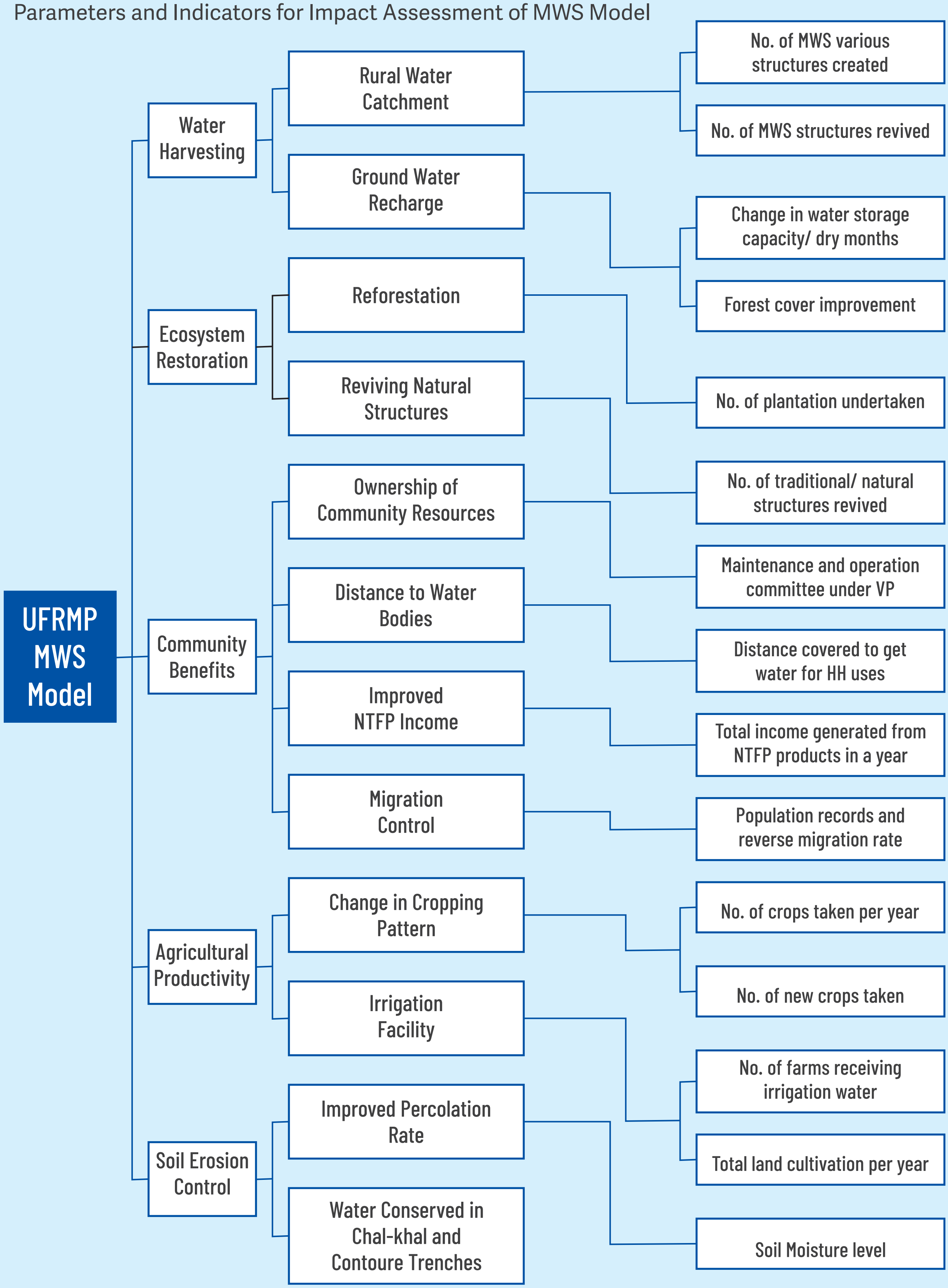
Additionally, these case studies will offer insights into areas for potential improvement in the efficiency and management of MWS structures, as well as regional challenges affecting project outcomes. They are based on interactions with beneficiaries and forest officials, who have provided insights into the project's progress over time and its impact on the ecosystem.

1) Case Study of Mallgad MWS: Ecosystem Restoration

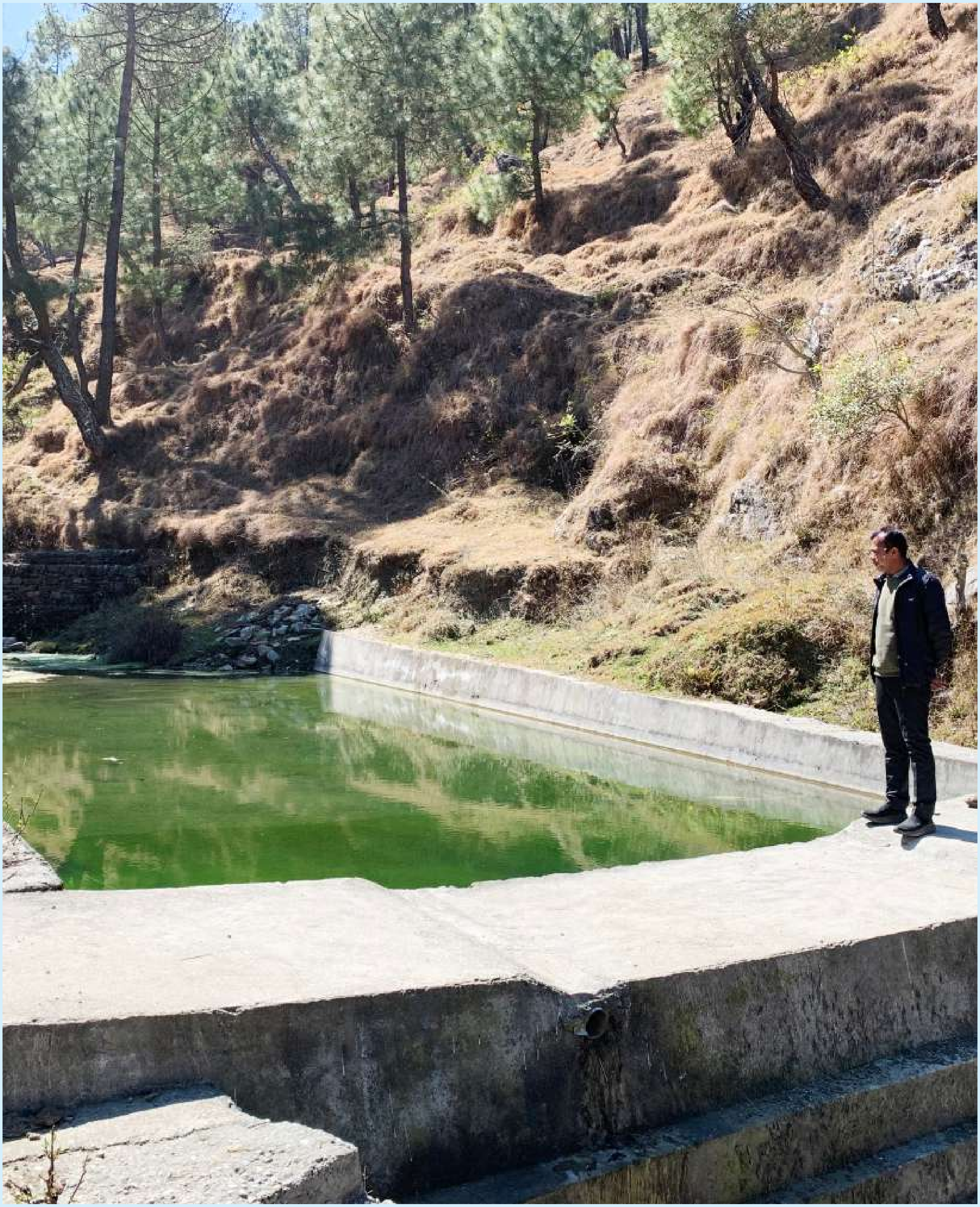
Mallgad MWS project has led to significant ecosystem restoration, through the construction of 3 *jalkunds* and *guls*, soil erosion of farm and forest land has been notably reduced. The revival of these water structures has improved the sustainability of agricultural practices and

Figure 3

Parameters and Indicators for Impact Assessment of MWS Model



Check dam developed in Mallagad watershed



improved the biodiversity conservation. Picture on page 47 shows one of the jalkunds constructed under the project. The rejuvenated ecosystem has led to improved soil health and increased water availability, benefiting both the environment and local communities.

The project area of 4,757 ha covers 2,930 ha of medium dense forest, 836 ha of open forest and 72 ha of shrubs. The work included the contour trenching in two areas and the plantation of native species of trees. For water conservation, the project intended to create 9 crate wire dams, especially where the width of the flow was wider, which has helped reduce the run-off rate and sourcing water for the *chal-khals*.

Before the implementation of the MWS, 36 beneficiaries responded to having water availability in post-monsoon time, but 24 of these beneficiaries said there was a water shortage in the summer months. After the project implementation, all beneficiaries confirmed that water availability improved even in the summer months. Table 17 provides a detailed impact assessment of the MWS project site based on the proposed model.

The beneficiaries confirmed that with the improved soil quality and reliable water sources, farmers in Mallgad are improving the productivity per season crops and receiving increase yields. Additionally, the natural beauty and restored biodiversity in Mallgad present opportunities for ecotourism development, allowing them for additional income source while showcasing their conservation efforts to visitors.

In the picture on p. 52, we can see that beneficiaries have begun to dig small ponds within their farms, emphasising on the water conservation requirement and practices in the area. The water from these ponds were mainly used for the household chores and needs.

It was noted and discussed through the PRA that for the continued benefits of the model, maintenance of the infrastructure must be adopted by all community members. So far, the beneficiaries were expecting some financial support and guidance from the PMU or the DMU in this matter.

As the model was built after the deliberation at Van Panchayat level, the sharing of the responsibility has to be done similar way. A decision was taken to consider allocating some financial resources at Van Panchayats level for retaining the full functionality of the model.

