HI-AWARE Working Paper 23

Experiences and lessons learnt from HI-AWARE's climate change adaptation pilots

Consortium members

About HI-AWARE Working Papers

This series is based on the work of the Himalayan Adaptation, Water and Resilience (HI-AWARE) consortium under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) with financial support from the UK Government's Department for International Development and the International Development Research Centre, Ottawa, Canada. CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The programme supports collaborative research to inform adaptation policy and practice.

HI-AWARE aims to enhance the adaptive capacities and climate resilience of the poor and vulnerable women, men, and children living in the mountains and flood plains of the Indus, Ganges, and Brahmaputra river basins. It seeks to do this through the development of robust evidence to inform people-centred and gender-inclusive climate change adaptation policies and practices for improving livelihoods.

The HI-AWARE consortium is led by the International Centre for Integrated Mountain Development (ICIMOD). The other consortium members are the Bangladesh Centre for Advanced Studies (BCAS), The Energy and Resources Institute (TERI), the Climate Change, Alternative Energy, and Water Resources Institute of the Pakistan Agricultural Research Council (CAEWRI-PARC) and Wageningen Environmental Research (Alterra). For more details see www.hi-aware.org.

Titles in this series are intended to share initial findings and lessons from research studies commissioned by HI-AWARE. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the HI-AWARE consortium, they have only undergone an internal review process.

Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

Authors

Nuvodita Singh	Email: nuvodita.singh@columbia.edu
Farid Ahmad	Email: farid.ahmad@icimod.org
Ali Kamran	Email: engr.alikamran87@gmail.com
Aparna Unni	Email: aparna.meghpyneabhiyan@gmail.com
Bashir Ahmad	Email: dr.bashir70@gmail.com
Christian Siderius	Email: christian.siderius@wur.nl
Eklavya Prasad	Email: meghpyneabhiyan@gmail.com
Ganesh Gorti	Email: ganesh.gorti@colorado.edu
Ghulam-Muhammad Shah	Email: ghulammuhammad.shah@icimod.org
A.K.M. Hassan Syed	Email: hasansayed2004@gmail.com
Kumod Kumar Das	Email: kumod.meghpyneabhiyan@gmail.com
Md. Abu Syed	Email: mabusyed@gmail.com
Muhammad Khalid Jamil	Email: khalidjamil2169@gmail.com
Sultan Ishaq	Email: sultan.iq11@gmail.com
Suruchi Bhadwal	Email: suruchib@teri.res.in
Tanvir Hassan	Email: tanvirhassan.bd@gmail.com
Tanya Singh	Email: tanya.singh@wur.nl

Acknowledgements

This work was carried out by the Himalayan Adaptation, Water and Resilience (HI-AWARE) consortium under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) with financial support from the UK Government's Department for International Development and the International Development Research Centre, Ottawa, Canada.

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Experiences and lessons learnt from HI-AWARE's climate change adaptation pilots

Authors

Nuvodita Singh[1], Farid Ahmad[1], Ali Kamran[2], Aparna Unni[3], Bashir Ahmad[2], Christian Siderius[4], Eklavya Prasad[3], Ganesh Gorti[6], Ghulam-Muhammad Shah[7], A.K.M. Hasan Sayed[5], Kumod Kumar Das[3], Md. Abu Syed[8], Muhammad Khalid Jamil[2], Sultan Ishaq[2], Suruchi Bhadwal[6], Tanvir Hassan[8], Tanya Singh[4]

Himalayan Adaptation, Water and Resilience (HI-AWARE) Research

Kathmandu, Nepal, July 2020

[1] Corresponding Author, International Centre for Integrated Mountain Development, Nepal

[2] Pakistan Agricultural Research Council, Pakistan

[3] Megh Pyne Abhiyan, India

[4] Wageningen University and Research, The Netherlands

[5] C4RE Services Pvt. Ltd., Bangladesh

[6] The Energy and Resources Institute, India

[7] International Centre for Integrated Mountain Development, Nepal

[6] Bangladesh Centre for Advanced Studies, Bangladesh

Published by

HI-AWARE Consortium Secretariat
Himalayan Adaptation, Water and Resilience (HI-AWARE) Research
c/o ICIMOD
GPO Box 3226, Kathmandu, Nepal

ISBN 978 92 9115 6887 (electronic)

Production team

Rachana Chettri (Editor)
Debabrat Sukla (Communication officer, HI-AWARE)
Mohd Abdul Fahad (Graphic designer)

