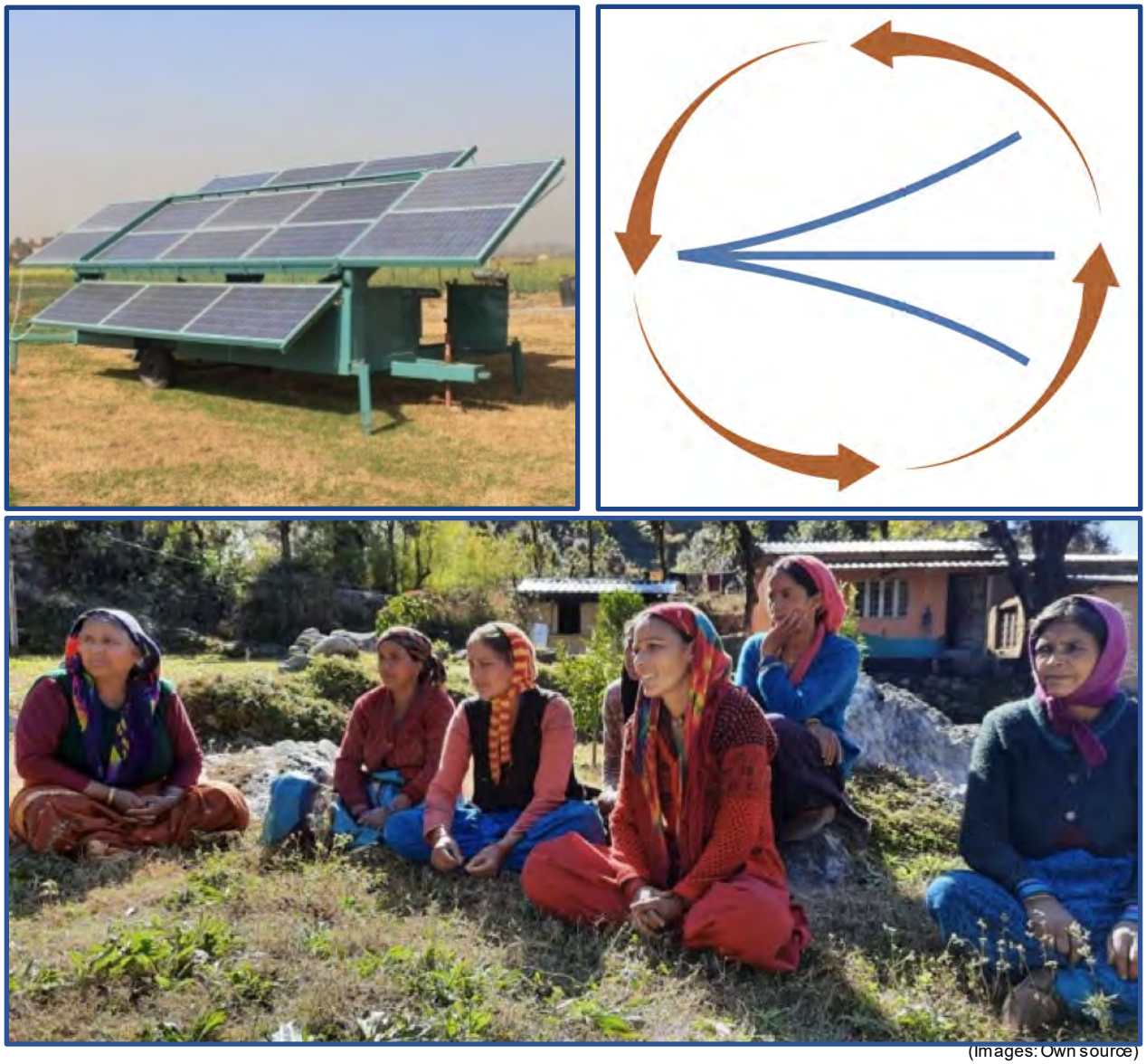
Final Technical Report - HI-PATH Project

Climate resilient development pathways
in the Hindu Kush Himalayan region



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Colophon

This report was produced under the *HI-PATH Project: Climate resilient development pathways in the Hindu Kush Himalayan region*. The Hindu Kush Himalayan region is a climate change hotspot. For development to be sustainable in the Hindu Kush Himalayan region, interventions need to include choices and actions that improve livelihoods and alleviate poverty, counteract climate change, and are inclusive for the most vulnerable and resilient over time. In this context, the HI-PATH project aimed to co-create climate resilient development pathways for the Hindu Kush Himalayan region. Climate resilient development pathways consolidate climate action and development decisions towards long-term sustainable development. The project built on livelihood innovations that were piloted by the Himalayan Adaptation, Water and Resilience (HI-AWARE) consortium under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA). HI-PATH strengthened and maintained the HI-AWARE partnership. HI-PATH was implemented by six cooperating partner institutes: the Bangladesh Centre for Advanced Studies (BCAS), Bangladesh; the International Centre for Integrated Mountain Development (ICIMOD), Nepal; the Institute of Civil Engineering of the National University of Sciences & Technology (NICE - NUST) together with the Climate Change, Alternative Energy, and Water Resources Institute of the Pakistan Agricultural Research Council (PARC), Pakistan; the Energy and Resources Institute (TERI), India; Wageningen Environmental Research (WUR), the Netherlands; and the United Nations University - Institute for Environment and Human Security (UNU-EHS) (international coordinator). HI-PATH is carried out under the CLimate And REsilience Framework Programme (CLARE).

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1. Introduction

Communities throughout the world face substantial challenges in the face of climate change. This is of particular concern in climate change hotspots, especially where extreme climate effects coincide with large numbers of vulnerable and poor people. The Hindu Kush Himalayan region is one such climate change hotspot. For development to be sustainable in the Hindu Kush Himalayan region, interventions need to include choices and actions that improve livelihoods and alleviate poverty, counteract climate change, are inclusive for the most vulnerable and resilient over time. Climate resilient development pathways present an option to bring together these goals, by consolidating climate action and development choices to generate pathways towards sustainable development.

The HI-PATH project aimed to co-create climate resilient development pathways in the Hindu Kush Himalayan region. The project built on four livelihood innovations that were piloted in climate change hotspots in a previous project initiated under the CARIAA program named HI-AWARE. The four pilot livelihood innovations that were investigated in HI-PATH are listed as follows:

1. Springshed restoration in selected communities in the Gandaki basin, Nepal.

2. Climate and flood resilient housing in the Teesta river basin, Rangpur district, Bangladesh.

3. Climate Smart Agriculture, emphasizing commercial crops, in the hill district of Rudraprayag, Uttarakhand, India.

4. Portable solar pumping systems for crop irrigation in the mountain districts of Potohwar and Thal sandy desert, Pakistan.

The four livelihood innovations piloted in HI-AWARE were selected from a range of evidence-based options that aimed to enhance climate resilience and strengthen sustainable development processes for communities around the Hindu Kush Himalayan region. However, the potential for upscaling these innovations, their long term sustainability, and the relationship between innovations and community resilience remained understudied. In HI-PATH, researchers monitored and evaluated the outcomes of the pilots and placed them in the context of climate resilient development pathways and policy. This was deemed crucial to understand the impact of livelihood innovations since they had been implemented, and to identify what connective interventions could be taken for long-term sustainable up-scaling and out-scaling.

The **overarching objective of HI-PATH** was to map the outcomes of the four livelihood innovations and co-create climate-resilient development pathways for the upscaling of these innovations. Thus the project also aims to influence relevant long-term adaptation planning and policy processes. The project focused on the above four locations in the Hindu Kush Himalayan region, however, the approach was designed to be transferable to other climate change hotspots for which alternative futures can be foreseen.

HI-PATH had **four specific project objectives** that related to the overarching objective. A further reflection on the objectives, activities undertaken by the consortium and project outputs is given in Section 3.1.3. The four specific project objectives are as follows:

1. Map outcomes of HI-AWARE pilots and what attributes determine what worked / not worked
2. Define monitoring required to upscale livelihood innovations in context of climate-resilient development
3. Co-create climate resilient development pathways that upscale / outscale the learnings within policy and practice.
4. Provide guidance on how co-creation of pathways gives communities and governance actors ownership to select, implement and monitor livelihood innovations towards sustainable development and climate resilience

Next to the above objectives, the HI-PATH project also aims to strengthen and maintain the HI-AWARE partnership. HI-PATH was implemented by six cooperating partner institutes: BCAS (Bangladesh), ICIMOD (Nepal), NICE-NUST together with PARC (Pakistan), TERI (India), WUR (Netherlands), and UNU-EHS (international coordinator).

1.1. Reading guide

This technical report consists of five chapters, with supporting materials in the Annexes. In **Chapter 2**, we discuss the outcomes and results of HI-PATH. In **2.1** we reflect on how the results from HI-PATH relate to the outcomes sought under the CLARE program, followed by four stories of change from each of the livelihood innovations in **2.2**. In **2.3** and the accompanying annex, we present project outputs and in **2.4** we reflect on the most important results and consequences that arose from the project. In **Chapter 3**, project implementation is discussed. In **3.1**, activities undertaken over the project period are discussed, followed by the challenges that were faced. Then we reflect on the specific objectives of the project. In **3.2**, we discuss steps that were made towards gender, social inclusion and safeguarding. In **Chapter 4** we discuss research uptake, focusing on demand in **4.1** and endorsements in **4.2** and in **Chapter 5** we highlight additional insights and future research direction from the project.

2. Outcomes and Results

Chapter 2 of this report critically reflects on the outcomes and results of HI-PATH. In Section 2.1, this reflection asks how the results of the project have contributed to the outcomes and four objectives of the CLARE program. Section 2.2 recalls four stories of change from each of the livelihood innovations in HI-PATH. Following this, project outputs are discussed in Section 2.3 and a reflection is made of the most important results and consequences in Section 2.4.

2.1 Reflection on the outcomes sought under the CLARE program

Section 2.1 discusses how the activities and results of HI-PATH contributed to the outcomes and four objectives sought after under the CLARE program. First, we directly link HI-PATH results and activities to the CLARE objectives. Followed this, we give a more detailed explanation below.

CLARE Outcome: *"Actors in planning, programme implementation, policy and research use a range of evidence-based options to enhance and support communities' livelihoods in the face of climate challenges in ways that benefit the most vulnerable women and men."*

1. ***Maximize uptake of existing knowledge by policymakers and practitioners***
    - By explicitly focusing on upscaling and outscaling of four livelihood innovations designed and implemented through participatory processes in HI-AWARE, the project builds on and advances our existing knowledge.
    - Pathways as a methodological approach allowed for the integration of existing knowledge using a range of participatory techniques, from policy makers, practitioners and communities (See pathways in Annexes 3, 4, 5 and 6).

2. ***Drive development of new knowledge to support adaptation and boost resilience among the most vulnerable***
    - Mapping the outcomes of the four pilot innovations, novel insights were given as to the strengths/ weaknesses of the work implemented in HI-AWARE at the community and institutional level over medium - longer time periods.
    - Climate resilient development pathways were discussed with direct beneficiaries and other stakeholders to upscale / outscale the learnings within policy and practice. Lessons emerged from the cases for the practice of climate resilient development pathways, which can be found in 2.4.6.
    - A research paper has been published titled *'Advancing climate resilient development pathways since the IPCC's fifth assessment report'*[1]. For the paper, researchers conducted a systematic review of literature and held reflexive focus group discussions with experts on the topic. A guiding framework on 8 lessons for climate resilient development pathways emerged from this work.

[1] Werners, S.E., Sparkes, E., Totin, E., Abel, N., Bhadwal, S., Butler, J., Douxchamps, S., James, H., Meathner, N., Siebeneck, J., Stringer, L.C., Vincent, K., Wise, R., Tebboth, M.G.L., 2021. Advancing climate resilient development pathways since the IPCC's fifth assessment report. Environmental Science & Policy 126, 168–176.

- A *research report* and *draft peer reviewed paper* has been written which provides a novel approach for monitoring and evaluation of climate resilient development pathways, a subject that is currently underrepresented in the literature.

3. ***Strengthen capacity from research to action for sustainable climate-resilient development***
    - State/ national level workshops were held to strengthen the capacity for integrating insights on the pilot innovations (identified through outcome mapping and additional follow up engagements) with those of experts and decision makers in each country.
    - A structured pathways approach offered a useful tool to discuss and prioritise what actions were needed at different timescales and levels, bringing together inputs from communities, local, state and national level stakeholders through co-creation processes.
    - An online workshop template has been produced on the website Miro, which can be used by practitioners and researchers, with the aim to build capacity for creating climate resilient development pathways with stakeholders in a virtual workshop setting (See Annex 8 for images). This was developed so project partners and other interested parties could continue to deliver their work online both during and after the COVID-19 pandemic.
4. ***Support practical action by addressing trade-offs and barriers to climate adaptation for the most vulnerable***
    - There was an explicit focus on identifying challenges and barriers to upscaling and outscaling of the pilots at both the beneficiary and implementing agency (including policy) level during the outcome mapping and pathways workshops. Actors were selected to have knowledge and lived experience of how the livelihood innovations were influencing climate resilience, adaptation and development, and what possible opportunities or barriers could be for upscaling the technologies. Specific challenges and barriers, and how to overcome them are given in section 2.4.
    - The workshops provided a platform for vulnerable groups to be included in decision making processes that affect them. The co-creation process gave insights into new and practical participatory knowledge for policy makers, such as the development aspirations of communities, or where the innovations needed adjusting, and what 'soft' measures are needed to overcome barriers.

2.1.1 Outcome mapping

To collect evidence on the four livelihood innovations, HI-PATH applied outcome mapping, a systems oriented project design, monitoring and evaluation approach that is useful for understanding incremental changes in complex settings[2]. The pilot projects had been designed to enhance and support communities' livelihoods by building individual and community

[2] Earl, S., Carden, F. and Smutylo, T. 2001. *Outcome Mapping: Building Learning and Reflection into Development Programs*. Ottawa: International Development Research Centre.

resilience to specific climate challenges faced in the four respective research areas. The innovations were designed to support climate adaptation and development among vulnerable communities, and were informed through a thorough participatory scoping process that occurred during HI-AWARE. However, to develop a critical understanding and collect evidence of how interventions were actually working over medium and longer time periods, monitoring and evaluation was needed. HI-PATH employed outcome mapping, which included field surveys, interviews and focus groups with a range of actors as well as quantitative mapping. Actors were selected to have knowledge and lived experience of how the livelihood innovations were influencing climate resilience, and what possible opportunities or barriers could be for upscaling the technologies (for climate resilient development) in the research areas.

The outcome mapping in HI-PATH was imperative to: a) Measure the objectives and direction of the livelihood innovations, b) Learn from the HI-AWARE intervention to acquire new knowledge, c) Engage with the values and aspirations of stakeholders with whom the livelihood innovations influenced, d) Identify how the work designed under HI-AWARE has influenced the climate resilience for communities, and where trade-offs, barriers and opportunities may arise for upscaling. The outcome mapping methodologies were designed to ensure the voices of women were equally accounted for, for example through holding female only focus groups and analysing results that identified implications of the livelihood innovations specifically for women.

The results obtained for outcome mapping suggest that each of the livelihood innovations has supported climate adaptation and development for communities and other boundary partners, thereby strengthening resilience for stakeholders throughout the four research areas. Each of the innovations was providing benefits to communities as designed, for example through providing or expanding climate resilient livelihood opportunities, ensuring the provision of basic resources in the face of climate change or providing hazard resilient infrastructure during extreme events. Furthermore, outcome mapping found that the four pilot projects were strengthening climate adaptation and development capacities for institutions, such as NGOs and Government bodies, for example, by learning from the projects and replicating aspects of them elsewhere. There was explicit focus on identifying both opportunities and barriers for upscaling and outscaling for different groups of actors, and what role they can play in facilitating this process. This then informed the process for the co-creation of climate-resilient development pathways. For information on specific outcome mapping results, including barriers and challenges for each livelihood innovation, refer to Section 2.4.

2.1.2 Climate resilient development pathways

Building on the findings from outcome mapping, workshops were held with communities, regional and national level stakeholders to bring together multiple perspectives and explore possible opportunities and barriers for upscaling and outscaling of the pilot innovations in the context of climate resilient development pathways.

The workshops were tailored for each case based on the outcome mapping, the case study team and importantly the COVID-19 situation in each case region. Each workshop was designed so as to contribute toward objective 3 of HI-PATH. An online workshop format was developed in Miro and piloted with project partners (See Annex 8). Workshop formats were

derived from this online format. The workshop format is made publicly available as guidance on co-creating climate resilient development pathways (HI-PATH Objective 4).

The workshop results gave an indication as to what action pathways were needed from stakeholders across various levels to upscale the innovations to contribute to climate resilient development. Furthermore, a structured pathways approach offered a useful tool to discuss and prioritise what actions were needed at different timescales and levels. By bringing together inputs from communities, local, state and national level stakeholders through co-creation processes, the workshops provided a platform to consider vulnerable groups in decision making processes that affect them. The co-creation process gave insights into new and practical participatory knowledge for policy makers, such as the development aspirations of communities, or where the innovations needed adjusting, and what 'soft' measures are needed to overcome barriers. Lastly, by applying climate resilient development pathways approaches in the workshops, we hope to enhance the uptake and outscaling of these methods in research, policy and practice in the respective research areas. From the cases, numerous different lessons have emerged for the practice of climate resilient development pathways. These lessons arose from applying the methods in HI-PATH to address the projects four objectives, and will be summarised in a peer reviewed paper from the consortium.