Table 17

Mallgad: Impact Assessment Based on Proposed Model		
Parameters	**Sub-Parameters**	**Data and Observation**
Water Harvesting	Rural Water Catchment	3 jalkunds, 66 chal-khals and 15 roof water harvesting system were built under the project area.
	Ground Water Recharge	These structures capture and store rainwater, which has led to an increase in groundwater recharge and availability of water for agricultural and domestic use. The increased water availability during dry periods has been crucial for sustaining crops and meeting household needs in last three years.

Table 17 continued

Parameters	Sub-Parameters	Data and Observation
Ecosystem Restoration	Reforestation	• About 1000 trees were planted under the MWS region. • Under this project 3837 ha of the land has been undertaken for eco-restoration work by the forest division. • The three VPs falling under the MWS cover 244.66 ha, out of which 102 ha was selected for eco-restoration work.
	Reviving Natural Structures	Three *naulas* revived under project area and natural springs are revived for drinking water purposes.
Community Cenefits	Ownership of Community Resources	At multiple points the maintenance of the *chal-khals* was in poor condition. The beneficiary have complained of receiving poor quality of water due to unkept sanitation and hygiene standards.
	Distance to Water Resource	According to the Table 9, the distance to water resource for HH use is noted less than 100 meters, which is most ideal.
	Improved NTFP Income	Based on the response of the beneficiary, the availability of the NTFP has improved slightly due to new plantation but the trees are yet to reach its maturity for the benefits.
	Migration Control	Mallgad area has faced significantly less migration and during COVID time reverse – migration due to water unavailability. But the major reasons for migration remains to be education and work related opportunities in the urban areas.
Agriculture Productivity	Change in Cropping Pattern	The cropping pattern has not changed much but the produce has increased significantly even during the summer months. The field team noted the end of winter harvest and beginning of vegetable plantation especially mushrooms for the months of March and April.
	Irrigation Facility	The beneficiaries are availing more water from the canals and guls connected with the *jalkunds* as per Table 11.
Soil Erosion Control	Improved Percolation Rate	During PRA, the local communities reported that soil moisture has increased, which shows reduced runoff in the catchment area and increasing percolation.
	Reducing Run-off Rate	At nine places the crate-wire check dams were placed to reduce the run-off rate.

↓ Pond created for HH water use by a community

2) Case Study of Ghatgad MWS: Holistic Approach to Sustainability

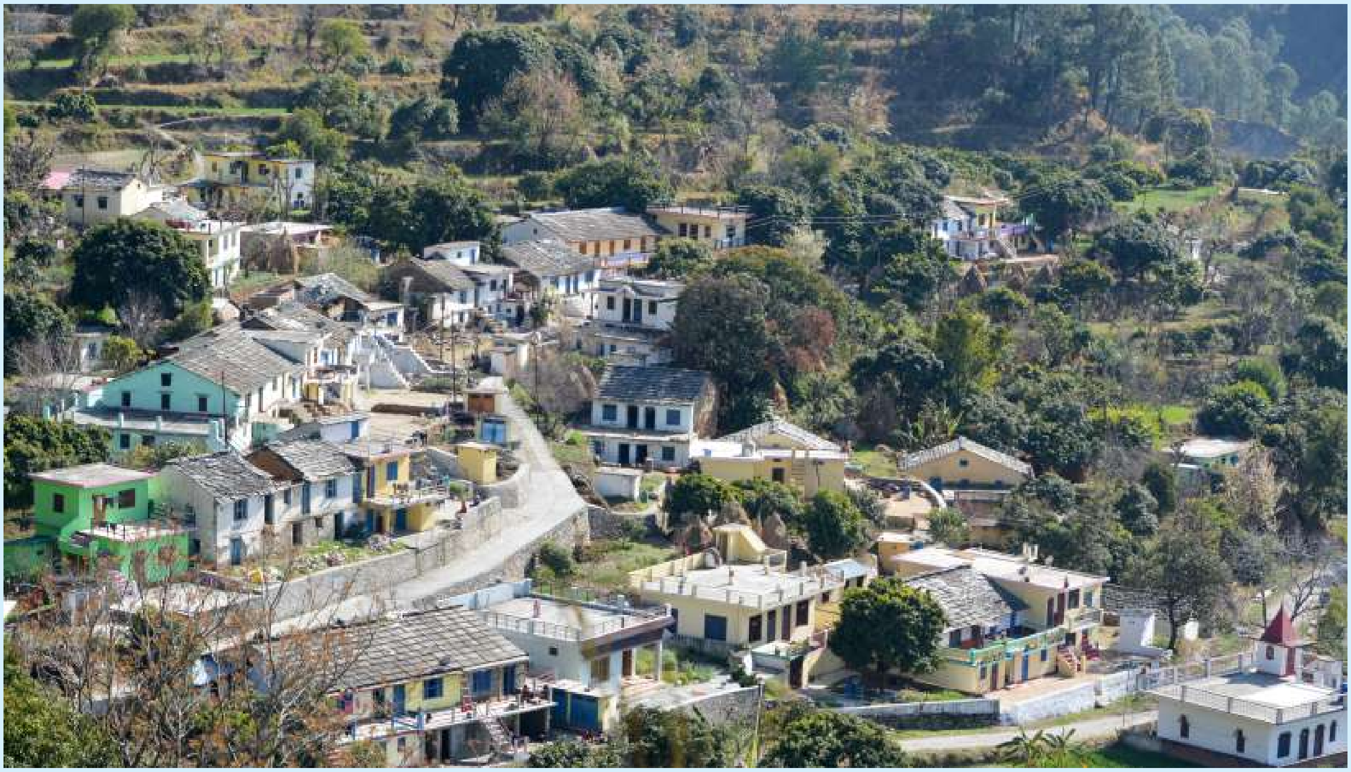
Ghatgad presents a journey of water resource management by the local community through challenges of water scarcity and declining agricultural productivity. As per the 2011 census, approximately 273 families with 1543 members inhabited the area spanning 1419.90 ha under the Kausi watershed catchment. The region primarily relied on rainfall for water supply for irrigation, which sustained agricultural activities and household usage for an average of 9-10 months annually. Additionally, the MWS area has natural streams and gadheras having water throughout the year, the only problem was accessibility to each VPs.

Despite the presence of a perennial water source from the Ramgad River, the micro-watershed network's capacity declined due to inadequate maintenance. To address these challenges, a micro-watershed management project was initiated, with a budget of 48.34 lakh, aimed at reviving traditional community water resources.

During the visit, the team discovered that this VPs were quite advanced unlike the traditonal forest community villages due to their proximity to the urban areas. Additonally, each household appeared to be invlved in regular jobs or work outside the agriculture activity, although primary income coming from farm produce. Picture on p. 55 shows the view of village seam to see the density of the VP and terrace farming in the area.

Using the core concepts of empowerment, sense of belonging, citizen participation, collective efficacy and social capital, a holistic approach was proposed to combat exclusion by bringing together economic, human, social and environmental aspects of community (Rogers et al., 2017).