Photos: HI-AWARE

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Citation: Singh, N., Ahmad, F., Kamran, A., Unni, A., Ahmad, B., Siderius, C., Prasad, E., Gorti, G., Shah, G.M., Sayed, A.K.M.H., Das, K.K., Syed, A, Jamil, M.K., Ishaq, S., Bhadwal, S., Hassan, T., Singh, T. (2020) *Experiences and lessons learnt from HI-AWARE's climate change adaptation pilots* . HI-AWARE Working Paper 23. Kathmandu: HI-AWARE

Contents

Executive summary

This document compiles the experiences and lessons learnt from specific adaptation pilot interventions under the Himalayan Adaptation, Water and Resilience (HI-AWARE) Research on Glacier and Snowpack Dependent River Basins for Improving Livelihoods. While subsequent sections talk about pilot-specific experiences, the broad messages that have emerged pertaining to the implementation of climate change adaptation interventions are presented here:

- The climate change adaptation solutions tested in the HI-AWARE pilots have shown huge potential in the areas of flood resilient housing and sanitation, water management, climate-smart agriculture, and heat stress management.
- Climate change adaptation solutions should be contextually relevant, customizable, cost-effective, and community driven, and have public and private sector support to be scalable and sustainable in the long run. They must accommodate different and evolving contexts.
- Adaptation is a multi-sectoral challenge and the design of interventions must address this for them to be effective.
- Local interventions should acknowledge and address the differential impacts of climate change on gender.
- Pragmatic and adaptive planning that maintains relevance to the context and flexibility in problem solving is required to achieve ambitious objectives under budget and time constraints.
- Strategies for scaling up and scaling out, including forging active partnerships with key stakeholders should be devised during the intervention planning phase. This helps promote ownership among the stakeholders.

1. Introduction

Background

Climate change is a universal challenge. It poses a multitude of threats, the different combinations of which affect diverse communities differently. Touted as the "third pole" for the amount of water locked in its glaciers, the Hindu Kush Himalayan (HKH) region is one of several climate change hotspots globally (Singh et al. 2011): The much debated 1.5 degree limit to temperature rise will translate into a higher increase in temperature for the HKH (Kraaijenbrink et al. 2017). It is prone to multiple vulnerabilities that intersect with high exposure to hazards like erratic rainfall, droughts, and riverine and flash floods, resulting in cascading disasters with upstream–downstream linkages and transboundary impacts. The region is also comprised of many low and middle income countries, many of which are struggling to provide basic services to their population such as education, employment, water, sanitation and health, infrastructure, etc. Four of the HKH regional countries are categorized as least developed countries (LDCs) (Bangladesh, Bhutan, Myanmar, and Nepal). Climate change impacts make the process of development all the more challenging and in turn affect the contribution of development to building adaptive capacity. Climate change adaptation for South Asia in general, and the HKH in particular, is a proposition laced with complexity.

Climate change adaptation (henceforth, adaptation) is a process of coping and adjusting our socio-ecological and economic systems to changes in our external environment due to climate change impacts (IPCC 2001). However, it is important to address the root causes of people's vulnerabilities, whether directly related to climate or not, to be able to shift from short-term coping to adaptation (ICIMOD 2009). Successful adaptation is context-specific, affected by socio-political-cultural-economic and geographical dynamics. Adaptation related interventions should ideally be structured keeping the community and their preferences on adaptation in mind. This should be an important tenet of piloting of adaptation interventions to understand a community's socio-cultural acceptability and use patterns. Social innovators and project implementers, therefore, also need to be effective communicators, negotiators, marketers, and advertisers (Nayar, Saleh, and Minj 2016).

HI-AWARE pilots

HI-AWARE worked in three HKH river basins – the Indus, the Ganges, and the Brahmaputra, spanning four countries – Bangladesh, India, Nepal, and Pakistan. The overall goal was to enhance the adaptive capacities and climate resilience of poor and vulnerable women, men, and children in the mountains and plains of the HKH through the use of robust evidence for framing people-centred and gender-sensitive climate change adaptation policies and practices that can improve livelihoods. Addressing climate-induced vulnerabilities locally and across similar regions requires solutions that are contextually relevant, cost effective, government supported, and community driven (Smit et al. 2001, Chambwera et al. 2014, UNFCCC 2017) so that climate change interventions are sustainable and pilot technologies can be scaled. HI-AWARE focused on understanding what works and what does not work as an adaptation solution from a community perspective in order to address and minimize vulnerabilities. Through pilots, four technologies, processes, and innovations were tested and co-evolved with the beneficiary communities as ways of adapting to climate-induced changes.