2.1.3 Desk work

As well as conducting fieldwork through outcome mapping and workshops, HI-PATH researchers conducted desk studies that have generated new knowledge on climate action, resilience and development, thereby contributing to benefitting vulnerable women and men in the face of climate change. A research paper has been published titled *'Advancing climate resilient development pathways since the IPCC's fifth assessment report'*[3]. For the paper, researchers conducted a systematic review of literature and held reflexive focus group discussions with experts on the topic. Results included presenting ambiguities found in the literature and supports practical action by providing guidance for researchers and practitioners aiming to uptake climate resilient development pathways approaches. Colleagues from CARIAA and CLARE working on the project 'Climate resilient development pathways in Semi-arid regions of Africa and South Asia' collaborated with us on this paper, having been brought together at the CLARE online event in April 2021. The paper was submitted in draft to the authors of the IPCC's 6th assessment report Chapter 18 on climate resilient development pathways. Unfortunately, the paper was approved 8 days after the literature cut off point.

Furthermore, a *research report* has been written which provides a novel approach for monitoring and evaluation of climate resilient development pathways, a subject that is currently underrepresented in the literature. This report aimed to develop new knowledge on the topic, and was informed from empirical lessons that were learned through the application of outcome mapping across the HI-PATH team, as well as from conducting interviews with outcome mapping experts and reviewing peer reviewed and grey literature on monitoring and evaluation. This work supports practical action by providing a framework for practitioners, and recommends

[3] Werners, S.E., Sparkes, E., Totin, E., Abel, N., Bhadwal, S., Butler, J., Douxchamps, S., James, H., Meathner, N., Siebeneck, J., Stringer, L.C., Vincent, K., Wise, R., Tebboth, M.G.L., 2021. Advancing climate resilient development pathways since the IPCC's fifth assessment report. Environmental Science & Policy 126, 168–176.

engaging with trade-offs and making gender considerations central in project design. The work can support actors in projects that aim to enhance and support communities' livelihoods and resilience. A 1st draft of this work has been produced for a peer reviewed paper.

An online workshop template has been produced on the website Miro, which can be used by practitioners and researchers to co-create climate resilient development pathways with stakeholders in a virtual setting (See Annex 8 for images). This was developed so project partners and other interested parties could continue to deliver their work both during and after the COVID-19 pandemic. It was tested in national level workshops by BCAS in Bangladesh and PARC in Pakistan. The work was also noted by colleagues in South Africa, who are considering using an adjusted version to create climate resilient development pathways for the Presidential Climate Commission of South Africa. This board has been designed with the purpose of safeguarding researchers and vulnerable communities from COVID-19 and future pandemics. Furthermore, it gives practitioners and communities the possibility to co-create pathways in a virtual setting, removing the necessity to travel and therefore limiting contributions to climate change. However, it must be acknowledged that digitalisation in the way we work has left those in vulnerable situations, with limited or no electricity and internet access, further behind in a rapidly digitalising world.

2.2 Stories of change from HI-PATH

The evidence-based approaches employed in HI-PATH, discussed in 2.1, have improved livelihoods through enhancing individuals' resilience to climate change while contributing to communities' sustainable development. In this section, we recount stories from individuals and communities who have been affected by the work done in HI-PATH.

Climate and flood resilient housing in the Teesta river basin, Rangpur district, Bangladesh

Bangladesh is one of the countries that is most vulnerable to climate change. Flash & seasonal flooding are common occurrences. Some of the most vulnerable communities who suffer from floods are people living in Char areas. Rahima Khatun lives in one such community, Char Haibot Kha, a village in the sub-district of Kaunia Upazila, located on a floodplain of the Teesta river basin. Due to riverbank erosion and the impermanent nature of the chars, houses are highly susceptible to flooding and Rahima's community are greatly affected by recurrent floods. Peoples' houses become inundated and communities lose their livelihoods and assets. These recurrent floods and associated riverbank erosion make millions homeless every year. To address some of the issues faced in Rahima's community, BCAS with C4RE Services Ltd, piloted the construction of climate and flood resilient housing in multiple Chars. The houses are made using flood-resilient building material on raised earthen foundations. They also provide space for homestead agriculture, and are fitted with solar panels, improved cooking facilities, sanitary toilets and wells. The design has been made to sustain occupants and provide a safe space during floods.

To understand how the houses have been influencing the lives of communities in Char Haibot Kha, BCAS conducted outcome mapping in HI-PATH. Results showed that the houses have provided adequate shelter for the flood-affected families. Rahima expressed she is highly satisfied with the benefits that the housing is providing, and her family are happy and leading

more comfortable lives as a result. In recent floods the house was not badly damaged, in contrast to previous floods which have been highly destructive, damaging infrastructure and destroying garden crops grown for subsistence. She told researchers that her family could give shelter to five other neighbouring families during floods, which she said has enhanced their social status in the community. Furthermore, children in the community love the concept of a two storied house, which is not common in the area, and they come together to study on the 2nd floor. The garden that was established in the winter of 2021 is showing a good yield with a variety of types of vegetables for subsistence. Even during very extreme floods in July and August of 2017, the climate and flood resilient houses only sustained minor damage. According to the community, there have been other extreme flood events since 2017, in which the housing remained secure, however specific data on the severity of these floods cannot be confirmed due to a lack of data in the area. Due to the success of the pilot, the government of Bangladesh has requested information on the livelihood innovation to assist them with a resettlement programme that aims to house all landless and homeless people by 2030. Initial commitment of the policy from the government is 200.000, expanding to 900.000 disaster resilient houses, overall costing $1.2 Billion Taka (14 Million US Dollar). Although specifics are yet to have defined, BCAS is in ongoing consultations with the government of Bangladesh, and hopes to take lessons from the pilot to develop concrete policy plans.

Overall, the work under HI-PATH has found that the climate and flood resilient housing is a good initiative for improving the lives of vulnerable women and men in the flood-prone areas of Bangladesh, as this personal story emphasizes. Rahima's community are now safer from flooding than they were before.

Figure 1: Community workshop in Dimla, Nilphamari district (06/10/2021)

Springshed restoration in selected communities in the Gandaki basin, Nepal

Springs are the major source of water in the mid-hills of Nepal, with around 80% of people depending on them for drinking, domestic and agricultural uses. In recent years, the drying up of springs due to climate change, and the shifting of spring locations due to seismic activity, has resulted in water scarcity for many communities. One such community is Charghare VDC,

situated on the upper part of Gandaki River Basin, Bidur Municipality of Nuwakot District. People have been forced to cover longer distances to fetch water for daily consumption, which has particularly resulted in increased burdens for women. Furthermore, there has been increased discrimination against Dalit communities (a marginalised caste in Nepal) when using communal taps, and purchasing spring immersed land has initiated conflict. To overcome these challenges, spring shed monitoring research was carried out by ICIMOD to understand spring hydrogeology as well as socio economic and governance aspects of spring management in the region. ICIMOD with its partners developed a "6-step spring revival protocol" to understand spring dynamics. Based on the protocol, 31 springs of high significance were mapped, two rain gauge stations were installed, and locals were trained to keep a log for bi-monthly spring discharge and daily rainfall. Under HI-PATH, outcome mapping assessed the social and governance aspects of spring use, focusing on the challenges faced by women and Dalits. A hydrogeological study was carried on 4 springs to identify the recharge area and recommended possible interventions. Furthermore, there was an assessment of the change in behaviour of communities after the spring revival intervention.

The project has directly initiated a number of positive changes. Springshed mapping identified areas for conducting restoration/ recharge measures. These were carried out by the local government and communities. Measures included afforestation, cleaning campaigns, construction of ponds and repairment of water tanks and pipes. The work has educated communities, who are now more aware of the importance of conservation activities and contribute both to labor and financial support. Durga Khadka, a representative for the female community in Charghare VDC told HI-PATH researchers "With sufficient access to water in nearby springs, women don't have to travel as far a distance to fetch water, even during night. They can focus more on their children and household chores". Following this, Kamala Paneru, another female community representative, said "We formed a women's water management committee and have carried out conservation measures, such as afforestation, construction of trenches and pits and promoted a sanitation campaign, for which we have received a conservation award from local government". Dhanmaya Sunwar, a Dalit community representative, noted "We don't face any discrimination while collecting water from communal springs, we also contributed labour support to construct a recharge pond". Lastly, Ambika Sunuwar, a local government representative, told researchers "We have targeted a one household / one tap policy under government schemes to ease water access. The community have come forward with concerns and want to carry out spring revival activities in the area".

The results from HI-PATH have found that the implementation of a spring revival protocol has had a significant impact for communities. People now have a better understanding of both hydrogeological and socio-economic aspects of spring resources, which is contributing to resolving water scarcity issues.

Figure 2: A spring water source for 50 households in the village of Mulabari (left) and Shalik Ram Bhatta (the local resource person) who was trained as a data collector in HI-AWARE and HI-PATH (right). Mr Shalik has extensive local knowledge of spring conservation.

Climate Smart Agriculture, emphasizing commercial crops, in the hill district of Rudraprayag, Uttarakhand, India.

Uttarakhand is a hill state nestled in the northern Indian Himalayas, supporting diverse ecosystems of forests, glaciers and river systems. Communities' livelihoods in this area largely depend on the agricultural sector. A decade ago, the villages in these regions were covered in snow during the winter season, which runs from December to February. However, now climate change has significantly decreased the amount of snow. Despite more bare land now being available to farm, communities continue to practice traditional methods of growing wheat, millets, and tuberous roots such as turmeric outside of the winter months. Furthermore, climate change is affecting the growth of fruit crops such as Malta Orange that once frequently dotted the slopes of these hills, and have now almost disappeared, which has resulted in farmers working even harder for their livelihoods. The temperature, soil condition and traditional methods of cultivation here did not allow for profitable farming during the winter, but due to climate change this dynamic has shifted. In this context, Huddu, a village in the Ukimath block of Rudraprayag district was identified to explore opportunities for extending livelihood support to households by diversifying agricultural practices that work with the changing climate in the region. TERI along with Society for Himalayan Agriculture and Rural Development (SHARD), a local not-for-profit organization, undertook the pilot project, introducing cash crops to be grown in the winter season and promoted horticultural crops to suit the changing climate, such as potatoes. Activities included the procurement of seeds, conducting hands-on training/ demonstrations with the community. Consultations were held with women, who constituted the majority of the farming community in Huddu. These consultations led to land consolidation schemes, allowing for bulk procurement of cash crops in the community. During monitoring and evaluation activities in HI-PATH, TERI mapped the outcomes of the pilot to identify what had/ had not worked and to gain a holistic understanding of the impact of the pilot.

The activities in HI-PATH identified a number of changes in the community as a result of the pilot undertaken during HI-AWARE. In July 2018, 7,500 kilograms of potato was harvested, and was sold for approximately INR 1.50 lakhs by the community. The 37 households of the village

that participated in the initiative earned an average of about INR 3,600 from a holding size of 200 m^2, as compared to an average of INR 700 from wheat crop yields harvested from the same farm size in previous seasons, approximately a fivefold increase. Despite the increase, the yields were perceived to be low according to TERI agricultural experts, who felt that with procurement of better quality seeds, the yields could be further improved in future. Although HI-PATH activities have identified significant positive changes for participating households, challenges have been identified. While initially households have continued on a collective mode for production, since the introduction of the pilot, practices narrowed down and became more individualistic and soil moisture conditions were reported to have changed resulting in low harvest. Furthermore, formal market access was discussed as a barrier for selling crops at the state level. However, the education from the HI-AWARE interactions were noted as directly boosting communities' confidence in experimenting with new crops for growth for commercial purposes. A farmer from Huddu, Ms. Lalita Devi and other members of the community continue to explore opportunities to diversify with cash crops that suit the soil, water and climatic conditions of the region. She shared her experience of profiting from growing kidney beans (rajma) by selling it in the local market of Ukimath. Interactions also reflected that households are willing to explore opportunities to grow herbs, medicinal plants as well as crops which are not labour intensive given the terrain characteristics- steep slopes and gradients and scattered land, to be traversed to produce food.

With the direct support provided by TERI and SHARD, Huddu emerges as a fine example of how community farming can help offset the adverse impacts of climate change in the agriculture sector.

Figure 3: Surji Devi, a farmer in Huddu village, "Earlier, that land wouldn't give me much". *Image Source: Julie McCarthy*

Portable solar pumping systems for crop irrigation in the mountain districts of Thal and Potohwar, Pakistan

Agriculture is the biggest user of freshwater resources in Pakistan, consuming more than 90% of the total available water for irrigation of crops. Currently, Pakistan has more than 1.4 million groundwater pumps, most of them installed privately by farmers running on diesel or electricity. Diesel-operated pumps have large fuel cost and produce greenhouse gas emissions; electric pumps have issues, including high tariffs, frequent power cuts, unavailability of transmission networks at remote locations and high initial costs thus creating burdens in the form of subsidies for the government. Therefore, there has been a need for farmers to reduce dependence on diesel and electricity pumping by finding alternative clean energy sources for water pumping.

Recognizing these problems, the Pakistan Agricultural Research Council (PARC) conducted successful experiments with solar-powered tube wells between 2010-11. However, from this work, PARC encountered issues with solar water pumping. At the forefront of these problems is the high capital cost of solar pumping systems. In addition, farmers cannot take full advantage of solar energy because they do not need to water crops 365 days a year, so fixed solar tube wells stand idle on days where there is no need to water. Moreover, farmers' land is divided into segregated plots, and due to the high costs they cannot put separate solar pumps at each parcel of their land and theft of solar panels is a big problem. To solve all these problems, the Pakistan Agricultural Research Council invented the solar trolley to facilitate portable solar pumping systems. A solar trolley is a transportation structure on which solar plates are mounted. These solar plates can be easily opened and closed. Farmers can easily move this trolley from one place to another with the tractor and all areas where freshwater is available at shallow depths can take full advantage of this technology.

Sanaullah, a sugar cane and rice farmer interviewed for a short documentary that was produced in HI-PATH noted *"I bought this portable solar pump three years ago. Firstly a lot of Diesel fuel is saved, Secondly the crop production overall has improved and thirdly, in comparison the yield average is significantly higher. I used to spend six hundred thousand rupees for diesel cost annually. Not only am I saving six hundred thousand, but the crop production is also better. The Crop yield used to be somewhere between nine hundred monds per acre now it is about twelve hundred monds, all due to better water and fertilizer use. I thank the Almighty Allah, my overall condition has improved a lot after installing the system."* Under activities in HI-PATH, PARC, have mapped the outcomes for many farmers who have taken up the technology, and have found similar results. Crop yield for high irrigation crops such as sugar cane have significantly improved, and diesel costs have significantly reduced, which has resulted in more capital available for other products such as fertilisers. The results suggest that farmers see a return on their investment after three years, therefore increasing the incentive for any small to medium scale farmers with access to capital. Furthermore, to meet the demand for the innovation, local manufacturers have started producing the solar trolleys, with included additions to meet specific needs of farmers, which has diversified and increased their income as well. Estimates show that

approximately 1500 units have been produced in Thal region alone. However, financial facilitation is still an important barrier for those without the initial capital, and needs more support from governmental actors to ensure the benefits of the innovation are improving the lives of smaller scale farmers more vulnerable to volatile markets and climate stressors.

Due to the success of the pilot innovation, and from the new information obtained in HI-PATH, PARC and NUST have conducted training workshops to educate farmers across Pakistan on the benefits of using portable solar pumping irrigation systems, specifically in the areas of Sheikhupura Gujranwala Narowal Gujrat Bhakkar Sukkur and DI Khan. Furthermore, the research team has developed a short documentary, which has been made to further promote (and raise awareness of) the benefits of solar water pumping and the portable solar pumping systems to farmers, trolley manufacturers and other interested parties. The final draft of the documentary can be found here, with both Urdu and English commentary.

Figure 4: National consultation workshop on solar water pumping, Islamabad 17/02/2022.

2.3 Project outputs

HI-PATH supported a suite of internal and external project outputs that contributed toward the project's four objectives. Outputs include fieldwork reports, research reports, peer reviewed papers, workshops, conference contributions, an online workshop platform and a documentary. Annex 1 provides a full list of project outputs.

2.4 Most important results and consequences

Undoubtedly, the most important result from HI-PATH is that the project confirms the work initiated in HI-AWARE has had a positive influence on vulnerable communities living in climate change hotspots in the Hindu Kush Himalayan region. The outcome mapping process monitored and evaluated many positive impacts that can be attributed to enhancing climate resilience, improving development processes and alleviating vulnerability and poverty for women, men and children as highlighted in the stories of change. Furthermore, the work has confirmed that the livelihood innovations have inspired others to follow, examples of which are

given below, where we reflect on the most important results and consequences from each of the four project components and desk work conducted under HI-PATH.