Van Panchayat settlement in Ghatgad MWS



View of Ramgad river

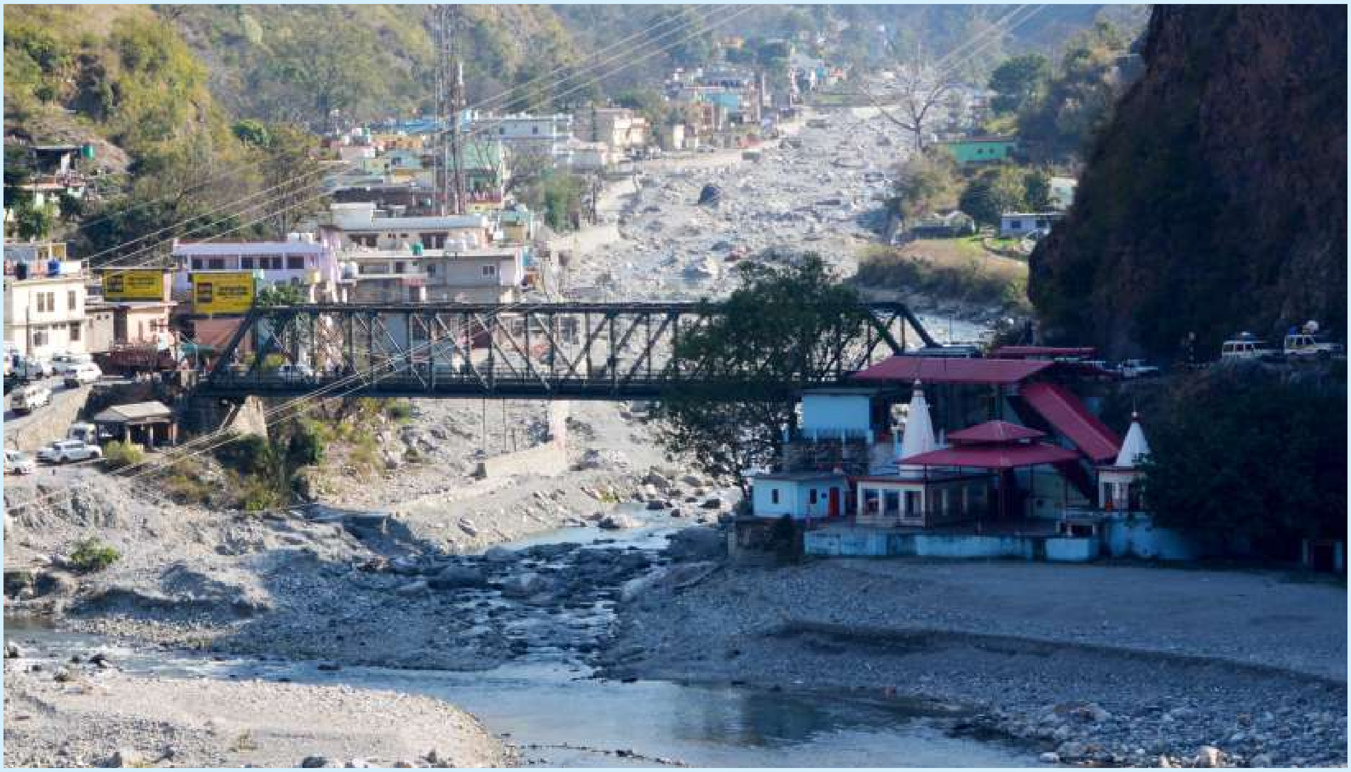


Table 18

Ghatgad: Impact assessment based on proposed model		
Parameters	**Sub-Parameters**	**Data and Observations**
Water Harvesting	Rural Water Catchment	3 *jalkunds*, 110 *chal-khals* and 2 roof water harvesting system were built under the project area.
	Ground Water Recharge	These structures have significantly improved water harvesting capabilities, ensuring a steady water supply for agricultural and domestic use even during dry periods.
Ecosystem Restoration	Reforestation	As per the beneficiaries, the restoration efforts have also enhanced the habitat for local wildlife, contributing to biodiversity conservation.
	Reviving Natural Structures	1 *naula* natural water spring and channels have been revived.
Community Benefits	Ownership of Community Resources	The involvement of the local community in decision-making processes has empowered them and fostered a strong sense of ownership and responsibility towards watershed management.
	Distance to Water Resource	According to the table 9, the distance to water resource for HH use is noted within 200 meters which is most convenient.
	Improved NTFP Income	NTFP reliance is comparatively low in the region, except for grazing and cooking wood, the beneficiary were highly reliant of farming and allied activities.
	Migration Control	Ghatgad has faced some migration issues in last few years due to increased frequency of the natural disasters.
Agriculture Productivity	Change in Cropping Pattern	The cropping pattern had changed right after the MWS work in the area but in last few years it has reversed to original condition. The water reliability for farming has been
	Irrigation Facility	The beneficiaries are availing more water from the canals, guls and hydro pumps as per Table 11.
Soil Erosion Control	Improved Percolation Rate	N/A
	Reducing Run-off Rate	At six places the crate-wire check dams were placed to reduce the run-off rate.

Discussion with community members in Tandigad

Field observations revealed the implementation of various structures to enhance water harvesting and conservation. Out of four, one *naula* – the traditional water tanks catching dripping water from springs and streams, was identified for revival. Additionally, two roof water harvesting systems were proposed, with individual capacities of 15,000 litres each. Furthermore, measures were undertaken to restore the functionality of the *gharat* (water mill), which had become dysfunctional due to reduced water force.

The project's impact was noticeable as adequate water management infrastructure was strategically implemented, regulating water flow and enhancing agricultural productivity. Community empowerment and engagement were observed, with local involvement in decision-making processes fostering a sense of ownership and responsibility. With the restoration of damaged infrastructure and implementation of plantation initiatives unlocking resources essential for comprehensive development efforts opportunities for holistic development has emerged.

3) Case Study of Tandigad MWS: Community–led Operations

Tandigad, once plagued by dismay and water stress, has witnessed a remarkable turnaround in the past 2-3 years, thanks to the collaborative efforts of the UFRMP-JICA model and community-led decision-making processes. This transformation, facilitated by implementing the Managed Watershed System (MWS), has not only revitalised water harvesting structures but spurred additional initiatives to address water scarcity in the region.

The development of this site during COVID-19 received overwhelming support from the community due to the non-availability of manual labour. Picture below shows a discussion with the village women on water resource management, sanitation, and hygiene during the survey exercise. On average, 4-6 months of water availability was found in Tandigard before the MWS project.

Situated in the Kalsa River sub-watershed of the Nainital region, Tandigad encompasses an area of 9151.94 hectares. The primary water source for the three Van Panchayats—Pokhrad, Malla Ladfoda, and Aksoda—is the Pokhrad naula, catering to approximately 288 households and 1562 people per the 2011 census. Before the initiation of the MWS project, the region relied on eight naulas, with water availability averaging around 4-5 months of the year.

Recognising the need for intervention, the community proposed several measures to address the water crisis. Firstly, they emphasised the revival of guls connected to the Pokhrad MWS, which is crucial for irrigation purposes. Additionally, efforts were directed towards enhancing water availability in the naula, which had dwindled over time. As part of the MWS project, three jalkunds with a capacity of 2.50 lakh litres were constructed to provide irrigation water to 70 families and facilitate watermill operation for Aksoda Van Panchayat.

Furthermore, the project proposed the construction of 40 chal-khals for water conservation and six roof water harvesting structures. The initiative with a total project cost of 62.55 lakh, which included reviving old structures and establishing new ones,

↓ Community interaction at Gwaldam

aimed to benefit approximately 35 families through kitchen gardening. Moreover, 32 RR dry check dams, 13 crate wire check dams, and 15 gully plug structures were proposed to optimise water flow and minimise soil erosion in farmlands.

The MWS not only addresses immediate water needs but also empowers local communities to take collective action and responsibility for water resource management. Fair operation of watermills ensures equitable access, thereby promoting socio-economic development. Additionally, the implementation of techniques like rainwater harvesting and percolation tanks establishes a resilient framework for sustainable development, benefiting present and future generations.

4) Case Study of Gwaldam MWS: Soil Erosion Control with MWS

Gwaldam is situated in the Chamoli district under the Alaknanda forest division, nestled in the Sagnayani catchment area. Its higher elevation characterises this region, providing a unique environmental setting for micro-watershed (MWS) projects. The project area encompasses two Van Panchayats (VPs), Chidiga Malla and Kalyani, with a population of approximately 350 households and over 400 livestock. The perennial water streams in this area offer a vital resource, though their potential is often under-utilised due to infrastructure deficiencies. Annexure III provides of the impact assessment based on the data and interaction with the beneficiary under the project area.

↓ Natural stream cutting through rocks in Gwaldam

The micro-watershed initiative in Gwaldam focuses on reviving and enhancing water management structures to optimise the usage of available water resources. The reconstruction and revival of 1,600 meters long defective *guls* to ensure water from perennial streams reaches the farms. The construction of three *jalkunds* with a total capacity of 1.50 lakh litres to supply water to 46 families. The proposal to build 30 *chal-khals* aimed at reducing runoff, enhancing percolation, and conserving soil moisture. Beneficiary families contributed approximately 30% towards the cost of pipelines leading directly to their farms, promoting ownership and maintenance.

The farming community in Gwaldam primarily cultivates staple crops such as wheat, paddy and millets. However, water scarcity due to inefficient water resource management and distribution systems poses significant challenges. The project's interventions are designed to improve irrigation facilities, thereby enhancing agricultural productivity. The revival of *guls* and the construction of *jalkunds* and *chal-khals* are critical steps towards ensuring a reliable water supply for farming activities.

The enhanced irrigation infrastructure, including the reconstruction of 1,600 meters of *guls* and the construction of three *jalkunds* with a total capacity of 1.50 lakh litres, has provided reliable water supply for agricultural activities. This improvement has directly benefited 46 families and irrigated 883 *naulis*, promoting agricultural productivity and food security. Additionally, the project has fostered community involvement, with beneficiary families contributing around 30% towards the cost of individual pipelines, thereby encouraging ownership and maintenance of the infrastructure. The construction of 30 *chal-khals* has also been instrumental in reducing soil erosion, conserving water, and enhancing soil moisture retention, particularly during the monsoon season. Moreover, the project's success has generated interest from non-beneficiary areas, indicating its potential for broader community impact and further engagement in sustainable water management practices.

The Gwaldam micro-watershed project faces several significant challenges. The limited knowledge about check dam operations and irregular maintenance practices result in silt accumulation and clogging, increasing the risk of flash floods and reducing the efficiency of the water management system. Additionally, villager migration and frequent natural disasters disrupt community engagement, resource allocation, and maintenance activities, posing threats to the project's sustainability.

Inefficient water resource management, despite the proximity to a nearby river, exacerbates water scarcity issues, adversely affecting the crop cultivation. Besides, the absence of community collective action, knowledge sharing, and resource pooling undermine community empowerment and long-term planning. Moreover, the failure to deliver on promises regarding the construction of a new irrigation canal has significantly impacted agricultural productivity, increasing the villagers' dependency on government aid for necessities. Addressing these challenges through improved coordination, capacity building, and infrastructure development is crucial for the sustainable growth and resilience of Gwaldam's farming community.

5) Case Study of Muthugad MWS: In the Face of Natural Disasters

Located in the Chamoli district within the Ramganga catchment under the Maigad sub-watershed, Muthugad is a site where the micro-watershed has been implemented over the Kalimati *Naula*/ Gadhera. Encompassing three Van Panchayats, the MWS is home to 210 households and approximately 1179 people as per the 2011 census. However, the aftermath of COVID-19 and natural disasters triggered a significant migration trend in this area.

Despite being designated for irrigation purposes, the water flow in the region faced obstacles due to sedimentation in the *guls*, necessitating restoration work. Moreover, diminishing water levels in the Kalimati Gadhera over the years exacerbated the community's reliance on rainfall, leading to deteriorating forest lands due to water scarcity over multiple seasons. To address these challenges, the community proposed extensive plantation initiatives as part of the MWS.

Covering an area of 894.78 hectares, the treatment plan included gully plugging at the origin point of the Gadhera to enhance water flow to the *jalkunds* and subsequently the Van Panchayats. Additionally, plans for ten crate wire check dams, 48 RR dry check dams, and 43 gully plugging initiatives were put forth to improve moisture retention in the area. Furthermore, 20 roof water harvesting tanks were proposed to augment water conservation efforts.

A primary focus of the intervention was to mitigate soil erosion and control sedimentation during rainfall. The community proposed the revival of *guls* not only in forested areas but also extending to unproductive farmlands. Despite initial progress, the development in the area was disrupted by landslides, necessitating repair work to resume the restoration efforts.

With its potential for eco-restoration, Muthugad stands out among other MWS sites in Kumaon. The inclusive approach to community involvement empowers individuals to take collective responsibility for conservation efforts, promoting the preservation of water resources and the environment. Moreover, the region's ecotourism potential not only supports local livelihoods but also contributes to conservation endeavours, making it a model for sustainable development amidst natural challenges.