The objective of the pilots has been to test whether and how particular interventions can be relevant to a given context, can be functional in real-life scenarios, and whether they are appropriate, viable, economical, and worth expanding to a bigger scale. Tying together the different HI-AWARE pilot sites are certain vulnerability-enhancing characteristics. These are:

- Transformed ecology, its impacts, and limitations. Examples include restrictive primary and alternative sources of livelihood in agriculture, inaccessibility to safe water and hygienic sanitation (WATSAN), and threat to lives and livelihoods because of floods and frequent destruction of dwellings.

- Human poverty in terms of inaccessibility to basic requirements.

- Gender-related challenges in women headed households or households where men have migrated to urban centres for livelihoods, resulting in a multiplication of the workload and consequent health and psychological impacts.

These pilots have been implemented in three of four HI-AWARE countries: Bangladesh, India, and Pakistan, and address different challenges in their specific areas. The choice of pilot sites and the technology to test was guided by the consortium partners, their knowledge of local vulnerabilities, access to a network of organizations and policymakers, and presence of certain national socio-economic programmes.

In Bangladesh, the Bangladesh Centre for Advanced Studies (BCAS), in partnership with C4RE Services, implemented Climate and Flood Resilient (CFR) housing in Kaunia Upazila of Rangpur District in the Teesta and Atrai flood plains. The pilot aimed to bring relief from inundation and livelihood insecurity to flood affected communities through the provision of basic amenities such as water, sanitation, and kitchen gardens.

In India, the International Centre for Integrated Mountain Development (ICIMOD), in partnership with Megh Pyne Abhiyan (MPA), has implemented flood resilient habitat through customized interventions on EcoSan toilets, clean drinking water, and housing technologies for vulnerable communities in Pashchim (west) Champaran district, situated in the alluvial flood plains of North Bihar in the Lower Gandaki River basin. In Delhi, The Energy and Resources Institute (TERI) and Wageningen University, in cooperation with Mahila Housing Sewa Trust (MHST), have evaluated the impact of a novel roof module for its heat reducing capacities.

In Pakistan, the Pakistan Agriculture Research Council (PARC) has worked in Chakri – an area in the rain-fed (barani) lands of Potohar region in the foothills of the Indus basin – to implement a package of Climate Smart Agricultural (CSA) technologies. This package includes a solar-powered irrigation system to draw water from rivers or open surface water bodies, a high-efficiency irrigation system (HEIS), tunnel farming, crop diversification, and high-value off-season crops. Pilot demonstration sites have also been developed in Hunza in the Upper Indus basin and in Bhalwal, downstream of the Indus. The objective of the pilot is to improve integrated water resources management practices leading to food security and improved livelihoods in the mountains, hills, and dry and semi-arid zones of Pakistan.

This document aims to share the lessons that can be drawn from HI-AWARE's pilot implementation process to strengthen adaptation solutions in the HKH region. It starts by discussing the different approaches and methods used as warranted by the different contexts. Further, it discusses the principles of scaling up interventions. It moves on to discuss the experiences and lessons learnt through the planning and implementation process, and also the policy context and recommendations for individual pilots.

2. Approaches and methodologies for piloting

Developmental changes, especially in the global South and specifically in the HKH, are often results of multi-loop, non-linear, and complex interactions of actors and factors. There are always uncertainties attached to the implementation of development interventions. Climate change will contribute to increasing these uncertainties and risks. Therefore, innovation is essential to facing these challenges. At the same time, understanding the way climate change risk is framed locally, and the narratives and learning processes associated with that framing is extremely important for adaptation. (McEvoy, Fünfgeld, and Bosomworth 2013).