2.4.1 Springshed restoration

- Activities under HI-PATH identified a number of important enablers for the replication and upscaling of spring conservation activities, which can be beneficial in areas facing similar challenges to those of the pilot area. Firstly, coordination among the local government and communities was found to be of crucial importance in the overall project cycle, and is advised for all upscaling activities. Second, citizen science approaches to collect data on discharge and rainfall measurements have been identified as key enablers to understanding technical aspects of the hydrological study of springs, as more frequent and participatory monitoring cycles can be taken. The local resource person trained under HI-AWARE had extensive knowledge of the local context, surpassing that of experts at ICIMOD during follow up consultations in December 2021. This lesson has been useful for Objective 2, on defining requirements and approaches for monitoring climate resilient development pathways. Third, concerning scale, it is important to develop a spring shed management plan at the local level as communities can directly and actively learn the best practices through co-creation processes and the government can play an important role in transferring the knowledge from one community to another, thereby generating awareness and uptake of practice.
- Outcome mapping identified that springshed research conducted under HI-AWARE has directly contributed to positive changes in behaviour of communities. Training given to local resource persons and interactions with local government agencies have raised awareness of the importance of spring conservation and has increased stakeholders' interest to learn more about springshed management and technologies to implement them.
- In interactions with Dalit communities, individuals noted that since spring mapping and tap installation activities, they have been subject to less discrimination as there is less competition for water resources, and waiting times for access to water have reduced.
- Women have to spend less time, and walk shorter distances to collect water for domestic uses since the implementation of the intervention. Furthermore, informal water committees have been established led by women, whereby they collect $1USD per month to repair, maintain, clean and conduct conservation activities for springs.
- Different adaptation options have been envisioned as important for climate resilient development of spring management by communities and the municipality of Nuwakot. Shared options that were highlighted by both communities and the municipality are continual programmes of awareness raising and education and training on technical capacities to conserve springs. Due to lack of technical knowledge, the Mayor of Bidur Municipality admitted that they did not allocate a budget for the conservation and management of springs. As a result, the local resource person trained in HI-AWARE and HI-PATH and a technical expert from Bidur Municipality were invited to a training organized by ICIMOD on springshed management, which created an opportunity for them to share their problems, learn from other participants from the training and report back to the Mayor. As a result of this, the Mayor has dedicated funds for spring conservation.

- Climate resilient development pathways developed in Nuwakot in 2018 (Pandey et al., 2021[4]) showed that five years ago, road construction was of high priority to communities. In recent fieldwork, communities expressed concern for the impacts that unregulated road construction was having on spring hydrology, and there was increased interest in 'soft' measures such as spring conservation and training.
- Climate resilient development pathways have been developed for springshed restoration and management in Nuwakot district (Annex 3). These pathways include actions suggested by stakeholders during fieldwork consultations, defined as what they perceive are important steps taken by various actors. These pathways build on the work from Pandey et al (2021), and highlight actions that were mutually identified in both his work in in recent consultations.

Challenges and barriers

- Due to seismic activity and climate change influencing hydrology, it is important to develop an iterative process of updating springshed maps. By identifying recharge areas with appropriate land-use planning tools, such as ICIMODs 6 step protocol, solutions continue to improve livelihoods over long time frames.
- Women still face significant burdens concerning collecting water for domestic uses. Outcome mapping identified that on average, women spend nearly 2 hours every day collecting water. Less than half of women surveyed (43%) have access to water through pipelines, whereas 57% still have to wait in a queue to fetch water, even at night. Furthermore, 45% responded that they are not allowed to touch communal water taps while menstruating, and a small number were only allowed to collect water for themselves and not their families.
- After the spring mapping activities, some wealthy individuals bought land that contained spring water resources. This highlights an undesired result that can be attributed to the work in HI-AWARE, and emphasizes the need for iterative monitoring and evaluation to account for the full impacts of projects over time.
- During the second phase of fieldwork on the springshed management case, it was highlighted during community focus groups and interviews with political representatives that the construction of new roads in Nuwakot has either shifted spring locations or negatively impacted spring hydrology, enhancing water scarcity issues. However, climate resilient pathways developed in HI-AWARE in 2018 (Pandey et al., 2021) identified that short-term and medium-term priorities for both male and female community members and regional governmental bodies in Nuwakot are the construction of roads, as they improve connectivity to essential services such as hospitals, and enhance economic growth. Nuwakot has seen extensive construction of roads, therefore this also raises a question of trade-offs between roads for development and springshed for water security with regards to this observation.

2.4.2 Climate and flood resilient housing

- Outcome mapping confirmed that communities in the piloting areas are very accepting of CFRH, which has proven to be extremely useful during floods in providing a safe haven for

[4] Pandey, A., Prakash, A., Werners, S., 2021. Matches, mismatches and priorities of pathways from a climate-resilient development perspective in the mountains of Nepal. *Environmental Science & Policy*, *125*, 135-145.

the beneficiaries as well as their neighbours. During extreme flooding events, the houses had little damage, and design faults, such as the decomposition of wooden material over time, can be easily overcome. Participants in female only workshops noted the houses are safe haven for pregnant women and new mothers during floods and adjacent and separate toilet facilities for women on raised foundations have made living easier for women, girls and elderly, especially in flood time.

- It was identified that the largest obstacle for upscaling and out scaling of the pilot is the cost (Approximately $5000). This can be overcome through government support, involvement of private sector organisations, sourcing materials locally and partial funding from communities (which can help foster ownership and maintain structural components of the house that were found to degrade over time).
- Two workshops brought together knowledge from communities and experts, identifying numerous important actions to both upscale pilots and to reach the desired futures as highlighted by communities. The pathways visualised short, medium and long term actions needed to reach these goals, and include important stakeholder groups needed to mobilise action. Expert stakeholders from the national workshop were selected based on their involvement in working with the people in Char areas on housing, water and sanitation, livelihood and gender based issues. They ranged from Governmental organisations, to NGOs to research institutions. See Annex 2 for a list of attendees and Annex 4 for pathways visualisations from the BCAS workshops.
- In the community workshop, identified actions needed to develop climate resilient development pathways can be categorized into 5 clusters. 1) Government interventions & governance options, which mainly focuses on strengthening the linkage between local government bodies and communities to increase aid. 2) Technological interventions focused on a variety of actions including raising earthen foundations, introducing new crops, river dredging and embankment projects. 3) Climate and flood resilient housing options, which emphasized what actors play a role in upscaling the housing, including NGOs supporting implementation short term, NGOs, government and community implementing mid-term and government and community voluntarily building houses in long term. 4) Capacity building & training, focused on training for alternative livelihood options (such as livestock rearing), awareness raising for climate change issues. 5) Value chain & market linkage of livelihood opportunities, which was stressed as an important factor to raise the standard of living for the communities. Community pathways can be found in Annex 4.
- The top priority for communities was the implementation of hard infrastructural measures to reduce flood impacts, which was perceived as important to improve livelihoods. Following this, crop diversification, opportunities for better education, and government financial support during floods were also highlighted.
- HI-PATH researchers have been involved in multiple governmental consultations (with both national and local level institutions) who are involved in disaster risk management, development planning and engineering. These consultations involved requests for information on the CFRH housing project, as the government wants to learn from the pilot process, which will contribute (in part) towards a commitment for the provision of safe shelter for all citizens.The policy's initial commitment is to construct 200,000 homes, expanding to 900,000, in both urban and rural areas, costing $1.2 Billion. In the

consultations, the team integrated both local and scientific knowledge, strongly advocating to policy makers the benefits of CFRH for poor communities living in floodplains, and have advocated for an institutional framework or operational mechanism to invest in flood resilience with involvement from the private sector engagement and NGOs. The government have taken on recommendations made by the HI-PATH team and they are continuing to work in close cooperation, exploring opportunities across other regions.

Challenges and barriers

- In both workshops and during outcome mapping, researchers felt there was a low awareness of climate change risks among communities. More attention was given to challenges in the implementation of infrastructural measures, such as river dredging or the construction of hard infrastructure, which was perceived as the strongest driver of flood risk.
- The most significant challenge for upscaling of the innovation concerned the financial cost for individuals, which is too high (approximately $5000). Furthermore, it was found that some individuals lack a sense of individual ownership for the house, and expected C4RE Services Ltd to maintain the properties when there were structural issues. HI-PATH researchers found that partial funding from NGOs or government subsidies can help facilitate increased construction of the houses. This would also help foster a sense of ownership for individuals, as individuals would partially fund the house themselves and therefore be more likely to maintain structural components. Moreover, using locally sourced materials could reduce costs and provide income for local industry and carpenters.
- Despite BCAS interaction with the government on the provision of shelter for all citizens, no specific direct financial commitment has been given to build more CFRH to date.

2.4.3 Climate smart agriculture

- Surveys conducted in HI-PATH highlighted that 80% of the 37 households in the HI-AWARE pilot continued the practices they were introduced to. The cultivation of potato, in particular, has continued and farmers have reported an increase in net incomes from the crop. Other cash crops such as garlic, onion, peas, mint, spinach and green vegetables are being grown. The outcome of the pilot at the community level highlights that HI-AWARE has succeeded in motivating communities to grow alternative climate resilient cash crops, triggering a shift from subsistence based farming to enhancing incomes and livelihoods.
- In 2018, the land consolidation scheme initiated during HI-AWARE produced 7,500 kilograms of potatoes, which was sold for approximately INR 150,000 for the community. The 37 households of the village that participated in the initiative earned an average of about INR 3,600 from a holding size of 200 m^2, as compared to an average of INR 700 from wheat crop yields harvested from the same farm size in previous seasons, approximately a fivefold increase. As of 2022 findings under HI-PATH indicate that incomes from sale of potato harvest have been sustained and are reportedly estimated at 1.05 lakhs (net cumulative) for the community.
- Outcome mapping results found that women outside the 37 pilot households, in the communities living in close proximity to the pilot agricultural landholdings in Huddu, have begun experimenting with alternative cash crops, suggesting some small scale upscaling.

These crops are grown in small amounts and sold at local and informal markets. The women spoken to expressed that they were happy with the prices they were fetching for produce.

- Identified opportunities for more effective upscale include creating formal market links with the state's agricultural department (who have been creating market opportunities and introducing seeds for cash crops) and connecting communities with local agricultural experts to identify actions to maximise growth potential. The Society for Himalayan Agriculture & Rural Development (SHARD) have also been important in connecting communities with government departments for enhancing market access.
- Results from outcome mapping found that communities' awareness of climate change in the region has increased since the implementation of the climate smart agriculture innovation in HI-AWARE. In consultations, communities noted observed changes in precipitation and temperature patterns in recent years.
- During the work stream of HI-AWARE, TERI and SHARD engaged with state/ district agriculture and climate change department officials to share learnings and explore options for livelihood advancement beyond climate smart agriculture. State officials noted interest in expanding livelihood opportunities in the ecotourism sector, which is already popular in the region. This was also flagged by communities during the outcome mapping process, therefore suggesting further exploration of ecotourism opportunities as an avenue for diversifying livelihood opportunities that are less vulnerable to climate change. The state departments have now drafted an ecotourism policy, which in part can be associated with the ongoing interaction between TERI, SHARD and state officials.
- The government officials at the district level are aware of the pilot and have visited the sight multiple times. The District Magistrate and representatives from other concerned government department (e.g. Agriculture, horticulture, livestock) were enthusiastic about the project activities. To extend support to the community and encourage income diversification, departments distributed seeds and saplings to the villagers of Huddu. In addition, opportunities are being explored for better management of agriculture waste, and focusing on the promotion of local cattle breeds as part of larger state initiatives.
- From the interactions in HI-PATH, pathways have been developed at three scales (national, sub-national and local). These pathways concern actions that are needed by different boundary partners whose outcomes have been mapped, namely TERI (national scale), Uttarakhand State Environment, Climate Change, Conservation Directorate and Uttarakhand State department of agriculture (sub-national scale), SHARD and the local community (local scale). Multiple components for desired futures towards climate resilient development have been identified for each boundary partner, with short, medium and long term actions needed to get there. See Annex 5 for pathways visualisations for climate resilient development of boundary partners from the climate smart agriculture pilot.

Challenges and barriers

- Communities noted that there are increasing issues with pests affecting crops introduced under HI-AWARE. Monkeys break through the wire barriers erected to keep out pests and destroy potato crops that were introduced in HI-AWARE.
- Despite the community in Huddu being cognizant of changing climatic patterns in their region, there is little articulation with respect to establishing the link between climate change

and its impacts on agriculture, their dominant livelihood source. Therefore, there is scope to improve the community's knowledge and awareness on climate smart agriculture. Results suggested that climate smart agricultural practices need to be integrated with the use of local and traditional knowledge, as this would synergise with social practices of communities who have been farming for generations.

- Community respondents expressed concern over soil moisture content in agricultural plots. As a result of the relationship established when visiting the pilot site in Huddu, state department officials have been exploring the use of more effective irrigation methods such as drip and sprinklers. To identify the best possible solutions for this issue, further advice should be sought from agriculture experts.
- Given that agriculture in Rudraprayag is extremely labour intensive due to the steep topography, and the general migrational trend is that men leave the community to work in cities, significant burden falls upon women in the community. Opportunities to switch to low input crops should be explored. There is also scope for enhancing cooperation, learning and knowledge sharing between neighbouring farming communities/villages.

2.4.4 Portable solar pumping systems

- Outcome mapping conducted by the research team identified that the pilot solar irrigation pumping system has been substantially upscaled and outscaled throughout farming communities and manufacturers in the Thal region of Pakistan. Conservative estimates from survey results suggest there are more than 40 manufacturers producing the system, which have made at least 1500 units for farmers throughout Thal. This finding far surpassed expectations from the HI-PATH team. Public institutions in the region are also promoting use of the technology. The main factors for high adoption rate in Thal were the availability of ample, good quality groundwater, the high irrigation needs for sugarcane, low mean annual rainfall, historical social practice of using groundwater pumping for irrigation and fragmented locations of plots, which require portable systems.
- The original target region of the innovation was Potohar. During HI-AWARE and the SustainIndus project, training and awareness raising campaigns were conducted there, where some farmers from the Thal region participated. The innovation has grown organically in Thal due to farmers' demand for the technology. 84% 82 survey respondents, which covered farmers, manufacturers and district level institutions, were aware of portable solar pumping systems. This suggests that workshops, blogs, and social media activities for promoting the pilot during the HI-AWARE project were effective and these forms of communication are important for upscaling activities.
- Multiple benefits have been gained for the farmers who have converted from carbon intensive diesel or electric pumps (which are the dominant pumping types in Pakistan) to solar pumping systems. Portable solar pumping systems help local farmers to overcome the high energy costs of diesel and electricity. These savings were used to improve other agronomic practices such as nutrient applications. Of the farmers surveyed, before adoption of the technology, sugarcane yields were approximately 800 Monds/acre, whereas after adoption the yield increased to 1200 Monds/acre, recording a 50% increase. Furthermore, the system is more robust as it does not rely on electrical provision, which is unstable in

many rural regions, and if adjustments are made it can serve multiple functions to meet the owners' needs (such as water pumping for domestic uses) due to its portability.

- Farmers who adopted the technology increased their income considerably. Previously, they spent approximately 3000 Rupees per day, (600'000 per year) on irrigation (average of farmers surveyed). Once purchased, there are very limited operational costs of portable solar pumping systems. The initial investment is around 900'000 Rupees. Therefore, farmers see returns on their investing in 2-3 years.
- The current research for many plant scientists in the region focuses on developing more productive seed varieties, however HI-PATH findings show significant yield increases by adopting different agronomic practices using the same seed varieties.
- The high demand for portable systems has created further livelihood opportunities for manufacturers of haulage trolleys and for electricians in Thal, who are experimenting with different alterations of the structure to meet farmers' needs. For example, one of the manufacturers developed a 'book type' folding mechanism to replace the sliding mechanism of the HI-AWARE and SustainIndus design, which can fit through tighter spaces.
- Biophysical suitability maps for solar water pumping in Pakistan were developed with assistance from Wageningen University, which was the first attempt to map upscaling potential in the Indus basin. Six biophysical parameters were selected based on their relevance for groundwater extraction for irrigation of crops using solar energy. Changes in these parameters were assessed under different climate change scenarios (RCPs 4.5 and 8.5) until 2100, and an assessment was made of groundwater depletion under these scenarios (which is highly relevant for solar water pumping (Annex 7, Figure 7.2)). Results show suitability is high in the northern region (likely due to low salinity of groundwater), and along the Indus river (see Annex 7, Figure 7.1). The model suggests that salinity levels of groundwater and average slope are the most significant parameters influencing suitability. The maps were shared with water and agricultural experts in the region who agreed with this assessment.
- Due to the demand for portable solar pumping systems, training and promotion of the technology on a national scale is currently underway under HI-PATH, in which 10 workshops have been delivered by PARC and NICE/NUST.
- A national consultation workshop was conducted with policy makers and experts to present the work in HI-PATH and engage with experts to develop climate resilient development pathways. Many strengths, weaknesses, enablers and barriers of solar water pumping were identified, and preliminary pathways have been developed from the workshop. There was broad agreement that the technology has great potential, and can contribute to the nationally determined contributions of Pakistan to the Paris agreement through low carbon agricultural practices that do not require diesel or fossil generated electricity.

Challenges and barriers

- Some of the most prominent barriers identified from outcome mapping and the national workshop concern the high initial cost of the technology, limited facilitation in the form of policy measures (such as subsidies on photovoltaic imports), limited knowledge on farmer perceptions and behaviour at the national scale and uncertainty with overuse for groundwater depletion.