6) Case Study of Bilkhet MWS: Revitalising Water Resources

Bilkhet micro-watershed area, a region characterised by its diverse agricultural practices and intricate water management needs, is actively engaged in micro-watershed management to enhance its resilience against environmental and socio-economic challenges. It encompasses 2189.42 hectares area, located in the Bageshwar district of Uttarakhand within the sub-catchment area of Saryu River. This region includes four villages, Gairad, Bilkhet, Maswadi, and Bangdugra, has historically relied on the Gairad *naula* for irrigation. However, in recent years, a decline in water availability from the Gairad *naula* has significantly affected agricultural productivity and the livelihoods of the local population, and crop diversification to sustain agricultural productivity and ensure food security.

The Bilkhet micro-watershed project encompasses several key features designed to optimise water resource management and support agricultural activities. The primary objective of this project is to rejuvenate the Gairad *naula* and restore its functionality as a continuous flowing canal. To achieve

↓ Constructed Gul in Muthugad watershed of Gairsain

this, comprehensive soil and water conservation measures will be implemented. These measures aim to enhance water availability for both irrigation and drinking purposes while also mitigating soil erosion in the Bilkhet micro-watershed area. By restoring the Gairad *naula*, the project seeks to support sustainable agricultural practices and improve the overall livelihood of the local communities.

One of the notable initiatives is the establishment of a new protective wall. This infrastructure development is a proactive measure to protect agricultural lands from erosion and floods, thereby enhancing the resilience of the watershed ecosystem. Another significant aspect of the project is the focus on year-round water availability. Despite seasonal fluctuations, the partial availability of water throughout the year provides a stable foundation for agricultural activities, contributing to food security and livelihood stability.

Agricultural practices in Bilkhet are heavily influenced by the availability of water resources. The region relies primarily on rainfall for irrigation, which poses significant challenges due to natural constraints like limited water availability. This heavy reliance on rainfall makes the community vulnerable to climate variability, threatening agricultural livelihoods and undermining community resilience during periods of drought or erratic rainfall patterns.

To address these challenges, the micro-watershed project has proposed several interventions. These include the construction of contour trenches, additional check dams, and *chal-khals* to reduce runoff rates and improve groundwater recharge. The revival of the *naula*, a traditional water source, is also proposed to enhance drinking water availability. These measures aimed to create a more sustainable and resilient water management system that can support the region's agricultural needs.

At the time of proposal, the project activities included the restoration of irrigation canals, which aimed to bring 1656 *nali* of previously irrigated land back into productive use, benefiting 342 families. This restoration was expected to increase water availability, allowing villagers to cultivate more profitable crops and reduce migration caused by unproductive farming conditions. Additionally, the construction of water tanks in Bilkhet and Gairad villages was proposed to provide a reliable drinking water supply to 63 and 39 families, respectively.

The Bilkhet micro-watershed project has brought about several notable benefits. The partial year-round availability of water, despite seasonal fluctuations, provides a stable foundation for agricultural activities. This contributes to food security and livelihood stability, ensuring that the community can continue farming even during dry periods. Additionally, the region's focus on crop diversification demonstrates adaptive practices that enhance land use efficiency and mitigate risks associated with climate variability. This diversification not only offers economic benefits but also strengthens the resilience of the local ecosystem. Despite these positive outcomes, the Bilkhet micro-watershed project faces significant challenges. The heavy reliance on rainfall as the primary source of irrigation poses a major vulnerability. Natural constraints like limited water availability exacerbate this issue, threatening sustainable water resource management and agricultural productivity. During periods of drought or erratic rainfall patterns, the community's reliance on rainwater makes agricultural livelihoods particularly precarious.

Socio-economic pressures and migration further complicate the region's challenges. The phenomenon of migration, driven by socio-economic pressures, leads to dwindling local populations and the erosion of traditional livelihoods within the Bilkhet micro-watershed. This outmigration exacerbates existing issues, including inter-community conflicts and uneven distribution of benefits from initiatives like the Micro Watershed System (MWS). These disparities marginalise certain segments of the population, perpetuating socio-economic inequalities and hindering collaborative efforts towards sustainable water resource management.

Inter-community conflicts and inequitable resource distribution also present significant obstacles. Tensions between MWS beneficiaries and non-beneficiary locals highlight the challenges of unequal resource allocation. Neglect in maintaining critical water passages, such as the *naula*, perpetuates inefficiencies in water distribution, exacerbating socio-economic disparities and hindering agricultural productivity. These conflicts undermine collaborative efforts and exacerbate existing vulnerabilities within the watershed.

Check dam structure in Muthugad MWS

Irrigation infrastructure along with check dam in Muthugad MWS

Contour trenches and barriers at Bilkhet MWS

The Bilkhet micro-watershed project illustrates a community's proactive approach to enhancing water resource management and agricultural resilience. Through infrastructure development, improved water management, and crop diversification, the project has achieved notable successes in protecting agricultural lands, ensuring reliable water availability, and sustaining agricultural productivity. However, significant challenges remain, particularly regarding reliance on rainfall, socio-economic pressures, and inter-community conflicts. Addressing these challenges through comprehensive planning, equitable resource distribution, and sustainable water management practices is crucial for the long-term success and resilience of the Bilkhet micro-watershed and its community.

7) Case Study of Kali Nadi - Road to Water Resource Availability and Sustainability

The Kali Nadi Micro-watershed (MWS), established less than a year ago, faced initial challenges, primarily stemming from significant migration out of the Van Panchayat. Out of the total 56 households, 18 families had relocated to urban areas of the state in search of employment opportunities. Situated in the Ramnagar district in close proximity to Corbett

National Park, the MWS site encounters obstacles due to wildlife interactions and limited livelihood options in the region.

This study covers the Mandav Van Panchayat as part of the Mundal River sub-watershed, the area previously relied on minimal community water sources like 1 *naula*, and 3 *gadhera*s but not perennial source for irrigation purposes. The high slope of the mountain range, heavy sedimentation in the MWS structures and soil erosion frequently affected irrigation structures built by the farmers. To address these issues, the implementation of the MWS introduced two *jalkunds* with water capacities of 1.2 lakh and 0.85 lakh litres, significantly increasing water availability from the previous 2-3 months to 9 months. Additionally, the project proposed the construction of 50 *chal-khals* and primarily focused on contour trenching for water conservation, aiming to store approximately 13.5 lakh litres of water.

Water source at Bilkhet

Kali Nadi Jalkund

MWS through establishing efficient channel infrastructure ensures reliable water access, supporting agricultural practices and livelihoods in the region., Farmers can engage in diverse crop cultivation for the first time with year-round water availability thereby enhancing production and fostering economic growth. Although, the demand for manual labour is still high as well as the farmland remains untoiled, there was some hope of availing drinking and household water for the summer months. Moreover, the community members were discussing the sustainable use of water resources and rejuvenation of forest land with the MWS project. The Van Panchayats encouraged the members to look forward to sustainable agricultural activities and ecosystem health in the Kali *Nadi* region in coming years.

8) Case Study of Choptagad - Structural Stability and Innovation

Located in the Chamoli district, the Choptagad micro-watershed falls under the Pindar sub-watershed and is part of the Alaknanda watershed area. This study, covering 1800 hectares and encompassing nine villages, focused on Barali Gadhera within Choptagad, spanning three Van Panchayats.

Situated in the Middle Himalayas, the Chamoli district requires significant efforts in contour trenching and enhancing moisture reserves to support ecological services. The project implemented three *jal-kunds* and various support structures. Remarkably, within year, beneficiary households reported doubling of their income.

Newer MWS sites in Garhwal, such as Choptagad, have emphasised the use of local materials for constructing water harvesting structures. This approach aims to utilise easily accessible materials and reduce repair costs if the community manages these structures independently.

During the study, innovative techniques such as rocks encased in wire netting were observed, optimising water resource utilisation and fostering sustainable practices. These techniques enhance resilience to environmental changes and demonstrate a commitment to effective watershed management. Particularly noteworthy are the detailed construction methods observed in Kanda Van Panchayat, reflecting a meticulous attention to detail and excellence in implementation.

2) Case Study of Tripalisain

Tripalisain, situated in Pauri district and Thalisain block, encompasses an area defined by its rugged terrain and dependence on traditional agriculture. The region is largely reliant on terrace farming, a method necessitated by its hilly landscape. The Dulekh Gadhera and the associated Micro-watershed System (MWS) cover approximately 4,200 hectares, underscoring the extensive nature of the area involved in the project.

The project's initial phase included thorough discussions with the villagers, ensuring that all micro-watershed constructions were initiated with the full support and involvement of the local community. This collaborative approach has fostered a sense of ownership and responsibility among the villagers, who are now active participants in managing their resources. The project includes the repair of two *naulas* and four *guls*, each extending two kilometers, along with the proposed repair of three *jalkunds*. These *jalkund*s benefit 36 families and irrigate 171.50 *nali* of farmland.

Agricultural practices in Tripalisain, particularly in Kandavillage, heavily depend on rainwater, making the community vulnerable to weather fluctuations. This heavy reliance on rainfall poses significant risks during periods of inadequate rainfall, leading to instability in agricultural productivity. The dependency on rainwater as the sole source of irrigation threatens food security and the livelihoods of the community, especially during drought periods.

↓ Rock barrier to reduce the water flow speed on slopes

To address these challenges, the Tripalisain micro-watershed project has implemented several water management practices. The area is serviced by the Dulekh Gadhera, which, along with the micro-watershed system, spans approximately 4,200 hectares. The region's terrace farming is supported by irrigation channels known as *guls*. However, only 45% of the area is currently irrigated, highlighting the need for improved water distribution systems.

The project has focused on the repair and revival of these critical water passages. The *gul*s, crucial for irrigation, are in the process of being restored, with four *gul*s requiring repairs over a two-kilometer stretch each. Additionally, the community relies on two traditional water sources, known as *naula*s, which also need repair. The region also has three water mills that are in need of restoration to enhance local water resource management.