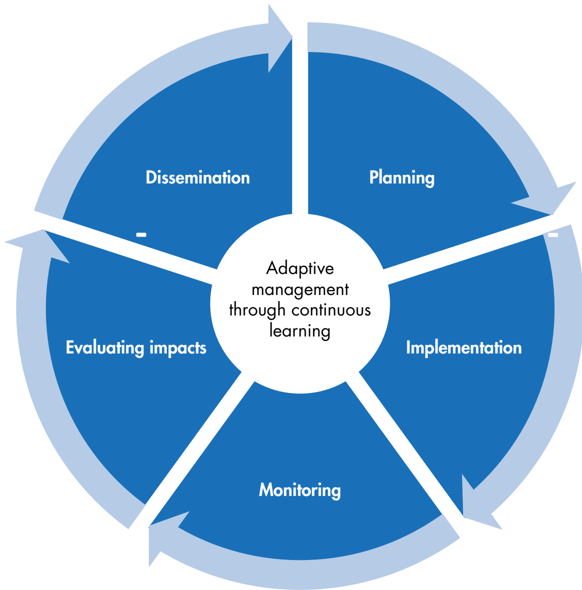

Figure 1: Adaptive management through continuous learning

Pilots are crucial to understanding which climate change adaptation options are innovative, promising, scalable, and sustainable for particular areas under certain conditions. The HI-AWARE consortium used the adaptive management approach at each stage of the design and management of its pilots to account for uncertainties through its structured and iterative nature. Pelling (2011) states, "Under adaptive management, individual and organizational learning is both encouraged from planned actions (such as change in the regulatory environment) and in response to unplanned environmental surprises (natural or technological disasters)".

The following steps were performed:

Selection of pilots

The pilot interventions were judged on relevance, feasibility, and the potential for scaling out and scaling up. Scoping studies in each of the river basins were conducted to understand the context and its specific vulnerabilities. As stated above, the choice of partners in each country, their expertise, wider network of organizations and policymakers, and national level development programmes also influenced the choice of interventions. For example, since the sites in the Gandaki basin and Teesta basin lay in floodplains that are regularly affected by increasingly unpredictable floods, the interventions focused on enhancing flood resilience. Given the contextual requirements that emerged, a flood-resilient sanitation system – through customized interventions of the EcoSan toilets within the larger framework of a flood-resilient habitat – was selected as one of the interventions piloted in the Gandaki basin, and Climate- and-Flood Resilient (CFR) housing models were chosen as pilot interventions in the Teesta basin. In selected upstream and downstream areas of the Indus basin, packages of CSA technologies were piloted to alleviate the farmers' dependence on rain. Additionally, modified roofs (ModRoofs) were tested in a few houses of a low-income colony in Delhi for potential reduction in indoor heat stress.

Planning

The HI-AWARE Theory of Change (ToC) was developed using the Participatory Impact Pathway (PIPA) approach, which is used to frame outcome and impact logic models – predictions by stakeholders on how impact will be affected through a research for development project (Alvarez et al. 2010). In this way, PIPA ensures inclusion of relevant stakeholders right from the planning stage.

Similarly, the planning process for the pilot interventions began with the development of a ToC and impact pathways. A clear ToC was considered mandatory for each pilot as this details the direction and goal of the intervention, makes intervention assumptions explicit, unbundles contextually relevant strategies, and chalks out broader activities, outputs, and outcomes. In other words, it elucidates how planned activities are understood to produce required results that contribute to achieving impacts with clearly defined causal links. Additionally, it allows for the absorption of and adjustment to any changes on the ground. Implementation partners at each pilot site developed pilot implementation plans for the whole pilot implementation period. These plans were used as references to develop yearly implementation plans which were revisited annually.

Implementation

The process of implementation began with baseline data collection at selected sites. At the same time, discussions around the appropriate evaluation design began, including whether to conduct an experimental study that would require establishing separate comparison groups. Baseline questionnaires were developed in order to understand the biophysical, socio-economic, and political landscape of the sites where pilots were being implemented. The baseline study provided an important starting point against which to measure progress during and after pilot implementation. It was instrumental in the selection of households for the interventions.

Pilot implementation plans were mandatorily drawn up for each pilot. The initial groundwork for this was carried out in the planning stage, as stated above. The implementation of the pilots began in earnest once the requisite permissions were sought and individuals from the communities expressed their interest and opted to invest their time and other resources in testing the interventions. The HI-AWARE team was mindful of the importance of having individuals/households develop ownership during the process rather than becoming mere recipients of an intervention. Positive experiences of individuals and households were expected to influence other members of the community to consider whether a given intervention could be useful for them as well. Therefore, considerable focus was given to effective interaction and communication with the community beyond implementing a particular technology.

Monitoring

The HI-AWARE pilots entailed testing of certain technologies and packages of practices that were co-developed with the beneficiary communities. Given the evolving nature of HI-AWARE pilots, a participatory and continuous monitoring process was recommended in order to facilitate learning, feedback, and course correction.