- Of the farmers surveyed during outcome mapping, 75% had adopted portable solar pumping systems in Thal, as opposed just 9% in Potohar region. It was anticipated that farmers owning land surrounding rivers would adopt the technology, however this was found not to be the case. Multiple reasons for low adoption were identified. Firstly, agriculture is predominantly rain fed in the region, and farmers prefer to cultivate low water delta crops, which require less irrigation. Second, due to uncertainty in rainfall patterns in recent years, farmers are more hesitant to invest substantial amounts in their businesses. Third, Potohar has more variability in groundwater depth, and the quantity and quality are lower than Thal, resulting in the need for surface water resources for use of the technology.
- Of the survey respondents, the average annual production of haulage trolleys for portable solar pumping systems is 8-10 per year. Local developers who had the capital experimented with designs and were able to develop multiple cost-effective alterations that meet the needs of local farmers, which further boosted adaptability. Production capacity and experimentation can be enhanced through subsidies from government agencies or full advance payment from buyers.
- Analysis of the progress marker "Further advancements in technology so that it can also be widely used for domestic use of farmers" found that almost all boundary partners suggested there is a need for modifications of the technology so that it can be more easily used for domestic energy needs. However, due to the unavailability of compatible inverters, many were not able to cross this technical barrier.
- No quantitative assessment has been done on the potential impacts of upscaling solar water pumping on groundwater depletion and water availability downstream, which is critical to undertake to ensure the sustainability of climate resilient development pathways for the technology. Due to the low running costs, if the technology is widely upscaled, it poses significant threats to groundwater uses if unregulated. This topic was heavily engaged during the national consultation workshop, and was a concern for many experts.
- Suitability maps did not take into consideration socio-economic indicators, which the above results highlight are critical. Expert consultations identified the main parameters as 1) type of crop; 2) type of irrigation method; 3) landholdings of farmers; 4) purchase power and 5) current expenses on irrigation. The suitability map (Annex 7, Figure 7.1) gives a good preliminary indication, however, future research with the inclusion of socio-economic indicators can strengthen suitability maps.

2.4.5 Desk work

- Concerning the evidence-based desk studies conducted under HI-PATH, there were two papers produced, of which a number of important results stand out. Firstly, the paper '*Advancing climate resilient development pathways since the IPCC's fifth assessment report*' presents key conceptualisations for the practice of climate resilient development pathways from the literature. The framing emphasises eight different lessons, such as the importance of accounting for equity, (climate) justice, recognising root causes of vulnerability and engaging with actor aspirations This work is timely as the concept and practice of pathways for climate resilient development is gaining momentum as an approach. Therefore, we find that producing this framing in a peer reviewed paper is important to advance the concept of

'climate resilient development pathways' on which there is a dedicated chapter in the upcoming workgroup 2 of AR6.

- Complementing the framing in the above mentioned paper, a research report and peer reviewed paper (under review) has been written titled 'Monitoring and evaluation of and food climate resilient development pathways' (See Abstract in Annex 8). This report presents a novel stepwise approach that aims to define monitoring and evaluation requirements, and provide guiding steps for practitioners engaging climate resilient development pathways approaches. This work was informed by the HI-PATH teams experience with outcome mapping in the four cases, in which strengths of the approach were incorporated, and also where limitations of outcome mapping were overcome. This output is important as monitoring and evaluation is often underrepresented in interventions and literature, particularly for (climate adaptation) pathways approaches. Therefore, by providing guidance, it is hoped that this approach can be applied and tested to advance knowledge and practice for monitoring and evaluating climate action and development using pathways approaches. Findings emphasize the added value that can be gained for both practitioners and communities from taking monitoring and evaluation into consideration.
- A third paper is planned, that will present lessons from the cases on climate resilient development pathways. This empirically informed work will complement the other two papers.

2.4.6 Lessons for the practice of climate resilient development pathways

To advance the practice of climate resilient development pathways, we first conducted a review of its conceptual advances since the fifth assessment report of the IPCC. The results were published in a research paper titled *'Advancing climate resilient development pathways since the IPCC's fifth assessment report'*[5].

In all four cases we developed climate resilient development pathways (See Annex). We followed a general methodology in which we interpret pathways as a set of measures to be implemented progressively that work toward an aspired future as well as take into account climate change. For this practice we learned the following lessons from the cases, which go beyond what we had identified in the literature so far:

1. **Climate and flood resilient housing (CFRH) in the Teesta river basin, Rangpur district, Bangladesh (BCAS)**
    - Actions are to be taken by different actors across governance levels. This creates dependency between actors and complicates implementation. In adaptation pathways literature the role of different actors remains underexposed
    - Adaptation and development (livelihood creation) need to be considered in tandem. Actors stressed that investing in flood proof housing on a flood prone location make less sense if there are no livelihood opportunities in the vicinity
2. **Portable solar pumping systems for crop irrigation in the mountain districts of Thal and Potohwar, Pakistan (PARC / NUST)**

[5] Werners, S.E., Sparkes, E., Totin, E., Abel, N., Bhadwal, S., Butler, J., Douxchamps, S., James, H., Meathner, N., Siebeneck, J., Stringer, L.C., Vincent, K., Wise, R., Tebboth, M.G.L., 2021. Advancing climate resilient development pathways since the IPCC's fifth assessment report. Environmental Science & Policy 126, 168–176.

- Pathways are location specific, with different areas requiring different pathways to be developed. What may be considered climate resilient in one area is not in another. This has to be considered when involving diverse stakeholder groups. Thresholds of adoption are critical to consider, as even innovations designed to be sustainable can have negative consequences if overused.
- Transformational pathways go beyond the livelihood innovation. A strategic choice for famers is whether to irrigate conventional crops (like sugarcane) or changed to new crop types in combination with water saving irrigation technology such as drip.

3. **Climate Smart Agriculture, emphasizing commercial crops, in the hill district of Rudraprayag, Uttarakhand, India (TERI)**
    - Implementation can go beyond the envisioned pathways. An overwhelming majority of households have continued to grow and expanded to growing similar cash crops they were exposed to during the HI-AWARE pilot. Surveys indicate a shift from subsistence farming to different types of commercial agriculture. There is also tremendous scope of further bolstering communities adaptive capacity and resilience, beyond planning for specific crop innovations.
    - The implementing entity as well as the state level stakeholders have taken cognizance of the changes in climate and there is a visible change in their approach of integrating climate resilience in existing policies and project. SHARD the implementing entity is keen on scaling up organic farming in the pilot and adjoining areas. Both points highlight the importance of broad monitoring and evaluation of implementation, outcomes as well as actor activities. Furthermore, it highlights that pathways need to be reviewed and updated frequently.
4. **Springshed restoration in selected communities in the Gandaki basin, Nepal (ICIMOD)**
    - The outcome mapping highlights that actions can trigger unexpected responses, which some actors will consider maladaptation (in this case the acquisition of land by one investor where spring source was mapped. In other words, the priority of one community member creates challenges for the others). In the adaptation pathways literature, mapping maladaptive choices is seldom practiced.
    - The pathways that were elicited point at trade-offs between development and the adaptive action from the livelihood innovation (here: road construction restraining spring restoration). Mapping trade-offs and potential maladaptation deserves more attention in the practice of pathways planning.

In sum, our research has identified the following attention points for the practice of climate resilient development pathways:

- Pathways need to map the roles and actions of different actors;
- Pathways can be highly location specific;
- Engagement with trade-offs and maladaptive choices is critical for climate resilient development pathways;

- Soft measures, such as enhanced awareness and willingness to conserve natural resources have a more indirect contribution to climate resilient development. These are however important precondition for action. Pathways need to include actions that have a direct and more indirect on climate resilience;
- Broad monitoring and evaluation of implementation, outcomes and actor activities is critical;
- Pathways need to be reviewed and updated frequently to include new ideas and activities that actors are developing in response to earlier interventions and evolving capacities.

2.5 Intended and actual results

Here we reflect on key results that were intended from the project's outset, but ultimately not realised, as well as unintended results from the project that came to light.

2.5.1 Intended but not realised results

A first result that was intended from the project proposal but not realised concerned the delivery of four national scale workshops for objective 3 (co-creation of climate resilient development pathways). Despite best efforts, two partners (TERI and ICIMOD) were unable to organise national workshops due to difficulties with COVID-19 restrictions and the subsequent delays that were brought. They did however, engage with state and community level stakeholders on processes for climate resilient development pathways co-creation. TERI were the co-organiser of the adaptation futures conference, of which a climate resilient development pathways session was delivered by HI-PATH. ICIMOD collected field level data using the local resource person and verified by rapid field visit when the travel was allowed for a short duration.

2.5.2 Unintended but realised results

A number of results emerged that were not initially intended or included in the proposal. Firstly, due to the shift to online working as a result of the pandemic, it was difficult to plan and conduct in person workshops for some partners. This resulted in the development of the open access Miro board that provides guidance on the co-creation of climate resilient development pathways.

Second, due to the limited capacity allowance of in person events in Islamabad, a second unintended result emerged from PARC / NICE-NUST. Initially, partners intended to deliver a national level workshop to approximately 70 stakeholders in person. However, due to rising COVID-19 numbers in Islamabad, a decision was made that the event should be held in hybrid mode, which could ensure safety precautions and additionally save costs. With the savings from hosting the workshop in hybrid mode, a small pilot study has been planned that will explore recent technological developments in solar water pumping with the aim of making the livelihood innovation more compact, efficient and economical. With this new pilot, interested stakeholders will be able to visit individually at more flexible times to learn how improvements can be made to solar water pumping. The pilot is being designed and fabricated on the learnings from the field during outcome mapping process, as well as from the hybrid national level workshop.

3. Project implementation

Chapter 3 reflects on project implementation in HI-PATH. First, project management is discussed, where we evaluate to what extent objectives, activities and outputs from the grant agreement were met. Following this, we discuss challenges that were faced throughout the project, followed by how researchers integrated considerations of gender, social inclusion and safeguarding.

3.1 Project objectives, activities and outputs

Despite significant challenges faced due to the pandemic, the consortium achieved all four of the objectives, completed all activities and produce all outputs for HI-PATH as stated in the grant agreement. Here we reflect on to what extent each of these were met.

Table 1: Objectives, activities and outputs listed in the grant agreement for HI-PATH.

Objective 1	Map outcomes of HI-AWARE pilots and determine what attributes have/ not worked
Activities	Scope the project by reviewing earlier data collection and appraisals. Conduct outcome mapping for the selected livelihood innovations. Assess attributes that determine what has/ not worked and identify attributes that facilitate/ hinder upscaling for building community resilience using a range of quantitative and qualitative techniques
Output	Report of activities that mapped intervention outcomes
Objective 2	Define monitoring required to upscale livelihood innovations in the context of climate resilient development
Activities	Develop a monitoring and evaluation framework for climate resilient development pathways approaches in HI-PATH. This activity builds on the results from objective 1 and will be reviewed for their use in the monitoring and evaluation of up / outscaling
Output	Publication on monitoring and evaluation for climate resilient development pathways
Objective 3	Co-create climate resilient development pathways that upscale/ outscale learnings within policy and practice. These pathways outline livelihood decisions to positively interact with selected policies, NDCs and SDGs
Activities	Building on objective 1, climate-resilient development pathways will be developed with a range of stakeholders to meet countries' broader policies, NDCs and SDGs. Pathways will be developed through a range of methods that build on earlier tested approaches in HI-AWARE from Werners et al (2018[6]).
Output	Deliver eight workshops, four at community level and four at state level (two for each livelihood innovation) that co-create climate resilient development pathways and deliver two conference contributions on pathways development at Adaptation Futures 2020

[6] Werners, S., Bhadwal, S., Pandey, A., Prakash, A., Wester, P., Mamnun, N., Hassan, T., Ishaq, S., Ahmad, B., Dahri, Z.H. (2018) Towards climate-resilient development pathways for the people in the Hindu Kush Himalayan region. HI-AWARE Working Paper 19. Kathmandu: HI-AWARE

Objective 4	Provide guidance on the co-creation of pathways that gives communities and governance actors ownership to select, implement and monitor livelihood innovations towards sustainable development and climate resilience
Activities	Develop a guidance manual, which extends the steps in Werners et al (2018) with a synthesis of the lessons from objectives 1-3 as well as the gender and equity considerations for HI-PATH (elaborated on in 3.3)
Output	Provide guidance and training materials for climate resilient development pathways that can be shared with communities, governance actors, practitioners and researchers

Objectives, activities and outputs realised in HI-PATH

Objective 1: Outcome mapping was completed by all four partners. This process resulted in a thorough scoping of the expected outcomes of the HI-AWARE livelihood innovations, uncovered numerous key results (discussed in 2.4) and provided important inputs for the remaining three objectives. Outcome mapping determined how the innovations have been influencing the lives of direct beneficiaries, the wider community and other relevant stakeholders since their implementation. Furthermore, opportunities and barriers for upscaling / outscaling the innovations were identified, as well as potential indicators that could be used to monitor and evaluate change in the communities and systems influenced by the innovations.

Activities 1: Outcome mapping was conducted by ICIMOD, BCAS, TERI, PARC/NICE-NUST with assistance from UNU-EHS and WUR. Approaches employed were mostly qualitative, and included key informant interviews, surveys, focus group discussions and workshops. As per the outcome mapping structure, stakeholder analysis was undertaken to identify which actors (boundary partners) to target for data collection activities. Quantitative analysis was conducted by WUR for the PARC component, in which suitability and water availability maps for solar pumping in the Indus basin were produced, based on survey results from outcome mapping.

Outputs 1: Four outcome mapping reports and been produced (internal project reports). The consortium is exploring options to publish this work in peer reviewed articles.

Objective 2: Research has been conducted that has defined monitoring and evaluation requirements for climate resilient development pathways based on outcome mapping principles and approaches. Both requirements and challenges for monitoring and evaluation of and for climate resilient development pathways have been defined. A matching process has been conducted as to what outcome mapping approaches can offer, and a stepwise guidance framework has been defined for practitioners. This framework highlights important steps to consider, such as accounting for gender dynamics, includes three core components and presents indicator guidance for upscaling / outscaling and accounting for changing system dynamics when monitoring climate resilient development pathways.

Activities 2: For the monitoring and evaluation objective, activities included interviewing and holding reflexive sessions with the HI-PATH team on their experiences of the outcome mapping process, to identify useful components for the resulting framework. Furthermore, lessons were expanded from CRDP positioning paper published under HI-PATH, external experts from the outcome mapping community were interviewed and a non-systematic review of literature was conducted. These activities were led by UNU, with support from all partners.

Outputs 2: A research report has been produced and released internally that synthesized the findings of activities for objective 2. The work has been presented at the Adaptation Futures 2020 conference and within various UNU departments (for which feedback has been given). The authors have contacted the Outcome Mapping Learning Community to explore publishing the report there. Furthermore, the work has been converted into a peer reviewed article, which will be published as a joint paper by the HI-PATH consortium. The first author is working with the Adaptation Resilience Alliance, building on this work to integrate lessons from outcome mapping into their Tracking, Sharing and Learning work stream.

Objective 3: Multiple workshops were held by partners to co-create climate resilient development pathways that intersected with both local aspirations as well as national level action on climate change and development (See Annexes 3,4, 5 & 6 for examples). No single common methodology was followed as each partner developed pathways based on the specific context, needs and situation that was allowed due to COVID restrictions. However, each built on the baseline information established through outcome mapping, and similarities can be seen (such as engagement with short, mid and long term actions). Workshops and consultation were conducted at community level by all partners to identify local insights and perspectives on each of the livelihood innovations. Through these consultations, researchers engaged with the desired futures that local stakeholders perceived and what steps they thought were important to get there, as well as building on the earlier identified strengths, weaknesses, enablers and barriers of the livelihood innovations. These critical community perspectives were then integrated into second workshops with other regional and national stakeholders. These stakeholders included:

- ICIMOD-led case: Provincial government representatives),
- BCAS-led case (National level academic, governmental, NGO institutions (See Annex 2 for full list)),
- TERI-led case (State agriculture and climate change departments),
- PARC/ NICE-NUST-led case (National level academic, governmental, NGO institutions).

By using pathways processes, researchers were able to integrate multiple stakeholder perspectives to identify actionable steps that need to be taken upscale innovations and improve wellbeing among the communities of focus. Through co-creating climate resilient development pathways, decisions were identified that intersect with regional and national policies (such as the Government of Bangladesh's commitment to house the landless and homeless or local governments in Nepal replicating springshed mapping to implement similar water resource management projects), nationally determined contributions (such as the phase out of an estimated 1.4 million diesel and electric ground water pumps in Pakistan) and the Sustainable Development Goals (such as SDG's 1, 8 and 13 for climate smart agriculture practices in Rudraprayag, India).

Activities 3: Six different workshops were held across the four study regions, both at the community and national level, which were conducted by ICIMOD, BCAS, TERI, PARC/ NICE-NUST, with assistance from UNU-EHS and WUR. The workshops did not follow one common methodology, but all built on the results from outcome mapping, incorporated pathways approaches for upscaling of livelihood innovations, and focused on desired futures of vulnerable communities in the respective research areas. Workshops were done online, using the app Miro, and in person, with a range of stakeholders including communities, local

business, NGOs, government departments and political representatives. In addition, PARC/ NICE-NUST hosted trainings to support the upscaling of the livelihood innovation.