The commitment to watershed management is evident in the presence of under-constructed micro watersheds across the Van Panchayats. This widespread initiative reflects the community's understanding of the importance of sustainable practices and their willingness to invest in these efforts. The proposed repairs of the *jalkunds* will benefit 36 families and irrigate 171.50 *nali* of farmland, demonstrating the tangible benefits of the project.

Natural constraints like limited water availability exacerbate this issue, threatening sustainable water resource management and agricultural productivity. During periods of drought or erratic rainfall patterns, the community's reliance on rainwater makes agricultural livelihoods particularly precarious.

Environmental degradation and soil erosion are also major concerns. The area suffers from high soil erosion, degraded lands, inadequate road construction, and low plantation levels, leading to significant environmental challenges. These issues threaten the health of the ecosystem and the livelihoods of the community by causing the loss of fertile land and diminishing natural resources. Another critical challenge is the over-reliance on temporary measures like check dams to address soil erosion. While these structures provide temporary relief, they are at risk of collapse and may not effectively halt soil erosion and environmental degradation. This highlights the need for more comprehensive and sustainable solutions.

Addressing these challenges through comprehensive planning, equitable resource distribution, and sustainable water management practices is crucial for the long-term success and resilience of the Tripalisain micro-watershed and its community. The future of Tripalisain's micro-watershed management lies in building on the strong foundation of community involvement and expanding towards more permanent and effective solutions to ensure sustainable development.

As per the scope of this study, this report has documented the phases of the UFRMP model and understood the intervention with the help of the treatment plan on each site. Based on field observations, data,

Table 19

Criteria for Scaling the MWS Model			
Stakeholder	**Project Planning**	**Execution**	**Post-Project**
PMU	Survey and Mapping	Technological Infrastructure	Monitoring
DMU	Community Engagement and Treatment Plan	Water Infrastructure Development	Capacity Building
VP/Village/ Rural Local Body	Participation	Awareness and Sustainable use	Regular Maintenance

and feedback received, the study provides an understanding of the scalability and sustainability of the model for replication in the following sections.

Scalability of the Model

The scalability of any project can be explained by studying project implementation undertaken and how the institutional support drive the indicators for change. The Graph 2 provides the method to evaluate each of the five indicators of impact assessment, but the scalability model would need to be understood with the project implementation process for a successful scalability and replicability of the model.

Table 19 proposes criteria for replication or scaling the UFRMP - MWS model to other UFRMP sites, within the state and other Himalayan states facing similar issue of water scarcity and forest management. For the scalability of the project, the following criteria are recommended at the three phases of project implementation for each of the stakeholder.

1) Project Monitoring Unit

The PMU has to undertake 3 major activities for the survey and mapping during the planning stage, building technological infrastructure for project execution and monitoring of project post-implementation.

- The planning stage includes a survey for site selection, resource mapping, baseline analysis, timely delivery of the project, and calculation of financial implications. MWS is an area—or land-specific project. Mapping of the area based on indicators like soil health, forest cover, land degradation, native vegetation, and catchment area needs to be prepared based on geographical, hydrological, and ecological parameters.

- After the planning and mapping, technological intervention, such as GIS, remote sensing, and satellite data, is required to identify the area and track the project at various stages.

- After the project implementation, the targeted intervention needs to be studied and evaluated with baseline indicators for analysing the impact of the interventions. Therefore, an MIS programme is important at the PMU level to track changes.

2) Division Monitoring Unit

The DMU is in charge of project execution on the ground level and their work can be classified in the three stages, which starts with community engagement and preparation of treatment plan, followed by building or creating water harvesting structures and improving the skilling the primary stakeholder for the operation and maintenance of these structures.

- The community engagement is one of the most significant interventions by the DMU as without the support, understanding and inputs from the community this MWS model is likely to be underutilised or collapse. The treatment plan is developed based on the environmental and community need of the water. The traditional practices of water conservation and the agricultural use of water is at the heart of developing the treatment plan. There is also a risk of additional expenditure if the need of the community and the knowledge and of local region is not considered.

- Building of water harvesting structure marks the initiation of the project based on the need and scope of the project. For example, the UFRMP model has focused on reviving and rejuvenating the traditional and natural structures along with constructing new infrastructure for water harvesting.

- Skilling and capacity building activities has to considered for scalability of the project to improve efficiency of operation and maintenance of the water harvesting structures.

2) Van Panchayat/Village/Rural Local Body

The VPs are responsible for the operation and management these structures, there for their activation in the process is required from the planning stage and right information and awareness about these interventions has to be circulated for the community's benefit.

- Participation from the VP or any primary such local body is essential for project success. The intervention planned by the DMUs for implementation of MWS from planning to execution and post-project ownership depends on the participation of the local community.

Table 20

Ensuring Sustainability of the Model			
Project Activities			
Parameters	**Forest Management**	**Environmental Service**	**Social Development**
Water Harvesting	Ground water recharge structures for hills and slopes	Water to support ecosystem – flora, fauna and wildlife	Water availability during harsh climate/seasons
Ecosystem Restoration	Reforestation and afforestation	Restoring the degraded land and structures	NTFP products and income
Community Benefits	Livelihood opportunity for forest communities	Improved source water quality	Water for domestic and agriculture use
Agricultural Productivity	Agroforestry	Improved soil fertility	Sustainable agriculture
Soil Erosion Control	Arresting the deforestation rate	Improving the percolation rate	Reducing the risk of natural disasters and soil productivity maintenance

- The awareness of the MWS project, objective, scope and need is must but information about sustainable use of the community resources is important. The natural resources are shared and scarce, therefore the understanding of equitable use has to be adopted among the users.
- In the post-implementation phase, regular maintenance and reparation of the structures has to be undertaken by the Van Panchayat or local bodies for two reason, one for the optimum efficiency and the other to maintain hygiene and sanitation of these structures to reduce any impact on public health.

It is imperative to understand and equally inform each stakeholder of their role and function with right set of skills to manage the community shared MWS structures such as UFRMP model.

Sustainability of the Model

A multipronged approach to sustainable management of forest, environmental services and the communities has been developed under the MWS model. The following Table 27 provides quantifiable indicators to check the sustainability of the project in three major categories, which aligns with the UFRMP project objectives. These Indicators for watershed sustainability are forest management, environmental service and social development.

1) Forest Management

- **Water Harvesting:** Groundwater recharge structures are implemented in hills and slopes to conserve water and maintain the forest ecosystem.
- **Ecosystem Restoration:** Reforestation and afforestation efforts are undertaken to restore degraded lands and forest structures, enhancing forest cover and health.
- **Community Benefits:** These activities create livelihood opportunities for forest communities through sustainable forest management practices.

- **Agricultural Productivity:** The introduction of agroforestry integrates trees with crops, enhancing forest health and agricultural yield.
- **Soil Erosion Control:** Measures to control soil erosion help arrest the rate of deforestation, maintain soil structure, and promote forest sustainability.

2) Environmental Service

- **Water Harvesting:** Ensures the availability of water to support ecosystems, including flora, fauna, and wildlife, especially during harsh climatic conditions.
- **Ecosystem Restoration:** Restoration activities focus on degraded lands, improving the quality and quantity of ecosystem services provided by the environment.
- **Community Benefits:** Improved water quality from better-managed sources supports the ecosystem and provides benefits to local communities.
- **Agricultural Productivity:** Sustainable agriculture practices, including agroforestry, improve soil fertility, supporting the ecosystem and agricultural productivity.
- **Soil Erosion Control:** By improving soil percolation rates and preventing deforestation, these activities reduce the risk of natural disasters and enhance soil productivity.

2) Social Development

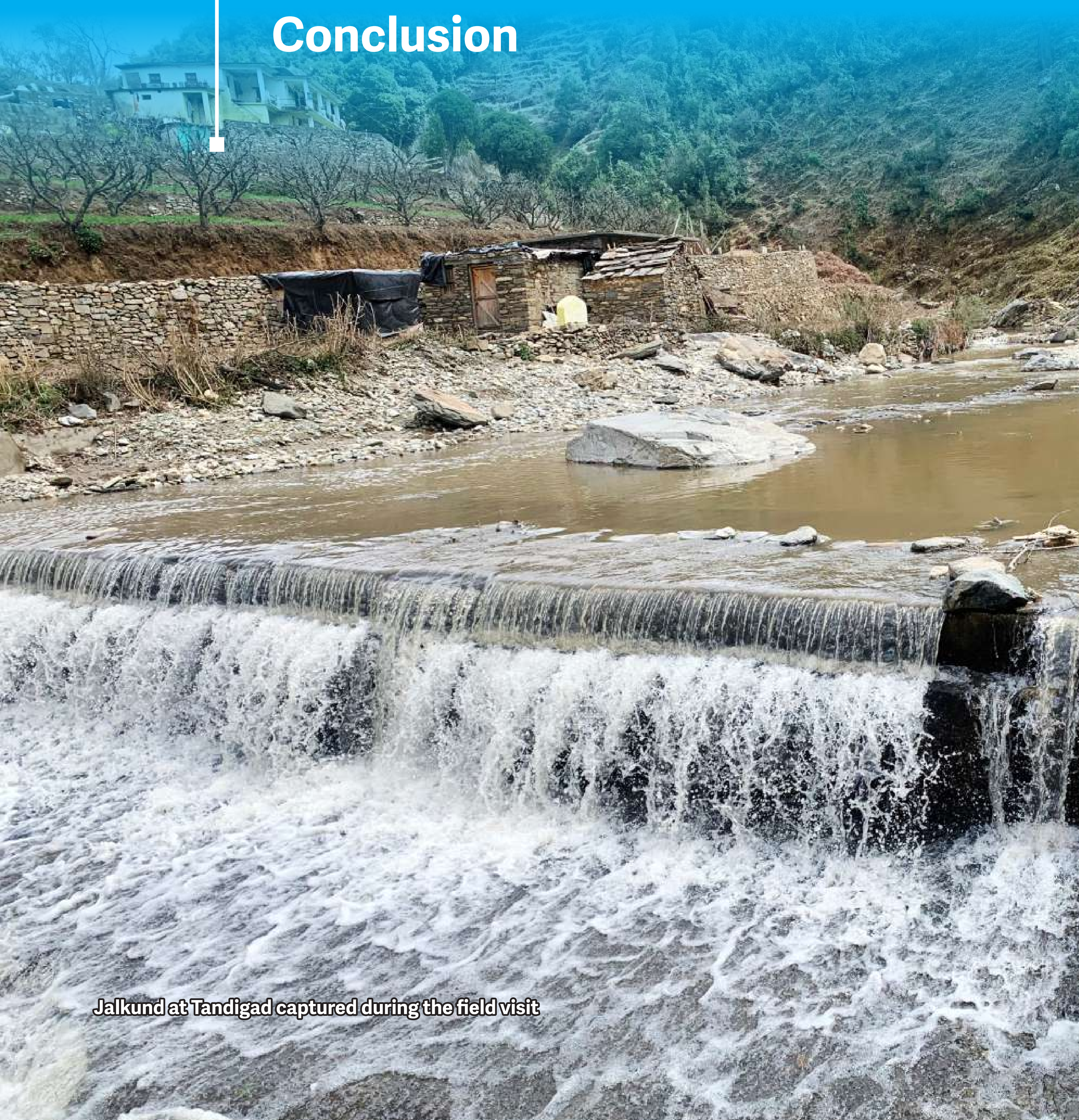
- **Water Harvesting:** Provides reliable water availability during harsh climates or seasons, ensuring that communities have access to necessary water resources.
- **Ecosystem Restoration:** Enhances non-timber forest product (NTFP) yields, contributing to community income and livelihoods.
- **Community Benefits:** Supports water for domestic and agricultural use, ensuring that community needs are met and improving overall quality of life.
- **Agricultural Productivity:** Adoption of sustainable agricultural practices ensures long-term productivity and food security for communities.
- **Soil Erosion Control:** Reduces the risk of natural disasters, ensuring stable living conditions and maintaining soil productivity, which is crucial for agriculture and community development.