The continuous monitoring approach that was adopted by the team enabled them to take note of beneficiary inputs and the evolving context, which helped better customize the implementation process. Additionally, process documentation has been an important component that entails capturing frequent information on the process of the pilot through logbooks, field visit notes, photos, and reflection on and addressing of issues as and when they emerge.

Evaluations and impact assessments

Monitoring and Evaluation are important functions to inform the design and selection of pilot interventions as well as provide relevant messages for policy level issues. The Development Assistance Committee (DAC) – DAC Criteria for Evaluating Development Assistance–OECD, 2018[1] – principles for evaluation of development assistance: relevance, effectiveness, efficiency, impact, and sustainability, were adopted in order to evaluate HI-AWARE pilots.

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[1]OECD's Development Assistance Committee

The adaptive management approach adapted for each of the pilots under HI-AWARE embeds these aspects into the pilot designs. ICIMOD supported each of the pilot implementers in establishing relevant evaluation designs. Looking at the overall objectives and associated outcomes identified and the nature of technologies implemented under each pilot, quasi-experimental designs were proposed for each of the pilots. These would be important in ascertaining whether the outcomes could be attributed to the pilots. However, objectives initially identified for each of these pilots were too ambitious given the time, budget, and systemic constraints related to the institutional setup of the consortium's partner institutions. This was hence, not fully achieved.

More time and additional efforts are required for pilot technologies to be adopted by wider communities outside the beneficiaries. Alternatively, a rigorous cost effectiveness and cost benefit analysis of the tested technologies is required so that the viability of the technologies for possible scaling up and hence policy influence is assessed.

An important lesson learnt from the implementation of the HI-AWARE pilots is the need to resist setting ambitious objectives, particularly under budget and time constraints. Alternatively, a time-bound inception phase could be agreed upon at the planning stage of such pilots so that objectives and associated outcomes can be revisited at the end of inception.

Communication and dissemination plan

Knowledge management, communication, and dissemination are important to ensuring that lessons and experiences are utilized to inform future interventions. For programmes that function in a consortium format, it is recommended that communication and dissemination plans be developed in close consultation with communication specialists at the consortium level. Different stakeholders must be recognized at the institutional and policy levels as well as in the media, and information about the need, progress, and impact of pilot interventions must be tailored to suit specific types of stakeholders. Both print and electronic media must be used and social media must be explored as a platform for larger public engagement. HI-AWARE developed these plans for each pilot. Frequent visits by government officials, experts, policy makers, and media outlets were arranged to provide visual evidence of the successful operation of the technologies being implemented. Such communication strategies are best kept flexible to address rising challenges in the field.

3. Key principles for scaling up

Since climate change is an all-pervading phenomenon, it is not enough for a climate change adaptation project to simply function within the confines of a given context. Interventions that are able to show effectiveness must be expanded, adapted, and sustained to creating a larger, perceptible impact that benefits more communities in varied contexts and over time (Hartmann and Linn 2008).

Along the lines of Uvin (1995) as cited in Hartmann and Linn (2008), HI-AWARE's pilots understood scaling up as expanding and adapting to more geographical territories with similar hydrogeological and agroclimatic contexts (what would typically be referred to as scaling out), featuring increased partnerships and greater engagement with policy makers and such stakeholders (referred to as organizational and political scaling up respectively). These processes are contingent on the availability of an enabling environment, in the absence of which the most technically sound interventions may not be able to create intended and expected impact. Adequate and supportive infrastrucutral, institutional, and governance frameworks are almost always prerequisites for an intervention to flourish or be scaled up (Pelling 2011). Adaptation will not be feasible without the support of both communities and governments to sustain it. It is imperative to have this support at the start of any adaptation project to enable scaling up later (Nayar, Saleh, and Minj 2016).

However, scaling up should not be understood to mean blanket replication of interventions. Sarker, Abed, and Seelos (2016) note that poverty may look the same in non-similar contexts, but the differences must first be disentangled before replicating past successes from elsewhere. Since socio-ecological systems are not homogenous across the board, this applies to climate change adaptation interventions as well. In fact, customizing interventions to suit local contextual settings is one of the key challenges to scaling up climate change solutions in developing countries where such solutions are needed in earnest (Coony 2016). He further adds that it is important to build capacity at the local level to enable the context to benefit from the intervention.