Outputs 3: Two of four partners held community and national level workshops (BCAS and PARC/ NICE-NUST) and two partners held community and local stakeholder/ governmental consultations (ICIMOD and TERI). Four final case reports have been produced that summarize workshop findings and outline livelihood decisions that interact with climate resilient development pathways for upscaling / outscaling innovations. Furthermore, due to the positive results uncovered from outcome mapping, 10 training workshops were held across Pakistan by PARC / NICE-NUST, which concerned upscaling and outscaling solar irrigation pumping systems. Lastly, two conference contributions were delivered by members of the consortium at Adaptation Futures 2020 that reflect on pathways utility and development.

Objective 4: Different project outputs provide guidance on the co-creation of pathways. Firstly, a review paper has been written with the intention of guiding concept development, as well as presenting a learning framework for practitioners. Furthermore, the objective 2 report and paper provide a guidance framework that can be used as a heuristic of researchers and practitioners applying CRDP approaches in projects. Lastly, an online workshop board including guidance has been delivered on the platform Miro, which was designed as a tool to guide practitioners to co-create pathways. These activities were led by UNU, with support from all partners.

Activities 4: For objective 4, activities for the peer reviewed article included conducting systematic review of literature published since the IPCC's 5th assessment report and bringing together experts on the topic for three reflexive learning workshops. Colleagues from the CLARE project 'Climate resilient development pathways in Semi-arid regions of Africa and South Asia' were involved in these sessions. The Miro board has been tested, ground truthed and adjusted accordingly in a workshop delivered by BCAS to 44 governmental experts, and parts of the board have been incorporated in the national workshop delivered by PARC. The results from the workshops and the use of the Miro board will be summarised in an infographic that synthesises the lessons from HI-PATH to provide guidance for practitioners.

Outputs 4: Outputs include a peer reviewed article '*Advancing climate resilient development pathways since the IPCC's fifth assessment report*', a research report and peer reviewed paper (final draft) for Objective 2 (discussed above) and an open access Miro board.

3.2 Challenges faced

The most notable challenge throughout the duration of the HI-PATH project concerned the COVID-19 pandemic. As occurred everywhere, this caused significant disruptions, resulting in delays to project work, particularly the outcome mapping and community workshops which required fieldwork. This challenge was particularly difficult for Indian colleagues due to the extremely severe second wave of COVID-19 infections experienced in the country. Due to lockdowns in respective countries and the necessity to safeguard communities and researchers, multiple precautionary steps were taken. For example, local people who lived within the communities were trained to conduct surveys and key informants who could represent communities were interviewed via telephone. A Miro board was developed to conduct workshops online (as highlighted in 2.1.3) and when rules allowed, masks and social distancing were practiced in focus groups and workshops. Moreover, for some fieldwork activities for TERI,

there was a shift of focus from communities to institutional stakeholders (governments, NGOs, Universities) as they had stable and accessible internet and therefore some data could still be collected. This challenge also resulted in TERI and ICIMOD conducting state level, as opposed to national level workshops.

Another challenge that occurred concerned project approval delays from the respective authorities in Pakistan, resulting in the introduction of an additional partner: NICE-NUST. Professors, researchers and students from both PARC and NICE-NUST were committed to carrying out HI-PATH project activities quickly and thoroughly and have produced all agreed upon deliverables, which were very valuable to the project's goals. The introduction of NICE-NUST was discussed with and approved by IDRC.

Integrating Gender considerations into the Pakistan component of HI-PATH proved a challenge for researchers when conducting fieldwork. It was noted that in rural regions, it is difficult, and culturally frowned upon, for men and women to have direct conversations with one another. In the design phase of the outcome mapping, the team explored options of how to overcome this, such as partnering with NGOs and hiring female student assistants. However, due to the tight timeline as a result of approval delays, this was unfortunately not possible. It is important to acknowledge that this is a limitation in the results for this component of the work in HI-PATH. When concerning portable solar pumping systems, female farmers and manufacturing employees are to be considered important boundary partners within the spheres of influence of the innovation too. Furthermore, solar water pumping has domestic applications as well, which are largely conducted by women, however we were not able to provide key data. In light of this, the upscaling of solar water pumping and engagement with climate resilient development pathways in national workshops needs further exploration focused on impacts for women before it can be considered sustainable. This is due to the reality that full implications of the technology (both positive and negative) are not yet fully understood for women. To overcome this challenge, the HI-PATH consortium recommends partnering with gender focused NGOs in Pakistan, to map the outcomes of portable solar pumping systems and solar water pumping with an explicit focus on impacts, threats and opportunities for women.

3.3 Gender, social inclusion and safeguarding

The core research team from HI-PATH comprised 13 members from six partner institutions in Bangladesh, Germany, India, Nepal, the Netherlands and Pakistan, of which 8 members were female. Throughout the duration of the project, efforts were taken to integrate considerations towards gender and social inclusions through research methods.

3.3.1 Gender and social inclusion

Pathway co-production (that is, collaboration of affected communities, decision makers and scientists) has remained methodologically underdeveloped, largely untested and challenging. HI-PATH aimed to support closing this gap by actively including communities, vulnerable groups and other relevant actors in co-design and monitoring of climate resilient development pathways. In doing so, HI-PATH aimed to ensure that the research process empowered the knowledge of local communities – both women and men - in relation to governance actors, and enhanced the relevance and impact of project interventions to community needs.

Data collection processes were specifically designed to represent the perspectives of female community stakeholders who were influenced by project activities, for example through holding female only focus group discussions and ensuring a balanced representation of genders in workshops and interviews (gender representation in engagement events can be seen in Annex 2). Furthermore, these processes were extended to marginalised groups in the research areas, for example Dalit communities in Nepal. These considerations were essential if monitoring of the project was to capture information regarding the true to life situation. Livelihood innovations were designed to influence the climate resilient development of vulnerable men, women and marginalised groups, therefore perspectives from all groups were needed. To illustrate an example for the climate and flood resilient housing component of the project, by creating female only focus groups, women were able to discuss issues that they likely would not have raised in front of men. Doing this captured important information concerning the benefits gained from having separated sanitary spaces. Furthermore, in the India component of HI-PATH, in the region of Rudraprayag, Uttarakhand, nearly all of the agricultural duties fall upon women in the communities. Therefore, steps were taken to ensure that the majority of community consultations were held with female participants so as to correctly represent the situation.

One of the central recommendations from the work on climate resilient development pathways produced in HI-PATH is for centralisation around equality, environmental and social justice and gender, which is highlighted in each of the outputs for the project. This recommendation was made because: a) it is the fair thing to do to account for the needs of the most vulnerable, who bear the least causal responsibility, and b) for climate resilient development pathways to be successful, the voices, concerns and aspirations of those centrally affected by decision making must be heard. Project outputs have reflected this in the context of climate resilient development. ICIMODs springshed restoration flags the increased burdens felt by women and girls for undertaking domestic water collection responsibilities, and emphasises the importance of conserving and regenerating springs through policy implementation to reduce these burdens. A key point for action in climate resilient development, as flagged in workshops in Bangladesh, concerned gender mainstreaming, providing alternative livelihood training for women and sexual and reproduction health rights training to youths. TERI's climate smart agriculture pilot is strongly focused on women, who conduct the majority of farming practices in communities of target. In outcome mapping reports, the monitoring and evaluation report and peer reviewed papers, the research team have highlighted the importance of accounting for gender dynamics and social inclusion. The framing is presented that if they are not accounted for, dominant ideas of influential (often male) stakeholders will continue to perpetuate over more vulnerable (often female) groups, which is a significant barrier for equitable climate resilient development.

We note that not in all cases we were able to reach out to female beneficiaries. Also the COVID-19 restrictions that limited the fieldwork were found to be more restricting to reach out to the female community members than to NGO and government actors.

3.3.2 Safeguarding

The HI-PATH team submitted a safeguarding protocol before the project had been running for six months, in line with the guidelines from IDRC. HI-AWARE was one of the projects in the CARIAA Programme. As such partners have worked together before under the auspices of

IDRC, which was advantageous for complying with high standard procedures and measures to prevent sexual exploitation, abuse and harassment of any vulnerable person involved in the project. Furthermore, all institutes participating in the consortium focus on research and education, and are committed to ensuring their employees are considered the most important asset of the organisation. The HI-PATH project team strictly followed the respective institutional policies, safeguarding protocol delivered to IDRC, and compliance with national legislations, to ensure safe, healthy and productive working environments, both on institutional premises and during fieldwork activities.

As the project has been running throughout the pandemic, additional steps were taken to ensure safeguarding for both researchers and external stakeholders from COVID-19. All work has been conducted in line with respective countries COVID-19 restriction measures. Furthermore, to reduce community exposure, additional steps have been taken such as training community resource persons to conduct surveys (ICIMOD) and conducting interviews and workshops through teleconnection (BCAS, TERI, UNU). Furthermore, as discussed above, one of the objectives of the Miro board deliverable was to safeguard against the pandemic.

4. Research Uptake

In Chapter 4, we discuss how the HI-PATH planning approach supported demand and endorsement of results. The team has influenced the uptake of research across the countries of the four pilots, as well as further afield. This uptake has been facilitated by the planning approach to hold consultations and workshops across a range of levels with affected, interested and decision making stakeholders. By design, pathways approaches are well suited to integrate multiple perspectives. Therefore, the plan to create climate resilient development pathways synergized well with the project objective to support the uptake of upscaling and outscaling project learnings within policy and practice (HI-PATH Objective 3). As co-creation has been a central component of the project's methodology, the team could bring perspectives from communities to national level decision making stakeholders and bodies, the evidence of which can be seen in the key results from Section 2.4 and in the pathways developed with high level stakeholders. Furthermore, the consortium have published in international peer reviewed journals, and will produce at least one more paper as a result of the work from HI-PATH, further expanding the reach for research uptake.

4.1 Demand

ICIMODs springshed mapping and conservation framework, which was developed in part under HI-AWARE, was found to be of high demand in the district of Nuwakot. In HI-PATH consultations, district level government officials requested provision of technical assistance, so they could develop policies to strengthen spring management. Furthermore, this protocol is highly replicable in similar regions facing spring conservation challenges, and has been of interest to governments of neighbouring countries.

The government of Bangladesh have requested data and information on the design of CRFH and results from the project, which has been provided to inform a national scale policy to house all landless and homeless people.

The Uttarakhand State Environment, Climate Change, Conservation Directorate and the state department of agriculture have made a number of sight visits to the experimental plot. They have been enthusiastic about the pilot, visited numerous times and have requested information and recommendations from TERI to develop climate resilient agricultural practices and policies. Through these requests, TERI have laid emphasis on augmenting capacities of departments, CSOs/NGOs and communities to upscale climate smart agriculture and other relevant climate resilient livelihood opportunities such as eco-tourism.

There has been significant demand for solar irrigation pumping systems throughout the Thal region of Pakistan. Both manufacturers and farmers have requested information and training concerning integrating the technology into their livelihood practices. It was interesting to note that the portable solar pumping system was adopted in the Thal region but farmers were not aware of other potential regions. PARC/ NICE-NUST completed 10 training workshops around the country to account for this demand. A national workshop was conducted on 17th February 2022, which brought together experts and national policy makers. In this workshop stakeholders requested data and evidence produced from the project, to develop recommendations for upscaling strategies on solar water pumping. Specific requests were made for information

regarding suitability of solar water pumping in different regions, and the impacts of climate change on groundwater depletion, of which the first steps have been developed in HI-PATH. Further research was requested on the potential impacts of upscaling solar water pumping on groundwater depletion under different climate change scenarios.

The HI-PATH team have been contacted by researchers in South Africa working on a project aimed at setting the direction for future knowledge co-production and planning work of the Presidential Climate Commission of South Africa. The work stream's aim is to link climate adaptation and climate resilience to the national “just transition” approach, and to develop detailed pathways that flow from it. The review paper produced in HI-PATH inspired the group in South Africa's thinking on climate resilient development pathways and was used as a basis for its position paper. Members of the HI-PATH team attended workshops to explore how the lessons from co-creating climate resilient development pathways in HI-PATH can be used to tailor and operationalize a climate resilient development pathway methodology for the South African context.

One of the members of the HI-PATH team (Muhammad Khalid Jamil) will be using the results from the Pakistan component of the project for one of his papers for his PhD, which he is doing with PARC and Wageningen University.

The team will co-present the work from HI-PATH at the International Mountain Conference, which will take place September 11 – 15, 2022.

4.2 Endorsement

The research team contacted Miro Online [miro.com/index] regarding the climate resilient development pathways workshop board, who have offered to include it as an open access tool on their website, which has at least 10 million users. Miro have expressed that they would like to promote the board on various social media channels.

The group working on the Presidential Climate Commission in South Africa have cited the peer reviewed paper as a key document for the planning of their project, and have used the figure from the paper to demonstrate core concepts of climate resilient development pathways.

5. Additional Insights

Here, we reflect on future research for the consortium that has emerged from HI-PATH, and provide feedback to IDRC and FCDO on their role as project donors.

5.1 Future research

Important additional insights have emerged as a result of the HI-PATH project. As highlighted in Section 2.4, multiple challenges and barriers have been identified for each of the livelihood innovations. These challenges and barriers pose important directions for future research for each of the pilots if sustainable upscaling and outscaling is to be realised with climate resilient development pathways. Furthermore, important lessons emerged for conceptual development via the desk work. The HI-PATH consortium welcomed the renewed announcement of CLARE at COP26, and are in consultation with regards to how to continue collaborating to implement research results from the project. Below we list future research topics that emerged from HI-PATH, that can strengthen climate resilience and reduce risks for vulnerable men, women and children in the Hindu-Kush Himalayan.

Springshed restoration

1) Assessment of trade-offs between different development pathways following the springshed mapping activities.
2) Outscaling of springshed mapping throughout the region, to neighbouring countries facing the same challenges, including a component on awareness and capacity building to influence policy.

Climate and flood resilient housing

3) Overcoming the barrier of high preliminary costs of the housing: Implementing actions needed to facilitate subsidization from NGOs and governmental organisations, and strengthening links with local material prevision entities and carpenters.

Climate smart agriculture

4) Integration of local and traditional knowledge with modern climate smart agriculture techniques, such as improving soil moisture retention practices under rising temperatures.
5) Implementing steps identified in HI-PATH to strengthen links to formal state markets for the selling of climate smart cash crops.

Portable solar pumping systems and solar water pumping

6) Qualitative and quantitative assessment of the potential impacts of upscaling on groundwater and downstream communities under different climate change and development scenarios.
7) In depth, specific analysis of the impacts of the technology on women.

8) Testing and implementing the monitoring and evaluation framework that was developed for Objective 2 of HI-PATH.
9) Analysis of trade-offs between different pathways for different groups of stakeholders over mid to long term time frames.
10) Investigation into the long-term utility of climate resilient development pathways in different cultural and development contexts in consideration of complexity and systemic risks.

5.1 Feedback to IDRC and FCDO

The transformational shifts brought about by the pandemic presented significant challenges to the HI-PATH work stream. As with much research, fieldwork is an essential component. This is especially true when working with rural and marginalised communities, where in person interaction is often the only possibility. The HI-PATH team feel that IDRC and FCDO have been exceptional in facilitating the difficulties brought about by the pandemic. They have been incredibly understanding with delays that have been brought about to the project. In particular, the two extensions that have been granted to the project highlight this facilitation. Without this additional time, the final output would have yielded less substantial results. During this extra time, three rounds of fieldwork were conducted by three partners, and a national consultation workshop was delivered. The results from this work will undoubtedly lead to advancing the pilot innovations, which will strengthen the resilience of vulnerable communities. Furthermore, the lessons captured from the work conducted during this extended period have provided extremely useful for our understanding of climate resilient development pathways and have informed at least two academic papers. To conclude, we can only express our gratitude to IDRC and FCDO for their excellent support throughout this process, and welcome calls to continue with this work stream in the near future.

Annex 1: Project outputs

Please include a list of all project outputs, engagement activities, and capacity[7] strengthening from the project in tables such as those below. You can find a list on the online CLARE monitoring centre at your project review link (contact Erika Malich).

Output Type	Title	Authors	Where
Fieldwork report (outcome mapping)	Adaptation pathways for water resource management in Gandaki basin Nepal: Lessons from springshed management	*Neera Shrestha Pradhan, Nabina Lamichhane, Suzeena Shrestha*	Internal
Fieldwork report (outcome mapping)	Outcome mapping and adaptation pathways for upscaling and outscaling of Climate and Flood Resilient Housing	*Abu Syed, Sidratun Chowdhury*	Internal
Fieldwork report (outcome mapping)	Adaptation pathways for Irrigation of crops in Indus river basin Pakistan: A case study of Portable Solar Pumping System	Khalid Jamil, Bashir Ahmad, Shakil Ahmed, Marijn Gulpen, Hester Biemans	Internal
Fieldwork report (Outcome mapping) & Final Case report	From HI-AWARE to HI-PATH, Guiding the transition using Outcome Mapping and Application for the case study area in India	*Suruchi Bhadwal , Ms Smita Chakravarty, Ms Vasudha Singh, Ms Faiza Jamal, Ms Neha Bharti*	Internal
Final case report	Final case report: Springshed management in the Upper Gandaki Basin, Nepal	*Neera Shrestha Pradhan, Nabina Lamichhane, Suzeena Shrestha*	Internal
Final case report	Climate resilient development pathways in the Hindu Kush Himalayan region, Climate and flood resilient housing in Bangladesh	*Abu Syed, Sidratun Chowdhury*	Internal
Final case report	PARC/ NICE-NUST (includes the final workshop results + tables / graphs)	*Khalid Jamil, Bashir Ahmad, Shakil Ahmed*	Internal
Research report	Exploring approaches for monitoring and evaluation of climate resilient development pathways: Lessons from the use of outcome mapping	*Edward Sparkes, Saskia E. Werners, Neera Shrestha Pradhan, Suzeena Shrestha, Nabina Lamichhane, Suruchi Bhadwal, Sidratun Chowdury*	Internal

[7] Capacity strengthening includes award recipients (individuals) and activities run through projects (typically in a group setting, such as training or workshops).