The sustainability of the MWS model is ensured through various project activities categorised under forest management, environmental service, and social development. Each activity aims to achieve specific goals within these parameters to maintain ecological balance and improve community well-being.

The sustainability of the MWS model is achieved through targeted activities that address forest management, environmental services, and social development. These activities not only restore and maintain the natural ecosystem but also provide tangible benefits to local communities, ensuring a holistic approach to sustainability. Further, this study will provide certain recommendations to improve this model based on scalability indicators and sustainability parameters discussed in this chapter.

Chapter 6

Conclusion



Jalkund at Tandigad captured during the field visit

The UFRMP - MWS model has created a robust structure for implementation. This study provides for further consideration for the next phase for the projects using the scalability and sustainability models.

Recommendations

In the context of Uttarakhand and the fragile Himalayan ecology, the implementation of the any developmental programme must transcend traditional approaches and evolve into an inclusive model of development. It is imperative to acknowledge that the challenges faced by this region extend far beyond mere water availability. Based on the UFRMP Micro Watershed Model and the field analysis presented in this report, these are the recommendations submitted to improve the implementation. Here's how the current model of MWS can be tailored to address the unique needs of Uttarakhand and the Himalayan ecosystem:

a) **Robust Planning with Local Community:** The planning stage should have multiple sessions with the community to identify the full extent of support and prepare them to take over the responsibility of community resources from an early stage. Active community involvement is essential throughout the development and maintenance phases to ensure sustainability and ownership.

b) **Responsibility of Operation and Management (O&M):** This should be given to VPs with a committee formation for management. At the advanced stage, the project might also consider charging a nominal fee for O&M to reduce dependence on the forest department.

c) **Inclusive Partnership with Van Panchayats (VPs):** The MWS should foster a robust partnership with Van Panchayats, recognising them as pivotal agents of change in mountainous areas. By involving VPs in decision-making processes, the model can leverage local knowledge and community participation for effective watershed management.

d) **Disaster Preparedness and Response**: Collaboration with VPs can extend beyond infrastructure development to include disaster preparedness initiatives. VPs can play a crucial role in community-based disaster risk reduction efforts, such as early warning systems, evacuation planning, and emergency response training, thereby enhancing the resilience of vulnerable mountain communities.

e) **Holistic Water Security:** Beyond conventional water management practices, the MWS should prioritise holistic water security, encompassing conservation of headwater areas, sustainable groundwater recharge, and watershed-based water allocation schemes. This approach ensures equitable access to water resources while safeguarding the ecological integrity of mountain ecosystems.

f) **Use of Local and Natural Material in Construction:** Encourage the use of locally sourced and sustainable materials in construction projects to minimise environmental impact and support local economies. The use of local material can reduce burden on the forest department to provide reparation and can maintain natural equilibrium of the space.

g) **Skill Development for Minor Repairment:** Provide training programmes to equip local communities with the skills needed for minor repair and maintenance tasks, ensuring long-term sustainability.

h) **Pre-Monsoon Sanitation Drive**: Conduct sanitation drives before the monsoon season to clean water sources and ensure the quality of new water deposits in the structures.

i) **Biodiversity Conservation**: The MWS must integrate biodiversity conservation measures to protect the rich flora, fauna, and wildlife of the Himalayas. By promoting habitat restoration, wildlife corridors, and sustainable land-use practices, the model contributes to preserving the unique biodiversity hotspots of Uttarakhand.

j) **Climate Change Mitigation**: Recognising the role of natural resources in climate regulation, the MWS should advocate for reducing the exploitation of forests, soil, and water resources. By promoting afforestation, sustainable agriculture, and renewable energy adoption, the model contributes to climate change mitigation efforts in the region.

k) **Sustainable Agriculture and Food Security**: The MWS should promote sustainable agricultural practices tailored to the mountainous terrain, such as terrace farming, agroforestry, and crop diversification. By enhancing agricultural productivity while minimising environmental impact, the model ensures food security and livelihood resilience for mountain communities.

l) **Capacity Building of Van Panchayats:** Empowering VPs through capacity building initiatives is paramount for the success of the MWS. Training programmes on watershed management, disaster risk reduction, biodiversity conservation, and sustainable agriculture equip VPs with the knowledge and skills needed to drive positive change at the grassroots level.

Based on these recommendations, the UFRMP-JICA model should transcend its conventional boundaries to embrace a comprehensive approach that addresses the multifaceted challenges of the Himalayan region. By fostering inclusive partnerships, promoting ecological resilience, and empowering local communities, the model paves the way for sustainable development in one of the world's most ecologically sensitive landscapes.

Considerations for Next Phase

For the next phase of the MWS in Uttarakhand, the focus should be on several key initiatives to enhance effectiveness and sustainability

Watershed Monitoring by VPs: Empower VPs with training and resources to conduct regular monitoring of watershed health, including water flow, soil erosion, and vegetation cover. This grassroots data collection ensures local ownership and timely response to emerging challenges.

a) **Improving and Monitoring Water Source Quality**: Implement systematic water quality monitoring protocols, enabling VPs to assess the purity and safety of water sources within their jurisdiction. This information guides targeted interventions to address pollution and contamination threats, safeguarding community health.

b) **Enhancing Data Efficiency and Transparency**: Establish a centralised database accessible to all stakeholders, ensuring efficient data sharing and transparency. Utilise modern technologies such as GIS mapping and remote sensing to streamline data collection, analysis, and reporting processes.

c) **Addressing Migration Population:** Develop initiatives to mitigate the negative impacts of rural-to-urban migration on watershed ecosystems and community resilience. Collaborate with government agencies and NGOs to create alternative livelihood opportunities, infrastructure development, and social support systems to discourage migration.

d) **Knowledge Sharing with Project Management Unit (PMU):** Facilitate direct knowledge exchange between VPs and the PMU to foster collaborative decision-making and alignment of project objectives. Regular forums, workshops, and information-sharing platforms facilitate mutual learning and adaptation.

e) **Integrating Livelihood Initiatives with Micro Watershed Management (MWM):** Align livelihood programmes with micro-watershed priorities to maximize socio-economic benefits while promoting environmental sustainability. This holistic approach ensures that livelihood activities complement watershed conservation goals, fostering community buy-in and long-term resilience.

f) **Synergising Soil Erosion Efforts under MWS:** Coordinate soil erosion control measures with broader watershed management strategies, emphasising the interconnectedness of land and water resources. By integrating soil conservation practices into micro-watershed projects, the MWS enhances ecosystem resilience and agricultural productivity.

g) **Creating a Platform for Multi-Stakeholder Convergence:** Establish a forum for multi-stakeholder collaboration, bringing together government agencies, NGOs, academia, and local communities to co-design and implement watershed management initiatives. This platform facilitates knowledge exchange, resource mobilisation, and consensus-building to address complex watershed challenges comprehensively.

h) **Extending the Project Area and Selection of Beneficiary Based on Demand**: The first phase of projects have initiated organic demand for project expansion within the VPs. A phase two extension under MWS could be considered after 2-3 years of project implementation as the water availability increase naturally. Ideally, taking the advances signatures and participatory commitment from interested households could help plan the extended project based on the phased benefits of the forest.

As the project plans to increase the timeline, these initiatives can be considered in the next phase of the MWS. This will help the state of Uttarakhand strengthen its community resilience, improve ecosystem health, and achieve sustainable development outcomes in its fragile Himalayan ecology.

Way Forward

Water security is not just about ensuring immediate availability but involves a sustainable, long-term approach that secures water resources for future generations. The MWS model, through its integrated and community-centric approach, addresses this need effectively.

In case of Uttarakhand the MWS model prioritises the conservation of headwater areas, sustainable groundwater recharge, and watershed-based water allocation schemes. These measures ensure equitable access to water resources while safeguarding the ecological integrity of mountain ecosystems. The involvement of VPs in regular monitoring and maintenance activities enhances the sustainability of water sources, making the system more resilient to climatic variations and other environmental challenges.