However, as Spicer, et al. (2014) note from different sources, factors that limit the potential of an intervention to scaled up include the innovation's simplicity, comparative advantage, and whether its benefits are observable.

As discussed, scaling a climate change intervention entails a process of expanding the use of a desirable practice, technology, or process either through upward changes ('scaling up') – subnational, national, regional, and international; or outward spread across sectors, jurisdictions or landscapes ('scaling out'); or both. Keeping the above discourse in mind, HI-AWARE adhered to the following principles for scaling up a pilot intervention:

i. **Credibility:** The results and impacts of a model intervention are well documented and provable. Such a model is evaluated independently and tested in a setting similar to the one for scaling up. The model is acceptable to relevant stakeholders outside the immediate implementation process.

ii. **Observability:** Results and impacts are visible and comprehensible to the project stakeholders and attributable to the intervention. They can be easily communicated to an interested public.

iii. **Relevance:** Relevant stakeholders, partners, and the project's target group consider scaling up necessary and desirable. The intervention reacts to an observable and expressed need, and is designed to include marginalized groups (women, youth, ethnic communities) in as many aspects as possible. It creates significant improvements in systemic (social and/or ecological) resilience towards climate change impacts.

iv. **Transferability:** Technologies or innovations promoted by the intervention are easy to adopt for the target group, and not likely to create conflict within the target group. These interventions can be applied to different scales and contexts.

v. **Compatibility** The intervention addresses social, political, and environmental aspects that can also be traced in the setting for scaling up. The activity is in line with relevant legal frameworks, policy, and practice.

vi. **Testability:** The intervention can be tested in small steps by the target group without full adoption.

It would be ideal for scaling up adaptation interventions if climate change was recognized as an imminent threat to development at the policymaking level. Where such an inclusive policy and institutional framework is not present, cross-sector linkages and opportunities within existing and planned programmes must be sought to enable adaptation interventions to flourish and be scaled up. Development needs climate change to be accounted for.

The following section provides some examples that illustrate this by detailing the implementation process and efforts geared at scaling up HI-AWARE adaptation interventions.

4. Adaptation pilots – case studies

Along the lines of the DAC criteria, the pilot interventions were designed in light of relevance, effectiveness, efficiency, and sustainability. Since the interventions are expected to span different scales eventually, the element of 'customization' of technologies and of processes associated with implementation was also included. The criteria are understood as follows:

Relevance: The suitability of the pilot intervention to the specific socio-economic, cultural, geographic and climatic context and needs

Effectiveness: The extent to which the pilots contribute to the project and pilot objectives

Efficiency: Inputs, both technological interventions as well as the different processes involved, to yield specific results

Sustainability: Elements that are like to sustain the interventions beyond the project period

Customization: The scope of pilot technologies and processes to suit different contextual conditions across scales

The following sections discuss the HI-AWARE pilots in further detail. The sections discuss context-specific factors that call for specific interventions, the details of these interventions, the prominent experiences and lessons learnt during the implementation process, and finally the actions being taken with respect to the specific policy climate in each country.

4.1. Solar-powered irrigation system and climate-smart agricultural packages

4.1.1. Context

Pakistan is among the world's most vulnerable countries to climate change (HSBC, 2018). For a primarily agrarian country, this poses grave challenges to the flourishing of agriculture. Extreme weather events and erratic rainfall can lead to high run-off and soil erosion, which can demolish on-farm water channels and render them futile. Areas outside the Indus Basin Irrigation System (IBIS) such as the semi-arid regions of Balochistan, Thal, and Potohar Plateau are under serious threat from agricultural water scarcity. The lack of irrigation planning, heavy dependence on rain, the difficulty in accessing markets, and vulnerability to climate change impacts are major hurdles in the lives of farming communities in these areas.

The rain-fed Soan River basin in Punjab's Potohar region, which lies midstream of the Indus River basin, is one such area where agriculture is heavily dependent on rainfall and ground water resources. This, combined with mono-cropping, makes the region extremely vulnerable to climate change impacts that can wipe out an entire season's produce. The lack of access to water, both underground and from the Soan River, prevents farmers from realizing the full potential of agriculture, and hence, land remains uncultivated.

Traditionally, in the absence or paucity of rain, farmers in some parts of the hill and mountain areas of the HKH have used dug wells for drawing water above ground with the help of Persian wheels driven by animals. However, these means are on the wane, particularly among the younger generation, because they require hard labour and are time consuming. Using conventional fuel/electricity-driven pumps to pump water for irrigation from rivers/streams can accrue high energy and monetary costs.