Research report	Suitability maps of portable solar pumping system in Thal and Pothwar districts (included in Fieldwork Report 'Adaptation pathways for Irrigation of crops in Indus river basin Pakistan: A case study of Portable Solar Pumping System')	*Hester biemans, Marijn Gulpen*	With PARC outcome mapping
Research paper	Advancing climate resilient development pathways since the IPCC's fifth assessment report https://www.sciencedirect.com/science/article/pii/S146290112100263X?dgcid=coauthor	*Saskia E. Werners, Edward Sparkes, Edmond Totin, Nick Abel, Suruchi Bhadwal, James Butler, Sabine Douxchamps, Harrhy James, Nadine Methner, Jana Siebeneck, Lindsay C. Stringer, Katharine Vincent, Russel Wise, Mark G.L. Tebboth*	Environ-mental Science and Policy, 14/10/2021
Research paper	Monitoring and evaluation guidance of and for climate resilient development pathways	Edward Sparkes, Saskia E. Werners, Bashir Ahmed, Neera Shrestha Pradhan, Sidratun Chowdhury, Muhammad Khalid Jamil, Abu Syed, Suruchi Bhdwal, Smita Chakravarty, Neha Bharti, Hester Biemans, Shakil Ahmed	to be submitted
Miro board	Workshop template: Co-creation of climate resilient development pathways	*Saskia E. Werners & Edward Sparkes, et al.*	
Stories of change	See 2.2 of this report (final technical report)	*All*	Na
Documentary	Portable Solar Pumping Systems (Final draft) https://drive.google.com/drive/folders/1o9vU5JdqkU2XjBTwHk8JJ1rCm2vl3aTU	*Bashir Ahmed, Jamil Khalid, Shakil Ahmed*	
Infographic	UNU	*Lessons for climate resilient development pathways*	public

Annex 2: Engagement events

Engagement event with stakeholders	Number of participants (% female)	Country where event took place	Date of engagement
(All) - Adaptation Futures Conference (Master class): Pathways Approaches for Climate Resilient Development: Lessons for climate-resilient futures	33 (30% female)	India / online	30/09/2021
(All) - Adaptation futures (Session): May your futures be bright: The value of adaptation pathways approaches and climate futures research when seeking climate-resilient development	Data not available	India / online	06/10/2021
(All) - Adaptation Futures Seminar series	Data not available	India / online	06/09/2020
BCAS community consultations (Objective 1) 1) Hatibandha 2) Dimla 3) Kauniya 4) Hoibot kha	 19 (32% female) 15 (33% female) 21 (19% female) 19 (42% female)	Bangladesh	 10/06/2021 12/06/2021 11/06/2021 11/06/2021
BCAS community focus group discussions (Objective 1) 5) Hatibandha 6) Dimla 7) Kauniya 8) Hoibot kha	 11 (81% female) 8 (50% female) 14 (100% female) 13 (0% female)	Bangladesh	 10/06/2021 12/06/2021 14/06/2021 14/06/2021
BCAS expert workshop (Objective 3) **Attending organisations** Dhaka WASA , Department of Agricultural Extension, Department of Livestock Services, Bangladesh Water Partnership, World Vision Bangladesh, The Hunger Project, Bangladesh Water Development Board, Care Bangladesh (RONGPUR), Research Initiatives	44 (30% female)	Bangladesh	27/10/2021

Bangladesh, Environment and Population Research Centre, C4RE Services, International Federation of Red Cross and Red Crescent (IFRC), Independent University of Bangladesh, Jahangirnagar University, Centre for Climate Change and Environmental Research (C3ER), BRAC University, Bangladesh Women and Water Network (BWWN), BASTOB.			
BCAS community workshop (Objective 3)	15 (47% female)	Bangladesh	06/10/2021
ICIMOD community workshop (Objective 3)	12 (42%)	Nepal	7-8/10/ 2021
TERI - Stakeholder consultations (Objective 3) ● (State Environment, Climate Change Conservation Directorate ● Department of Agriculture and Horticulture ● SHARD ● Community Consultations ● Household Surveys	 40% 50% 0 % 100% 100%	India	 Sep/ Oct - 2021 Sep/ Oct - 2021 12/2021 12/2021 02/2022
PARC – NICE/NUST national workshop	44 (5%)	Pakistan	17/02/2022
PARC – NICE/NUST series of farmer trainings	Data not available	Pakistan	Various dates between Dec 2022 – Febr 2022

Annex 3: Climate resilient development pathways for multiple boundary partners in the Nuwakot district, Nepal

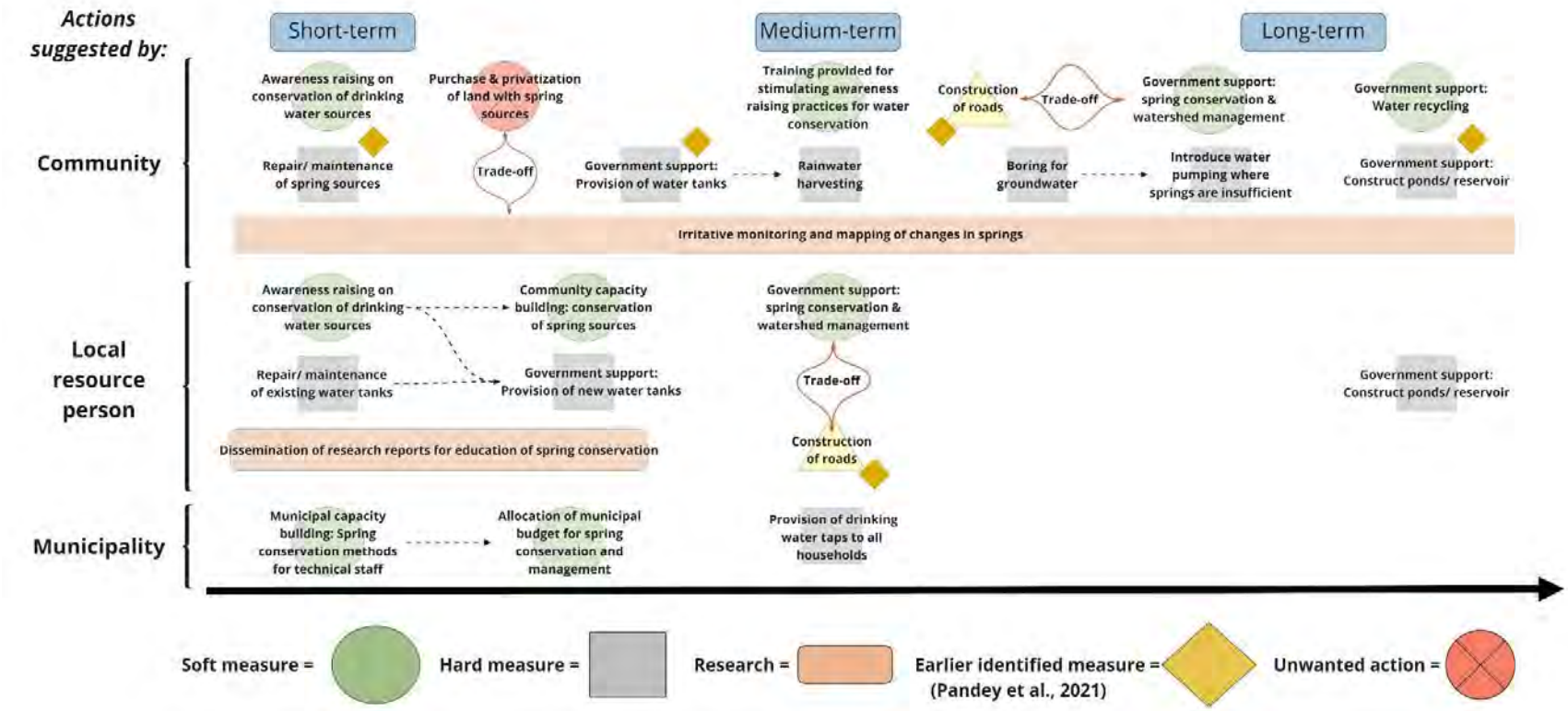

Figure 3.1: Livelihood pathways developed from community workshop in Nepal.

Annex 4: Climate resilient development pathways for communities in the Teesta river basin, Bangladesh.

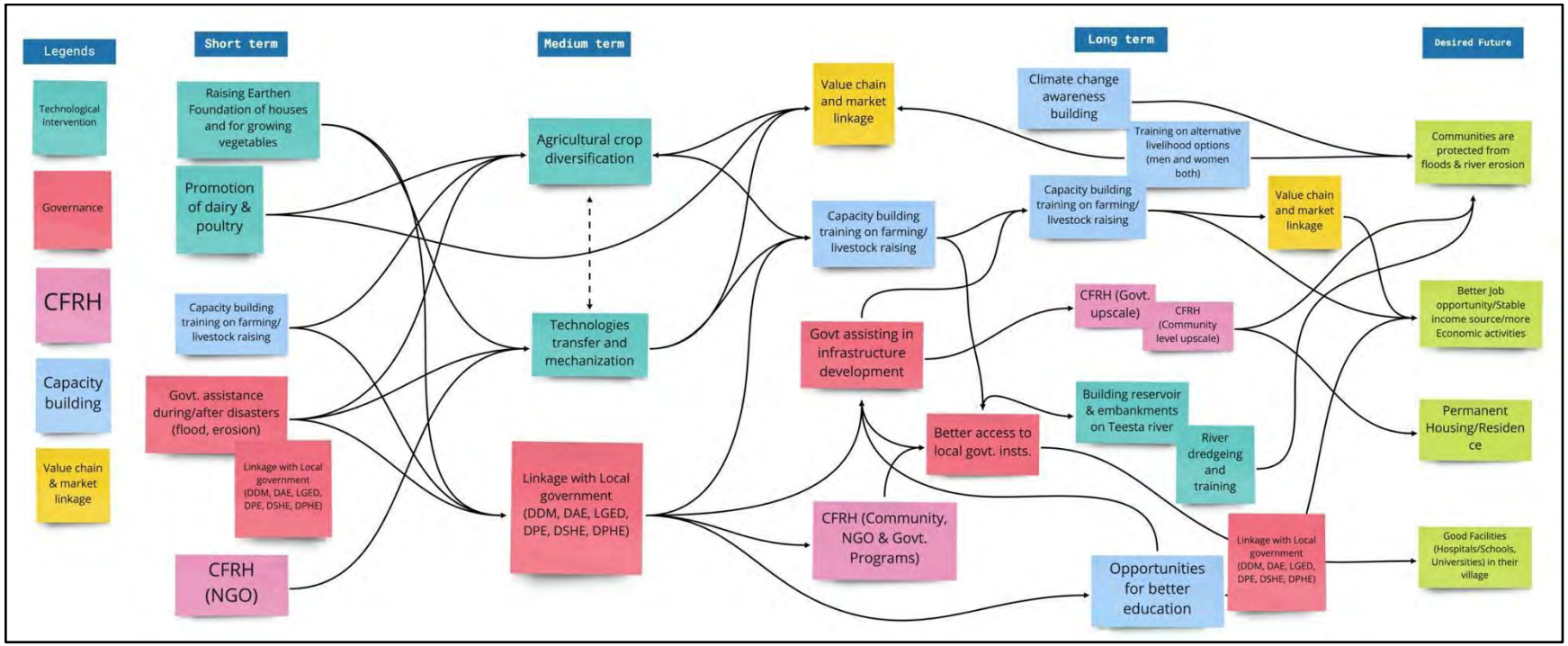

Figure 4.1: Livelihood pathways developed from community workshop on 06/10/2021.

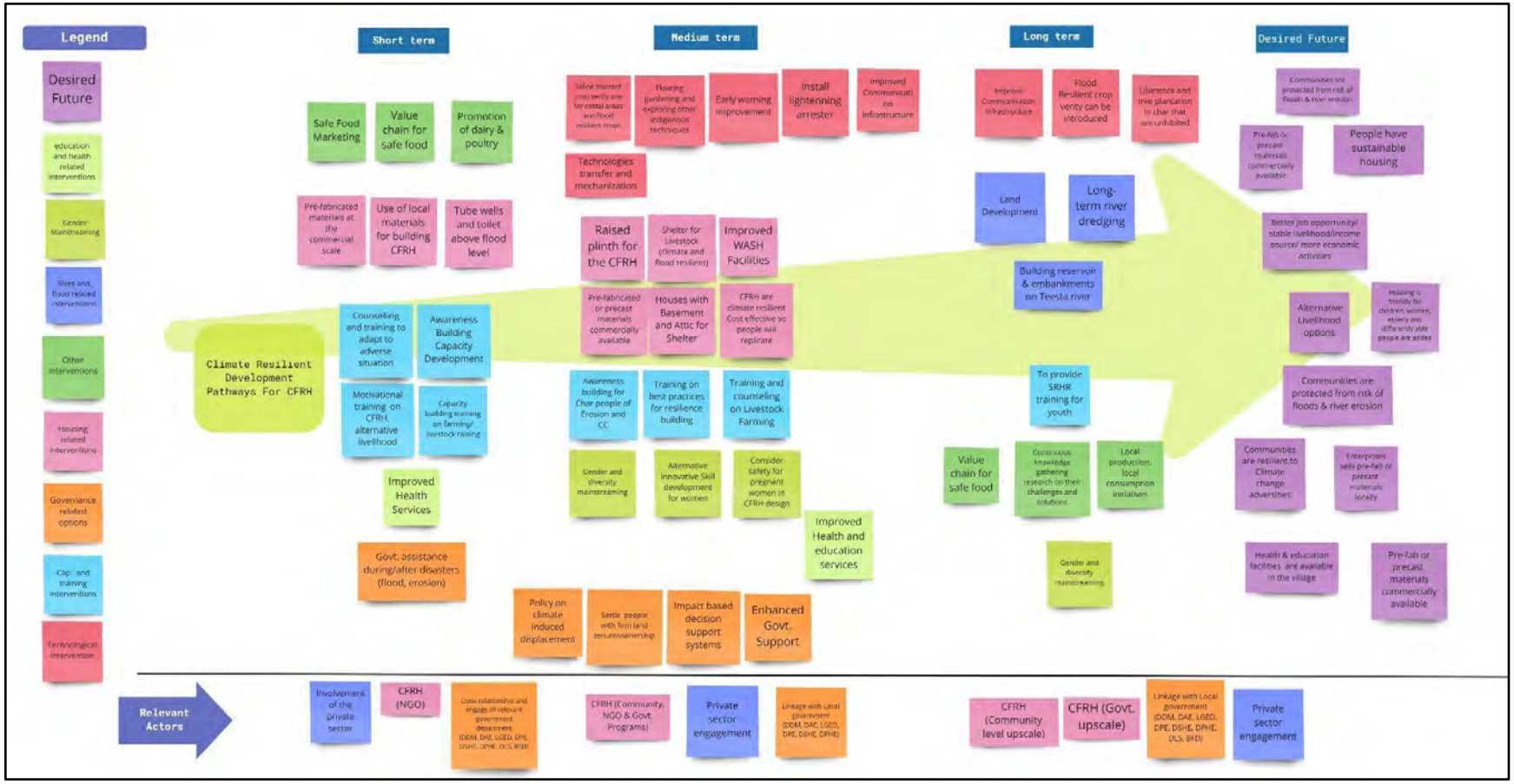

Figure 4.2: Livelihood pathways developed from national workshop on 27/10/2021

Annex 5: Climate resilient development pathways for multiple boundary partners in Uttarakhand state, India.