Effective watershed management ensures the sustainable use and conservation of water resources, which are foundational to any community's socio-economic stability. By preserving and restoring natural water systems, watersheds support agriculture, the primary livelihood in many rural areas, and ensure food security. In regions like Uttarakhand, where communities are heavily reliant on natural resources, the health of watersheds directly impacts agricultural productivity, access to clean water, and overall community well-being.

The MWS model demonstrates immense potential for addressing the unique challenges of the Himalayan region and should be considered for extension to other parts of the Himalayas, as well as to Indian states and regions beyond where water scarcity, socio-economic development, and forest cover depletion are pressing issues. By fostering inclusive partnerships, promoting ecological resilience, and empowering local communities, the MWS model offers a replicable and sustainable framework.

The socio-economic benefits of watershed management extend beyond immediate economic gains. By fostering inclusive community participation, particularly through the involvement of local institutions like Van Panchayats, watershed projects can empower communities, enhance social cohesion, and build local capacity for sustainable resource management. This participatory approach could ensure that development initiatives are aligned with local needs and that the benefits of natural resource conservation are equitably shared.

This model can create more perennial water sources, revive existing water structures, and contribute significantly to the overall socio-economic and environmental sustainability of these regions. Its success in Uttarakhand sets a strong precedent for its wider application, potentially transforming watershed management and development in ecologically sensitive and water-stressed areas across the country and beyond.

Moreover, well-managed watersheds contribute to disaster resilience, particularly in mountainous regions prone to landslides, floods, and droughts. By mitigating soil erosion, regulating water flow, and enhancing groundwater recharge, watershed management reduces the vulnerability of communities to natural disasters. This not only protects lives and property but also sustains economic activities and livelihoods, reducing poverty and promoting long-term economic growth.

It can be said that extending this model to states with Himalayan ecology under state government programmes can further enhance its impact. State governments should consider adopting the MWS model to address their unique environmental and socio-economic challenges. The model's adaptability makes it suitable not only for the upper Himalayan regions but also for the lower Himalayas, where similar issues of water scarcity and forest degradation prevail. Implementing this model in lower Himalayan areas in the next stage can help create more perennial water sources, restore ecological balance, and promote sustainable development, providing a comprehensive solution to the pressing needs of these vulnerable regions.

The slow yet steady geographical and ecological improvements fostered by the MWS model make it a sustainable and economically viable solution for water security. By adopting this model, Uttarakhand can mitigate the seasonal scarcity of water, reduce dependence on external water supplies, and improve the overall resilience of its communities against water-related challenges. The success of the MWS model in Uttarakhand provides a scalable and sustainable framework that can be replicated in other states with similar ecological conditions, thereby addressing water security issues comprehensively.

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List of Abbreviations

ADB	Asian Development Bank
AIBP	Accelerated Irrigation Benefit Programme
ADS	Area Development Society
CPD	Chief Project Director
DMU	District Management Units
FAO	Food and Agriculture Organization of the United Nations
FMU	Forest Management Units
GIS	Geographic Information System
Ha	Hectare, unit of land measurement
HH	Household
IWMP	Integrated Watershed Management Programme
JICA	Japan International Cooperation Agency
LULC	Land Use Land Cover
MGNREGA	Mahatam Gandhi National Rural Employment Guarantee Act
MWM	Micro-watershed Management
MIS	Monitoring and Information System
MWS	Micro-watershed
NGO	Non-governmental Organisation
NTFP	Non-Timber Forest Products
NWDPRA	National Watershed Development Project for Rainfed Areas
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PPA	Participatory Planning Approach
PRA	Participatory Research Appraisal
PMU	Project Monitoring Unit
SC & FD	Soil Conservation and Forest Division
UFRMP	Uttarakhand Forest Resource Management Project
UFRMS	Uttarakhand Forest Resource Management Society
UNDP	United Nations Development Programme
VP	Van Panchayat
WB	World Bank

Annexure – I

Questionnaire for Beneficiaries Under Micro-Watershed System (MWS) Project

S. No.	Questions	Answer Type
	Questionnaire ID*	Auto-generated by survey tool
1.	**General Information**	
a.	Name of the Assessor*	
b.	GPS location*	
c.	Photograph of the Assessor	
d.	Time*	
e.	Date *	
f.	Forest Division*	
g.	Name of Micro-Watershed/ River*	
h.	Name of the Van Panchayat*	
i.	Name of the Village*	
2.	**Details of the Respondent**	
a.	Name of the Respondent*	
b.	Age (In numbers)*	
c.	Gender*	
d.	Total Number of Family Members*	
	1 to 10 Years	
	11 to 18 Years	
	18 to 60 Years	
	Above 60+	
e.	Community	MCQ a. General b. SC/ST c. OBC d. Others

S. No.	Questions	Answer Type
f.	Education:	MCQ a. Primary b. Secondary and Higher Secondary c. Graduate d. Masters & Others e. No Formal Education
g.	If others (Please Specify):	
h.	Are you engaged in agriculture?	Yes/no
i.	Name of the crops cultivated:	
j.	Irrigation methods used:	MCQ a. Sprinkler irrigation b. Drip irrigation c. Furrow irrigation d. Centre Pivot irrigation e. Naula f. Any other (please specify)
k.	If others (Please Specify):	
l.	Primary Source of Income	MCQ a. Agriculture b. Horticulture c. Livestock d. Ecotourism e. Non-Timber Forest Products f. Micro Enterprises/Business
m.	If others (Please Specify):	
n.	How many household members have migrated from the village?	
o.	Migration Reason	MCQ a. Work b. Disaster c. Developmental Activities d. Others (specify)
p.	If other reason (Please Specify):	
q.	Land Holding:	MCQ a. Owned Land (Hectares/Nali) b. Leased Land (Hectares/ Nali)
r.	Do you have any Livestock?	

S. No.	Questions	Answer Type
s.	Please Specify	
	Number of Cow/Buffalo	
	Number of Goat/Sheep	
	Number of Poultry	
	Number of Other livestocks	
	If others (Please Specify):	
3.	**Availability of Water Resources**	
a.	Primary source of water for household use:	MCQ a. Groundwater b. Surface water c. Rainwater d. Others (specify)
b.	If others (Please Specify):	
c.	Distance to the main water source:	MCQ a. 0 - 100 meters b. 100 - 200 meters c. 200 - 500 meters d. 500 meters and above (specify)
d.	Are you aware of water conservation practices? List any water conservation methods implemented.	MCQ a. *Naula:* A stone-lined tank that collects water from springs and streams. b. *Dhara:* Springs. c. *Gadhera:* Small river tributaries. d. *Gul:* Traditional irrigation canals. e. *Chal and Khal:* Artificial ponds on hilltops. f. Any other (Please specify)
e.	If others (Please Specify):	
4.	**Area of Agricultural Irrigated Land by Check-Dam**	
a.	Name of the Check Dam	
b.	How many families have benefited from the check dam?	

S. No.	Questions	Answer Type
c.	Name of the Crops Cultivated	Predictive options a. Ginger b. Garlic c. Chilli d. Gooseberry (Amla) e. Mango f. Malta g. Rhododendron (Buransh)
d.	If others? (Please Specify)	
5.	**Status of Water Table Micro - Watershed due to Check Dam Construction:**	
	November Month (or After rainfall)	MCQ a. Good b. Bad c. I don't know
	May Month (or Before rainfall)	MCQ a. Good b. Bad c. I don't know
	November Month (or After rainfall)	MCQ a. Improved b. No Changes c. I don't know
	May Month (or Before rainfall)	MCQ a. Improved b. No Changes c. I don't know
6.	**Plantation Activities**	
a.	No. of Plantations (Individual + Common):	
	Name of the Planted Plants:	
	Live Plants:	

S. No.	Questions	Answer Type
7.	**Dependency on Forest Resources**	
a.	Which of the following forest resources do you regularly depend on?	MCQ a. Timber and wood b. NTFPs such as fruits, nuts, and mushroom c. Medicinal plants d. Firewood e. Grazing land for livestock f. Other (please specify)
	If others (Please Specify):	
b.	How has your reliance on forest resources has changed in last five years?	MCQ a. Increased b. Remained the same c. Decreased d. Not applicable
8.	**Monitoring/ PRA/ FDGs**	
a.	Changes in crop pattern/diversification: (any new crop introduced):	
b.	What lessons have learned, and are there any recommendations for improvement in this model? (for example: Plantation, Check Dams etc.)	
c.	Please tell us any other things which we have not discussed above and you think that is important for us to know.	
9.	**Submission Review**	
a.	Details corrected?	Yes/No
b.	Photograph of the Respondent	Subject to their approval

Annexure – II

Tandigad MWS: Impact assessment based on proposed model

Tandigad: Impact Assessment		
Parameters	**Sub-Parameters**	**Data and Observation**
Water Harvesting	Rural Water Catchment	• 3 *jalkunds*, 32 RR dry check dams, 15 gully plugging, 40 *chal-khals* and 6 roof water harvesting system were built under the project area. • 3 naulas revived under project area.
	Ground Water Recharge	The soil has improved the capacity to absorb the water comparatively more, but the dry months are still water-less. Although, there is enough water for irrigation throughout the year, but it only can sustain farming to feed the family and not more to sell in the market.
Ecosystem Restoration	Reforestation	In the MWS, a total of 60 ha of plantation has been done in three different phases.
	Reviving Natural Structures	Water springs and channels were revived under the project.
Community Benefits	Ownership of Community Resources	The quality of water and maintenance of community resources was one of the concerning observation due to lack of ownership of the community.
	Distance to Water Resource	According to the table 9, the distance to water resource for HH use on average is noted to be higher than 500 meters, one of the highest.
	Improved NTFP Income	Based on the response of the beneficiary, the availability of the NTFP has improved slightly due to new plantation but the trees are yet to reach its maturity for the benefits.
	Migration Control	Tandigad faced high migration during 2020-21 in search of work but it has slowed down in last 2 years.
Agriculture Productivity	Change in Cropping Pattern	The cropping pattern has not changed much but the produce has increased significantly even during the summer months.
	Irrigation Facility	The beneficiaries are availing more water from the canals and guls connected with the jalkunds and hydro pumps as per table 11.
Soil Erosion Control	Improved Percolation Rate	During PRA, the local communities reported that soil moisture has increased, which shows reduced runoff in the catchment area and increasing percolation.
	Reducing Run-off Rate	At 13 places the crate-wire check dams were placed to reduce the run-off rate.