Additionally, the recharge of dug wells that are dependent on groundwater availability are impacted by erratic rainfall patterns and the varying lengths of dry spells. This can mean low water availability when the crop requirement for the same is high. These factors make the use of traditional irrigation methods such as flooding unviable.

Thus, there is a need to explore alternative energy and technology to utilize available water and appropriate crop selection to build the resilience of farmers. Solar energy offers a more economically feasible and environmentally friendly alternative.

In order to address climate change and adaptation vulnerabilities in the Soan River basin region, specifically in Chakri in Rawalpindi district of Punjab province, PARC introduced a package of climate-smart agricultural practices and innovations under the HI-AWARE project. The package included fixed and portable solar pumps, an HEIS, tunnel farming, and crop diversification, and high-value off-season crops to enable on-farm use of drip irrigation, micro sprinklers, and dug wells.

4.1.2. Pilot solution

The Soan River basin around Dhok Pathan, Pakistan experiences very hot weather in the summer, while the more northerly Murree hills have very cold winters with heavy snowfall. According to local people and farmers, snowfall patterns in the higher elevations have changed drastically and the quantity of snowfall has gone down significantly. This has seemingly had a negative impact on water levels in the Soan River. The solar-powered water pumping system piloted by HI-AWARE was designed to enable water to be pumped from rivers or open surface water bodies. It can also withdraw water from dug wells in riverine areas where water recharge is sustainable. Importantly, the pumped water is used with an HEIS (which was not the case earlier), which helps to better utilize water that was previously being used inefficiently using diesel pumps and animal-driven Persian wheels.

The pilot, which combines water pumped through fixed and portable solar pumps with high efficiency irrigation technology, adopted a Developmental On-Farm Research Pilot (DOFRP) model. This entailed converting a single farm into a learning and training site for other farmers, researchers, students, and professionals in the region.

Features of portable solar pumps:

- Compatible motor power: 3–5 horsepower
- Capable of lifting water from depths up to 60 feet
- Lifts water from bore-holes, dug wells, ponds, rivers, etc.
- Discharge: 2–10 litres per second (high head to low head)
- Compatible with HEIS (drip and sprinkler) covering up to 7 acres
- Compatible with surface/sub-surface irrigation systems up to 7 acres (low head)
- Easy transportation and mobility
- Provides energy at the household and farm levels to meet fodder-related needs, including chopping, grinding, cooking, and other domestic needs

Potential users/benefits:

- Farmers in Potohar and Balochistan plateaus
- Farmers in Thal and Cholistan areas
- Local solar panels and pump manufacturing companies
- Small business owners
- Maintenance and service providers

Figure 2: Open view of a portable solar water pump

The farm is located on the banks of and across both sides of the Soan River. At the time of selection, the farm's owner was facing water scarcity. Sowing options on the farm were limited to wheat, mustard, and maize under rain-fed conditions.

Accordingly, HI-AWARE's pilot included innovative farm practices around integrated water resource management (IWRM) using tunnel farming and HEIS like the sprinkler system, drip irrigation, composite energy powered irrigation systems (CEPIS), and agricultural diversification (through field crops, vegetables, horticultural crops, livestock, and aquaculture) to address specific vulnerabilities. The solar pumps have been designed with careful consideration of discharge, total available head, sunshine hours, and potential evapotranspiration, among other factors, so that farmers have access to water throughout the year. The price of the system at present is around PKR 800,000 (USD 6,000 approximately). The introduction of compact and integrated panels, and economies of scale may lower this cost in the future.

Other components of the intervention include a solar geyser for water heating, on-farm solar electrification, and an energy-efficient stove for cooking. Rainwater harvesting is a feasible method to meet water demands during water scarce times.

4.1.3. Experiences and lessons learnt

The following points are based on the experience of planning and implementing pilots in the Soan basin:

Customized and efficient irrigation technologies improves resilience: Both fixed and portable solar pumps enable HEIS such as drip and sprinkler irrigation, and are part of a package of practices that help farmers improve farm productivity. The adoption of HEIS has enabled water saving for small farmers in a water stressed context and enabled them to double their cropping area.

High installation cost, low operational cost: After the one time capital cost of installation, these pumps entail low operational costs when compared to conventional fuel-driven pumps or animal-driven Persian wheels. The use of solar energy is environmentally friendly, socially acceptable, and economically feasible and hence presents a good alternative to vulnerable communities to enhance resilience through improving livelihoods.