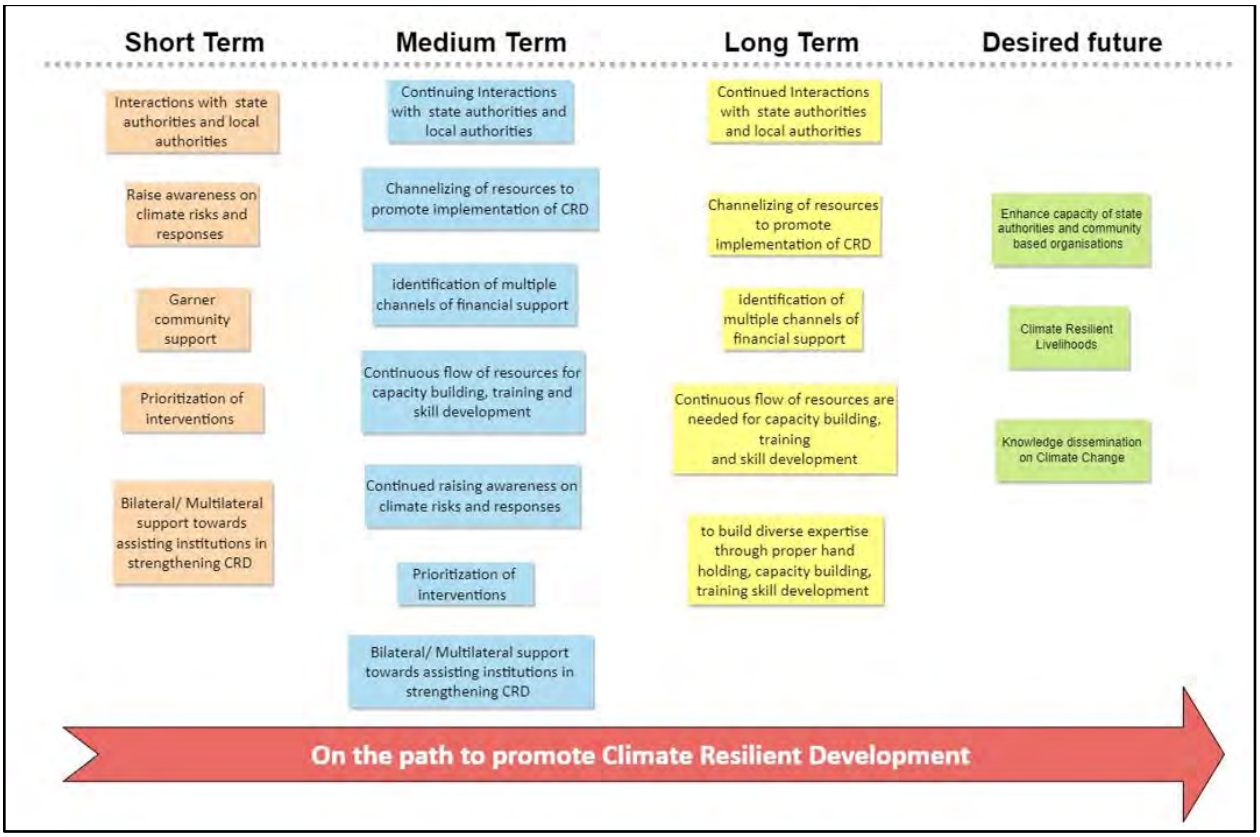

Figure 5.1: Climate resilient development pathways for TERI (national scale)

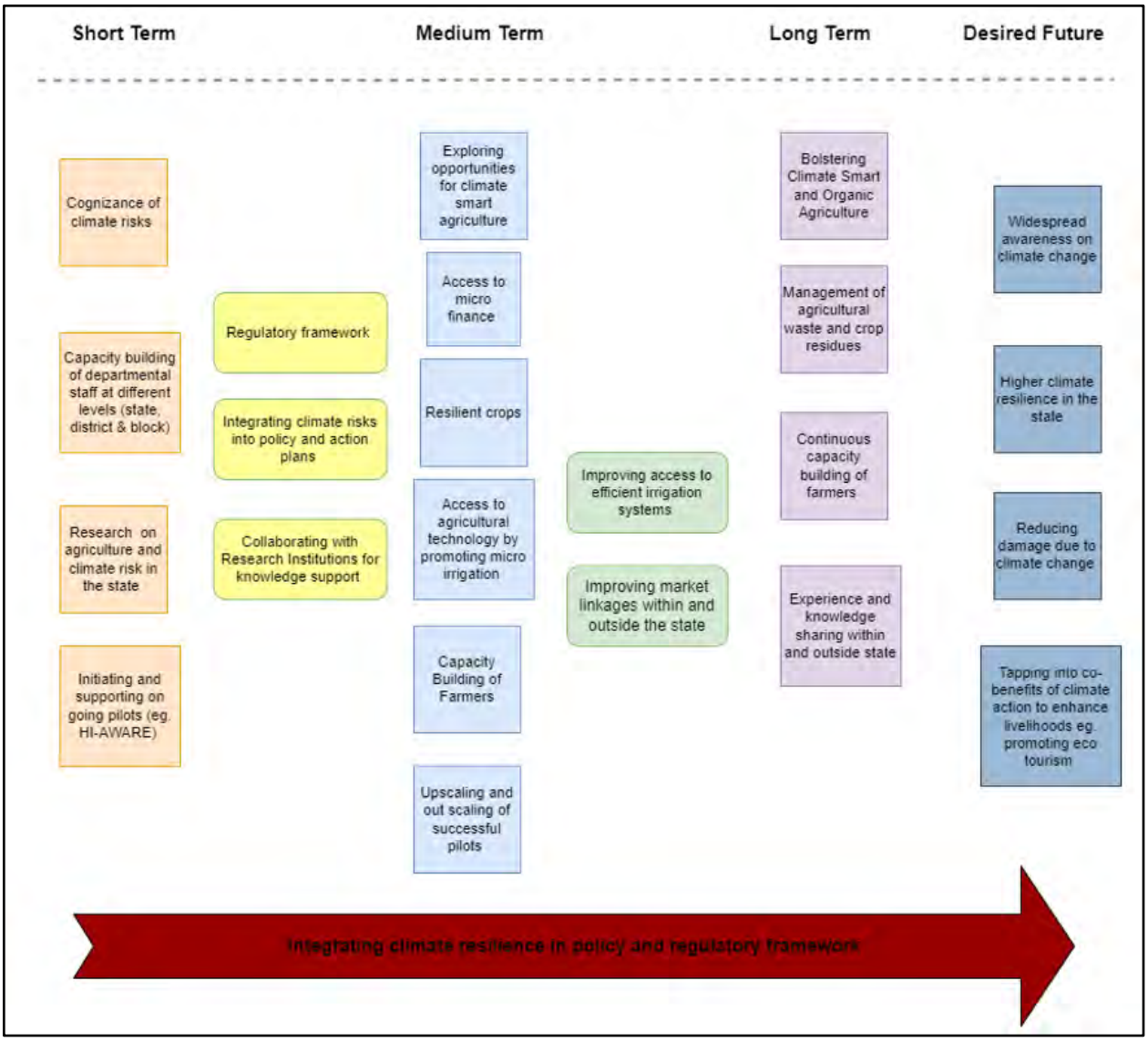

Figure 5.2: Climate resilient development pathways for State institutions (sub-national scale)

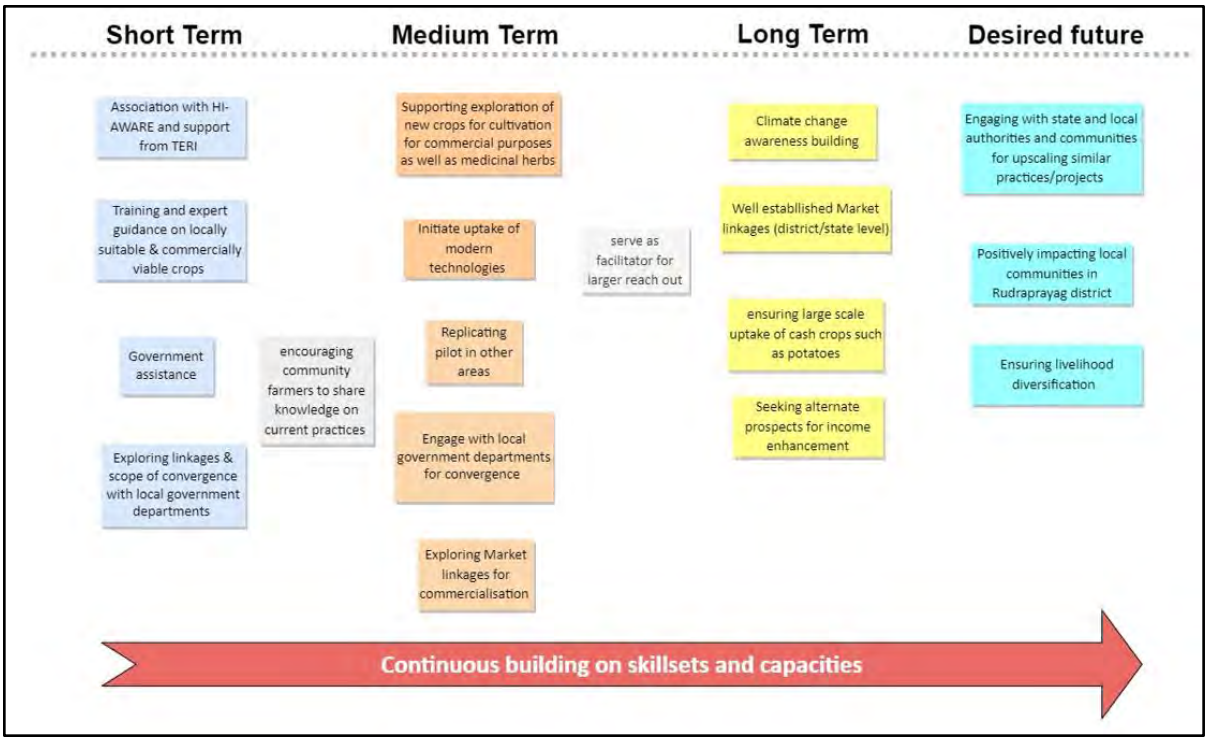

Figure 5.3: Climate resilient development pathways for SHARD (Local scale)

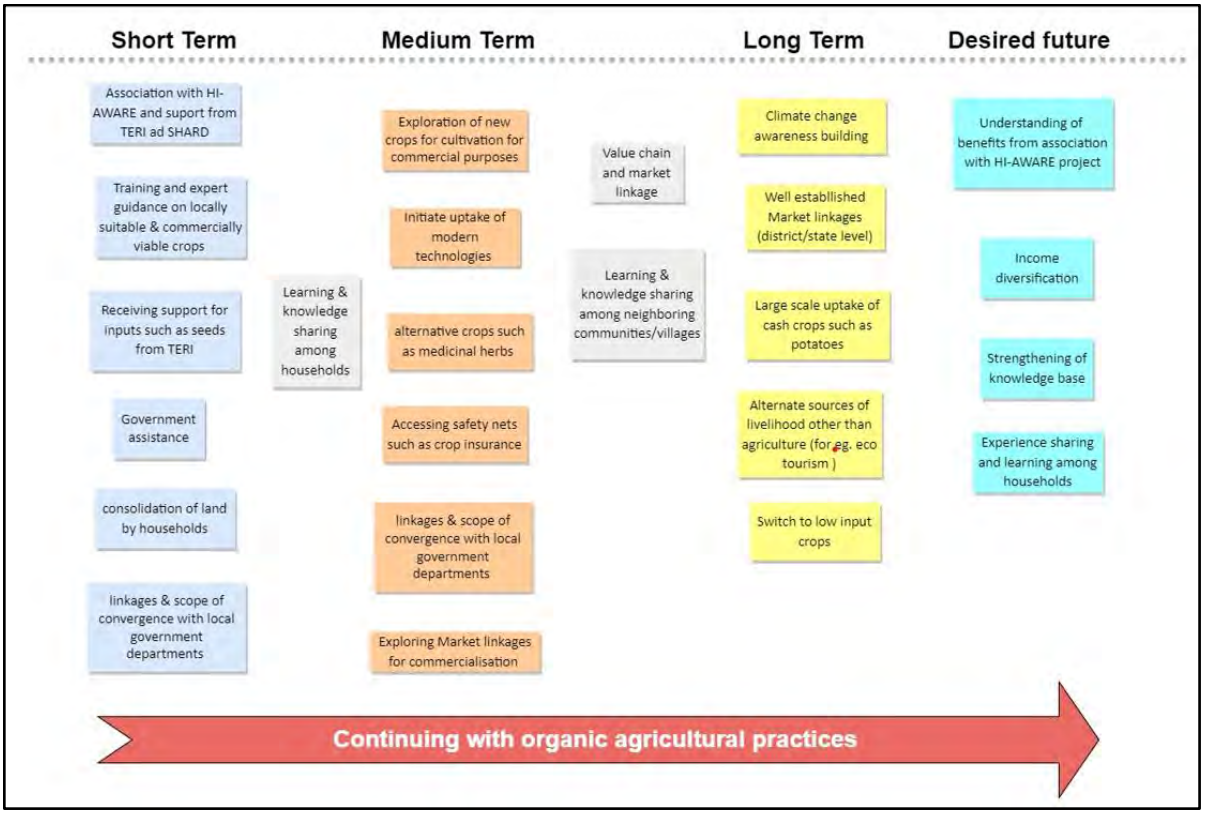

Figure 5.4: Climate resilient development pathways for the local community (Local scale)

Annex 6: Climate resilient development pathways and 'SWEB' anaylsis for sustainable upscaling of solar water pumping in Pakistan.

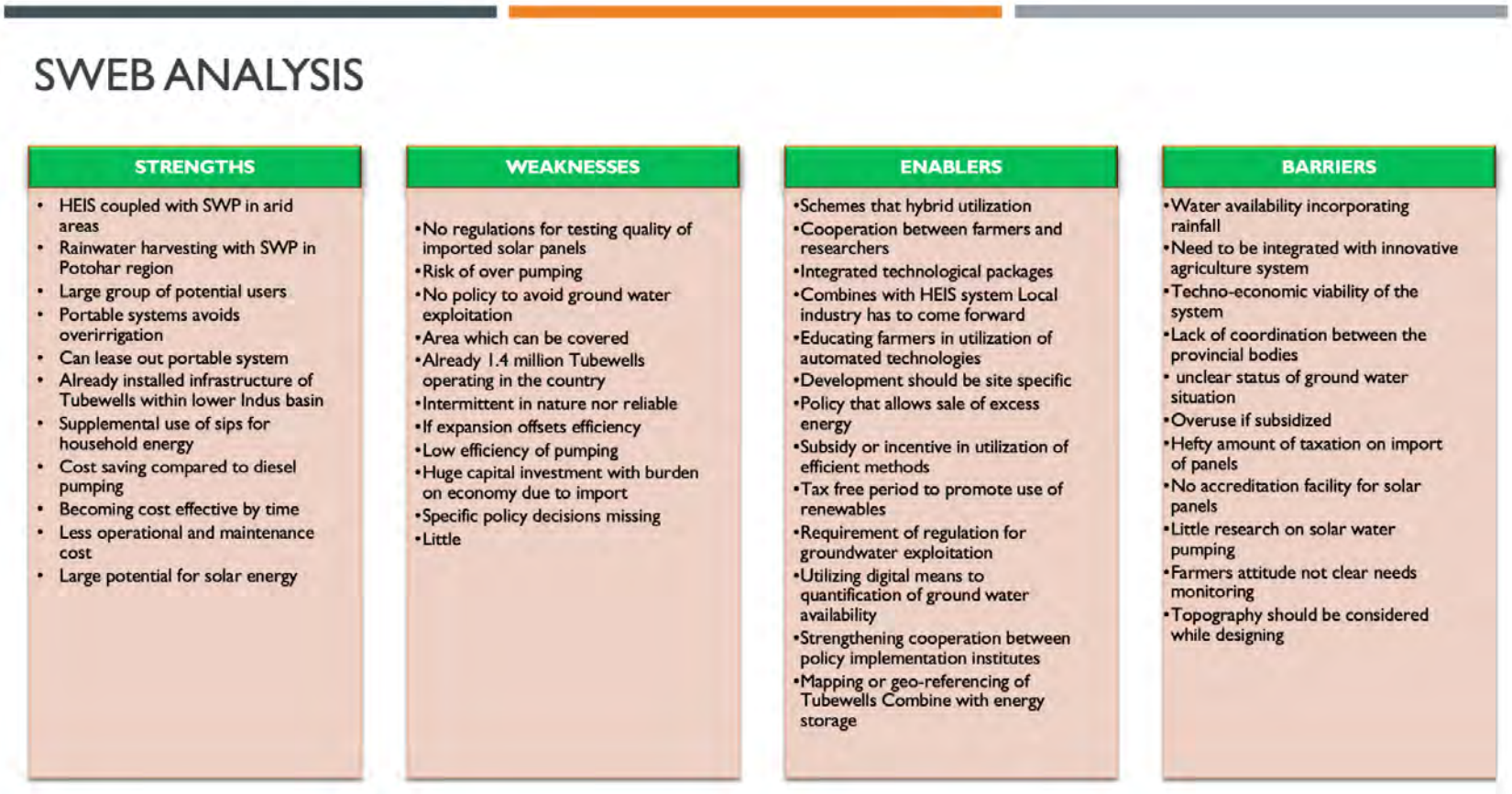

Figure 6.1: Strength, weakness, enablers and barriers (SWEB) analysis for determining sustainable solar water pumping barriers and drivers in adoption as an input to pathways development