Annexure – III

Gwaldam MWS: Impact assessment based on proposed model

Gwaldam: Impact Assessment		
Parameters	**Sub-Parameters**	**Data and Observation**
Water Harvesting	Rural Water Catchment	3 *jalkunds*, 30 *chal-khals* and 4 gul with average length of 1600 meters system were built under the project area.
	Ground Water Recharge	The water storage has increased in the new structures although the water recharge in the area is slowly improving.
Ecosystem Restoration	Reforestation	Plantation record not available.
	Reviving Natural Structures	Old *guls* revived providing water to 883 *nali* farmland.
Community Benefits	Ownership of Community Resources	The maintenance of the guls and *chal-khals* was in better condition at most HH, but the houses which were abandoned created blockage of the channels.
	Distance to Water Resource	According to the table 9, the distance to water resource for HH use on an average more than 500 meters, except of 14 beneficiaries out of 45 interviewed.
	Improved NTFP Income	Based on the response of the beneficiary, the availability of the NTFP produce has always remained higher than average MWs sites, but due to landslide and heavy soil erosion the NTFP income remains unstable. The water availability and conservation within the forest has increased due to MWS.
	Migration Control	Gwaldam is prone to natural disasters, therefore high events of migration have been noted.
Agriculture Productivity	Change in Cropping Pattern	The cropping production has increased in Rabi and Zaid seasons due to revivals of the *guls*.
	Irrigation Facility	The most beneficiaries are availing water from Gadhera nearby as the water availability in guls remains low as per table 11.
Soil Erosion Control	Improved Percolation Rate	N/A
	Reducing Run-off Rate	At 10 places the crate-wire check dams were placed to reduce the run-off rate.

Annexure – IV

Muthugad MWS: Impact assessment based on proposed model

Muthugad: Impact Assessment		
Parameters	**Sub-Parameters**	**Impact**
Water Harvesting	Rural Water Catchment	3 *jalkunds*, 42 gully plugs, 48 RR dry check dams, 50 *chal-khals* and 20 roof water harvesting system were built.
	Ground Water Recharge	Due to year-round availability of water in the source structures, the ground water recharge is at optimum level and the forest and farmland in the region remains productive. Although this year, the source water recharge had been affected, which has impacted the forest and ecology.
Ecosystem Restoration	Reforestation	Plantation record not available.
	Reviving Natural Structures	N/A
Community Benefits	Ownership of Community Resources	The resources developed under MWS and the traditional structures under this region was kept well throughout the year, especially the gully plugs and the roof water tanks. Although the *jalkunds* needed some maintenance once the winter season had passed.
	Distance to Water Resource	According to the table 9, the distance to water resource for HH use is noted within 100 meters which is most convenient.
	Improved NTFP Income	The new plantation under eco-restoration project is 3-4 years old and yet to mature fore fruiting, therefore the NTFP income is unchanged.
	Migration Control	The migration is the region due to water was not noted.
Agriculture Productivity	Change in Cropping Pattern	The farm produced has increased due to availability of irrigation water connecting to farms and farmers are taking crops all-round the year.
	Irrigation Facility	All the beneficiaries were receiving the water from the pipeline which was connected the guls. The figure 17 shows glimpse of the pipeline.
Soil Erosion Control	Improved Percolation Rate	During PRA, the local communities reported that soil moisture has increased, which shows reduced runoff in the catchment area and increasing percolation.
	Reducing Run-off Rate	At 10 places the crate-wire check dams were placed to reduce the run-off rate.

Annexure – V

Bilkhet MWS: Impact assessment based on proposed model

Bilkhet: Impact Assessment		
Parameters	**Sub-Parameters**	**Data and Observation**
Water Harvesting	Rural Water Catchment	4 *jalkunds*, 55 *chal-khals* and 38 gully plugs system were built under the project area. At strategic locations along the Gairad Gadhera 17 check dams were constructed. 2 *naulas* were revived under project area.
	Ground Water Recharge	The water availability has increased by the storage and recharge of water resources remains to be low.
Ecosystem Restoration	Reforestation	Plantation record not available.
	Reviving Natural Structures	N/A
Community Benefits	Ownership of Community Resources	The maintenance of the guls and *chal-khals* was found to be in poor state and the *jalkunds* were found with water contaminants. See figure 18 and 20.
	Distance to Water Resource	According to the table 9, the distance to water resource for HH use on an average was around 200 meters.
	Improved NTFP Income	The NTFP income has been affected in last few years due to water issues in last few years.
	Migration Control	Bilkhet has seen a huge rate of migration resulting from crop failures and lack of water for HH usage.
Agriculture Productivity	Change in Cropping Pattern	The cropping production has increased in Rabi and Zaid seasons due to revivals of the *guls*.
	Irrigation Facility	The most beneficiaries are availing water from Gadhera nearby as the water availability in *guls* remains low as per table 11.
Soil Erosion Control	Improved Percolation Rate	Construction of percolation tanks and *chal-khals* to enhance ground water recharge and reduce runoff.
	Reducing Run-off Rate	At 12 places the crate-wire check dams and 7000 contour trenches were placed to reduce the run-off rate.

Annexure – VI

Kali Nadi MWS: Impact assessment based on proposed model

Kali Nadi: Impact Assessment		
Parameters	**Sub-Parameters**	**Data and Observation**
Water Harvesting	Rural Water Catchment	2 *jalkunds*, 50 *chal-khals*, 39 gully plugs and 24 RR dry check dams were built under the project area.
	Ground Water Recharge	Contour trenches to conserve water up to 13.50 lakh litres to be dug over the slope.
Ecosystem Restoration	Reforestation	Plantation was not observed.
	Reviving Natural Structures	N/A
Community Benefits	Ownership of Community Resources	The beneficiaries undertook the maintenance of the *guls* and *chal-khals,* since only about half of them were left in the VP, the work remained irregular.
	Distance to Water Resource	According to the table 9, the distance to water resource for HH use on an average was between 200 – 500 meters.
	Improved NTFP Income	The NTFP income this area has remained historically low due to high conflict with wildlife in the region.
	Migration Control	One of the highest amounts of migration was observed in Ramnagar due to human-wildlife conflict. Some of the migration was noted to be seasonal in dry months.
Agriculture Productivity	Change in Cropping Pattern	The cropping production has remained more or less same and traditionally dependent on the rainwater availability.
	Irrigation Facility	Most beneficiaries are availing water from Gadhera and occasionally has gotten water tanker due to water scarcity in past.
Soil Erosion Control	Improved Percolation Rate	N/A
	Reducing Run-off Rate	At 7 places the crate-wire blockades were placed to reduce the run-off rate.

Annexure – VII

Choptagad MWS: Impact assessment based on proposed model

Bilkhet: Impact Assessment		
Parameters	**Sub-Parameters**	**Data and Observation**
Water Harvesting	Rural Water Catchment	3 *jalkunds*, 26 *chal-khals*, 26 gully plugs, and 28 RR dry check dams were built under the project area.
	Ground Water Recharge	The water storage has increased in the new structures although the water recharge in the area is slowly improving.
Ecosystem Restoration	Reforestation	Plantation record not available.
	Reviving Natural Structures	Old *guls* revived providing water to 883 *nali* farmland.
Community Benefits	Ownership of Community Resources	The maintenance of the guls and *chal-khals* was in better condition at most HH, but the houses which were abandoned created blockage of the channels.
	Distance to Water Resource	According to the table 9, the distance to water resource for HH use on an average around 500 meters.
	Improved NTFP Income	There has not been any changes in NTFP income.
	Migration Control	Choptagad faces seasonal migration due to heavy rain or lack of rain every other year.
Agriculture Productivity	Change in Cropping Pattern	The farming produce was found to be in poor state except for during the rain harvest season. No improvement was noted for other two season.
	Irrigation Facility	The most beneficiaries are availing water from Gadhera nearby as the water availability in *guls* remains low as per table 11.
Soil Erosion Control	Improved Percolation Rate	N/A
	Reducing Run-off Rate	At 10 places the crate-wire check dams were placed to reduce the run-off rate.

Annexure – VIII

Tripalisain MWS: Impact assessment based on proposed model

Tripalisain: Impact Assessment		
Parameters	**Sub-Parameters**	**Data and Observation**
Water Harvesting	Rural Water Catchment	3 jalkunds, 25 chal-khals, 80 RR dry check dam and 2 gul with average length of 2 km system are proposed under the Project area.
	Ground Water Recharge	N/A
Ecosystem Restoration	Reforestation	Plantation record not available.
	Reviving Natural Structures	Revival of 3 water mills proposed under the MWS project.
Community Benefits	Ownership of Community Resources	N/A
	Distance to Water Resource	N/A
	Improved NTFP Income	N/A
	Migration Control	Tripalisain has faced high rate of seasonal migration in past.
Agriculture Productivity	Change in Cropping Pattern	N/A
	Irrigation Facility	N/A
Soil Erosion Control	Improved Percolation Rate	N/A
	Reducing Run-off Rate	At 7 places the crate-wire check dams is proposed to be placed to reduce the run-off rate.

Glimpses of Sankala team with community members during field research in Uttarakhand

The Uttarakhand Forest Resource Management Project's Micro-watershed (MWS) model focuses on sustainable management of forest resources, environmental services, and community development. It employs a multi-pronged approach with activities categorised under forest management, environmental service, and social development. Key activities include water harvesting through groundwater recharge structures, ecosystem restoration via reforestation and afforestation, and community benefits by enhancing livelihoods and improving water quality.

Additionally, the model promotes agricultural productivity through agroforestry and sustainable farming practices, and soil erosion control to reduce deforestation and natural disaster risks. By integrating these efforts, the UFRMP - MWS model aims to ensure the ecological balance and resilience of local communities, aligning with the broader objectives of sustainable development in the Uttarakhand region.

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