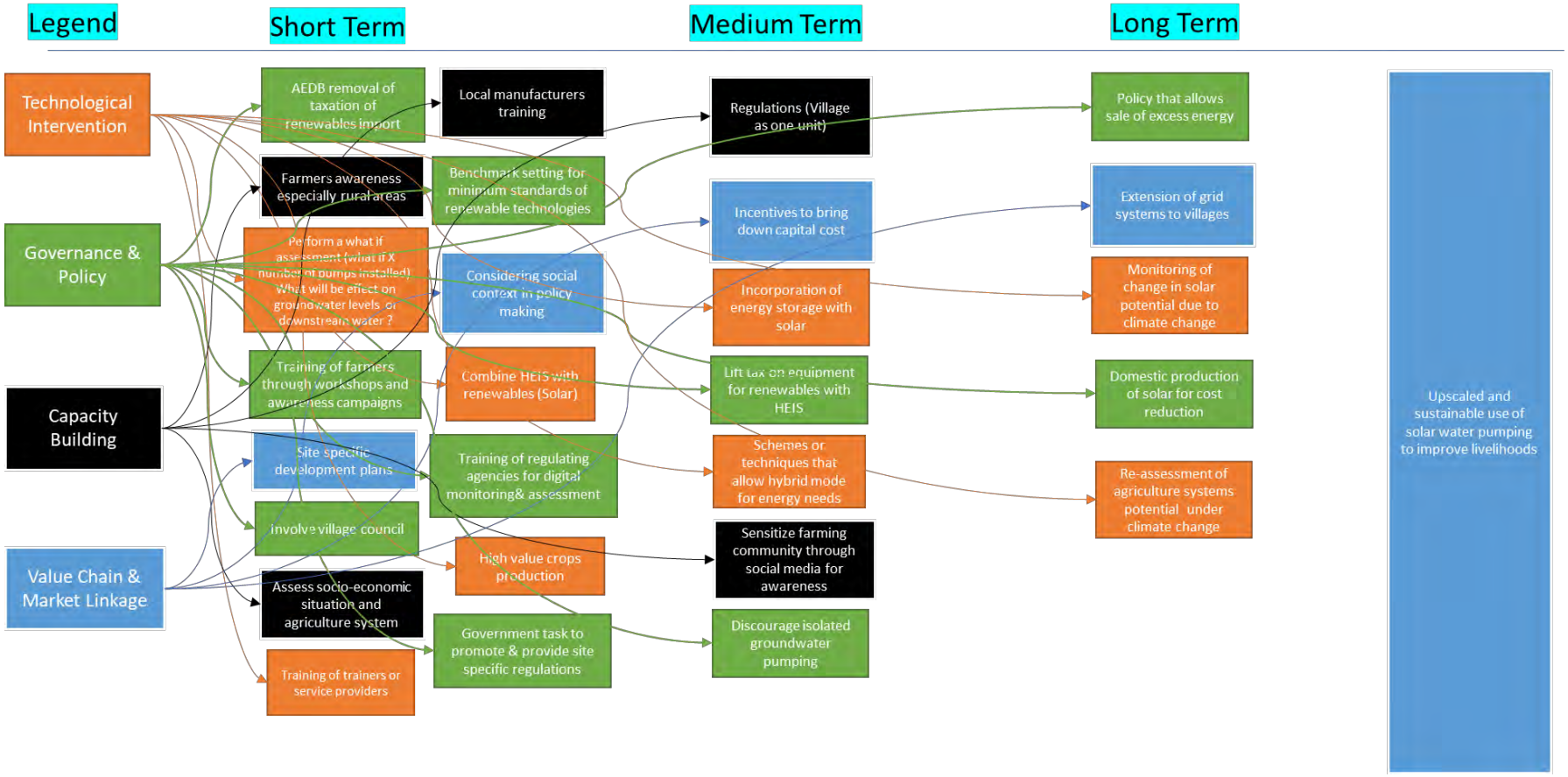

Figure 6.2: Pathways from the National Consultation on sustainable solar water pumping

Annex 7: Biophysical suitability map for solar water pumping in Pakistan and groundwater depletion under RCPs

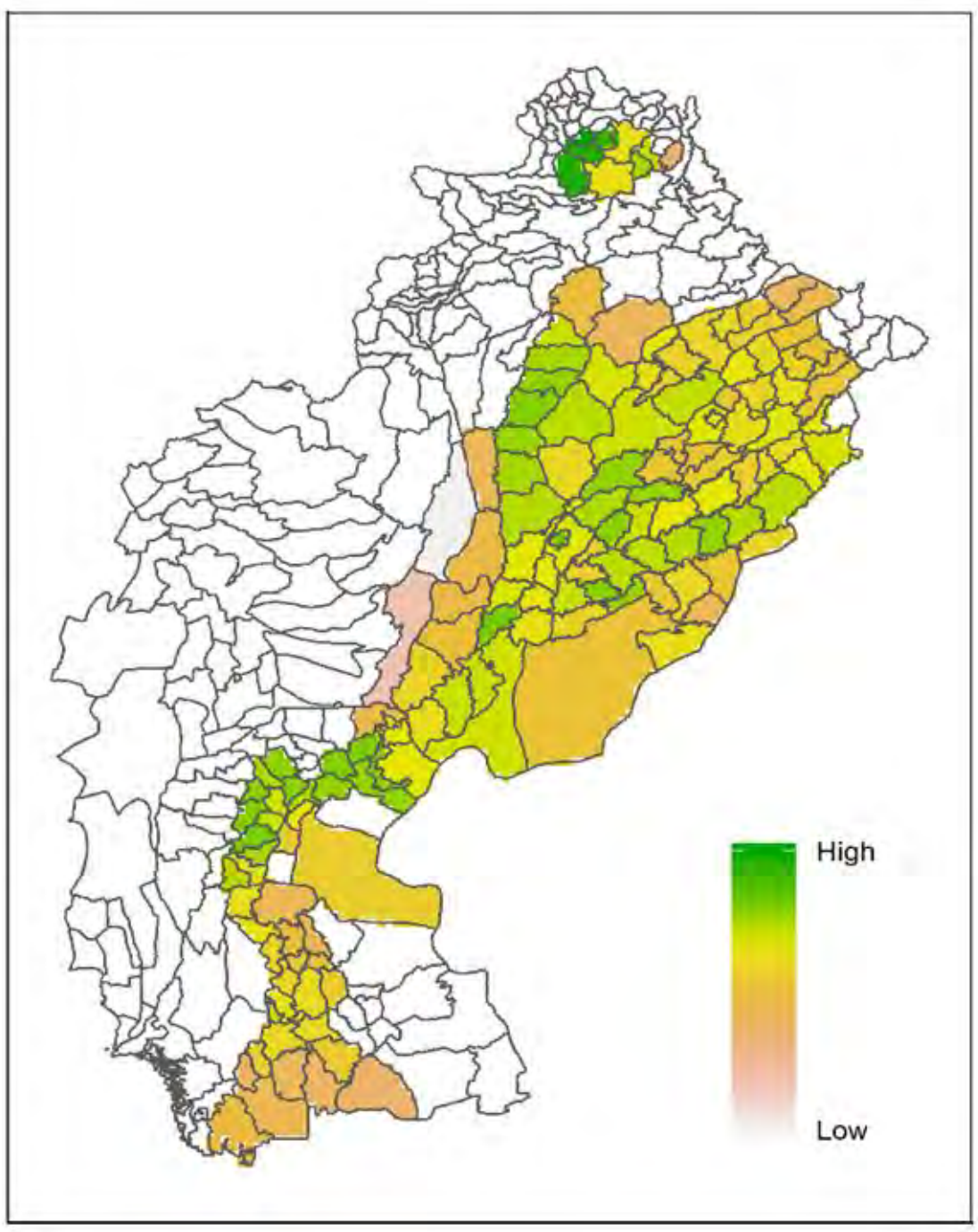

Figure 7.1: Biophysical suitability map. Green areas are having a high suitability whereas orange/white areas a less suitable

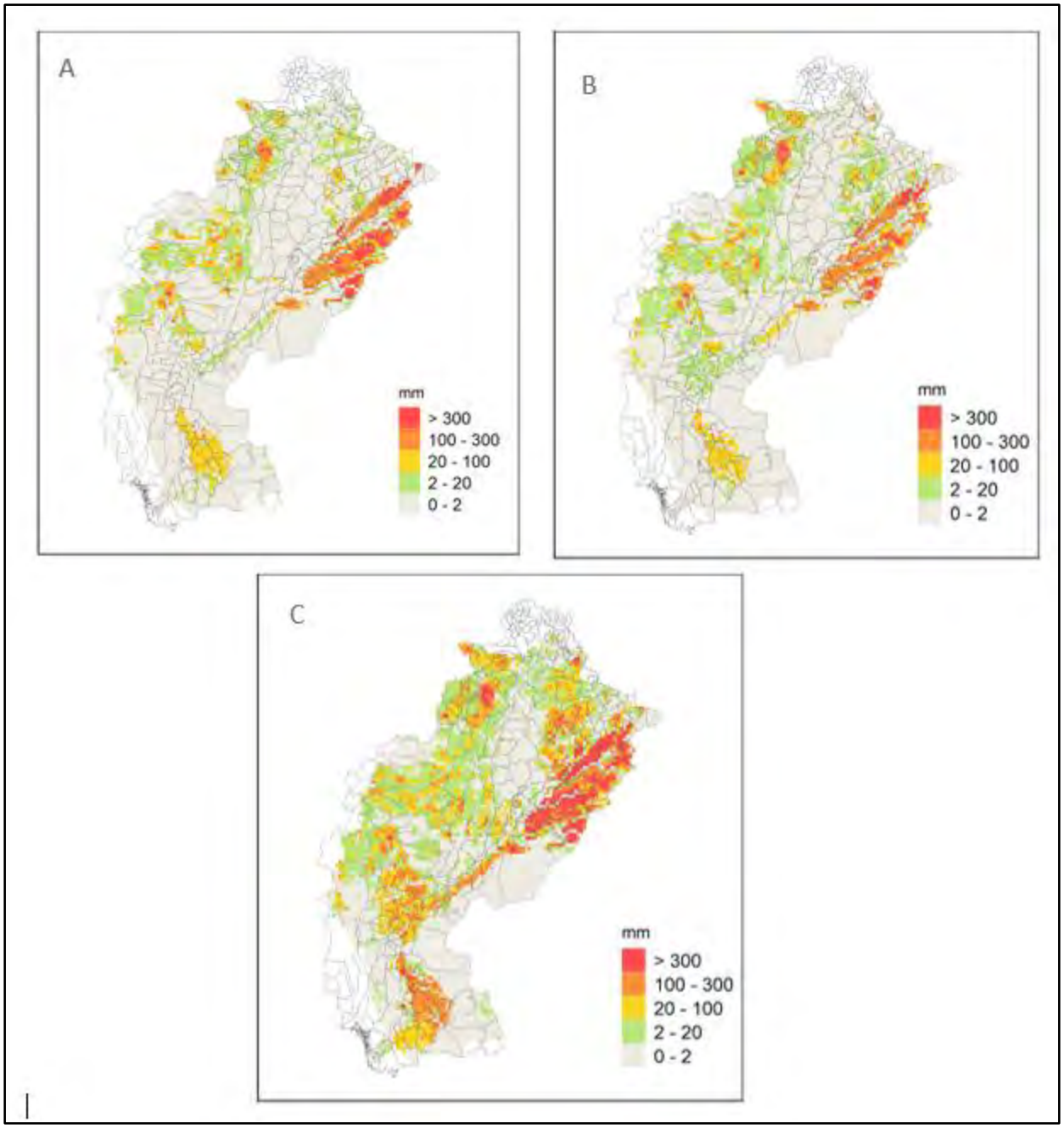

Figure 7.2: Annual groundwater depletion for the current situation (a) between 1981 and 2010, and for the future for RCP4.5 (b) RCP8.5 (c) between 2071 and 2100.

Annex 8: Co-create climate resilient development pathways Miro board

Link: https://miro.com/app/board/uXjVOQDfl7I=/

For who? The board has been designed to co-create climate resilient development pathways with stakeholders in an online setting, and can be used by anyone aiming to do so. Practitioners may include policy makers, government officials, NGOs, researchers, private sector and students. Concerning participants, we strongly recommend taking an inclusive and participatory approach towards those who will be affected by decisions made as a result of your work. With this in mind, it is highly important that those who are vulnerable and less powerful in decision making have an equal voice, and that power dynamics and gender considerations are accounted for when conducting workshops. Furthermore, it should be taken into consideration how those without access to internet can be represented.

Requirements. This workshop requires internet access, a digital communication platform (zoom or equivalent) and a MIRO account. It is useful if facilitators have some experience delivering workshops, however this is not necessary.

Number of participants. The workshop can be completed with as little as 2 people (one facilitator/ one participant), and up-to as many stakeholders the facilitators deem capable of managing in one workshop. However, we recommend a maximum of 40 per workshop, and using breakout rooms to manage inputs and comments. With over 40 participants, holding multiple workshops and synthesising results is recommended. This is because it can be hard to manage a large amount of participants in MIRO and, with an increasing number of participants it becomes harder to capture in-depth insights. We recommend using breakout rooms for more than 8 participants.

Workshop content. The board should not be thought of as a 'off the shelf' package that can be used with no preparation. Rather, it is a half-filled canvas, that should be tailored to the specific goals and context of the intervention, as well as the and needs of facilitators and participants. We recommend the 6 steps are included, as they are important components in the process for the co-creation of climate resilient development pathways, however they are by no means the only components. The board can be used for inspiration and reference and adjusted to the practitioners needs as required. As are the available time and the participants aspirations. Below are some guiding questions that may be useful for practitioners to help define the scope and objectives of the workshop.

Guiding questions

- What is the current context and scope for climate resilient development development?
- What could be climate-resilient development pathways for the people in the research area? What strategic decisions, interests, uncertainties and aspirations is this process about?

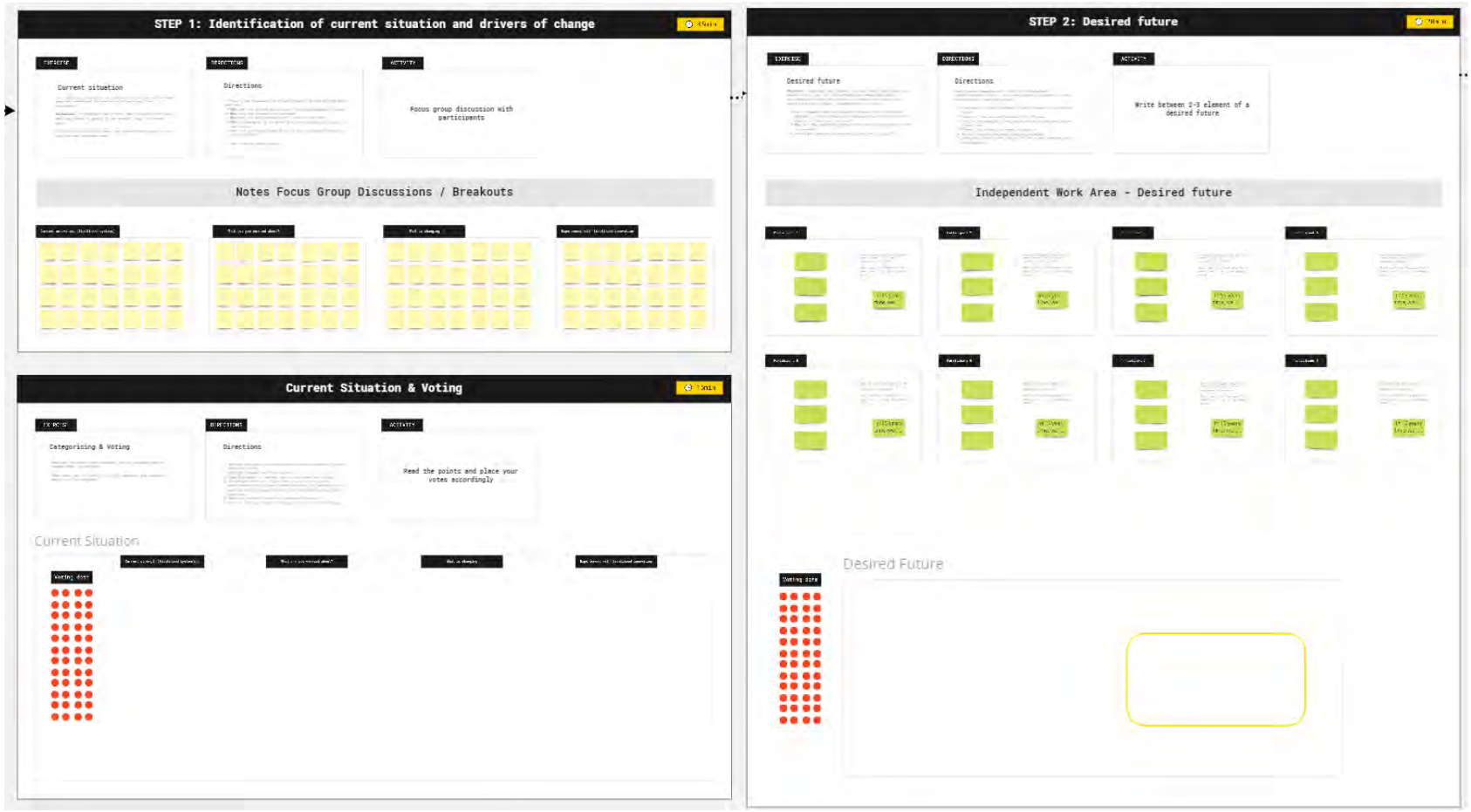

Figure 8.1: Screenshots from the Miro board, view the full board via the link