Innovation builds resilience: The 'portability' of solar pumps allows large-scale farmers flexibility to increase irrigated area by 3–4 times. The adoption of HEIS has enabled water saving for small farmers in a water stressed context and enabled them to double their cropping area. Increased crop diversification has led to improved resilience in the face of climate-induced changes, through multiple income sources. Small farmer's incomes have increased by 3–4 times as well (Jamil, 2018).

Reduce women's drudgery: Solar pumps also have emergent benefits for women as they reduce drudgery. In an interview with the HI-AWARE–PARC team, a village woman said "Solar pumps, with just the push of a button, have made our lives easier, and we are happier now".

Participation and ownership: Primarily, what has worked in favour of the pilot intervention is the support received from the beneficiaries who were involved in the process of implementation. In the case of the first farm that was converted into a learning and training site for other farmers, the owner was willing to take the risk of investing in, installing, and using new technology and agricultural production practices on his farm (i.e. tunnel farming, HEIS, etc.). He let his farm be used as a training site and acted as a resource person for other farmers, practitioners, researchers and media. He also convinced the local vendors to source vegetables from his village, thereby benefitting fellow farmers as well.

Scope for scaling out: The pilot has received widespread attention and appreciation, and is now being considered for adoption in other regions as well. The testimonies and evidence from different villages indicate exciting opportunities for scaling out this model to other areas. Importantly, the implementation of alternate energy in a pilot that aims to improve farmer resilience in the face of climate change can hopefully be viable in the current policy scenario in Pakistan as discussed in the following section.

However, since the pilot was more policy oriented and less focused on the adoption of the technologies by other farmers, it cannot be termed a community model. Unless the community is involved, it becomes difficult to evaluate adoption by other farmers or the relevance and comparative advantage of the pilot itself. Furthermore, the continuous use of the set of technologies will require adequate awareness, technical knowledge, and access to technology among the farmers, which is currently poor.

Having said that, however, HI-AWARE–PARC conducted nearly 49 trainings for farmers and professionals so that they fully understand the maintenance and operation mechanisms of the portable solar pumping system as well as CSA. This ensured that the small farmer communities would be self-sufficient in the system's operation and maintenance.

4.1.4. Policy context and recommendations

As a country vulnerable to climate change, Pakistan has shown interest in institutionalizing climate action by establishing the Pakistan Climate Change Council, the Pakistan Climate Change Authority, and the Pakistan Climate Change Fund through a bill passed in March 2017. The bill addresses both adaptation and mitigation needs while the fund provides financial assistance to projects and programmes working to alleviate the impact of climate change through research or implementation and sustainably develop resources. Therefore, there are encouraging signs for a supportive policy climate for projects such as the pilot in Chakri. Some provinces such as Punjab also provide subsidy for the initial one time installation cost of HEIS technology while not catering to any subsequent operational requirements. (Chaudhry 2017).

The HI-AWARE pilot has been able to influence many government institutes, international and private organizations, and individuals through consistent engagements. Inputs have been sought by the Punjab province for schemes on high-value agriculture through climate-smart technologies including sprinkler irrigation systems. In fact, based on PARC's extensive work in solar water pumping, the federal government launched the "Prime Minister's support programme for farmers for solar tube wells", where two experienced members of the HI-AWARE team were invited to lead the formulation of the policy. In addition, the International Fund for Agricultural Development (IFAD) has sought technical support from the HI-AWARE PARC team for a forthcoming project in Gilgit–Baltistan worth PKR 12 billion, under which 50,000 acres of barren land will be converted to agriculture land.

Furthermore, the On-Farm Water Management (OFWM) programme in Punjab has shown a great interest in adopting portable solar pumping system in their ongoing project "Promotion of Gram Cultivation through Life Saving Irrigation with Sprinkler System under Changing Climate".

The experience and success of the pilot will be used to reinforce climate-smart agriculture in the national climate change policy.

4.2. Climate- and flood-resilient housing

4.2.1. Context

Each year, floods affect 250 million people all over the world and cause some of the largest economic, social, and humanitarian losses; more than any other natural hazards (UNISDR 2013). Climate scientists have projected that flood frequency and severity (depth and duration of flood water) will increase in the near future due to climate change and its variability (IPCC 2013). People in the Indus, Ganges, and Brahmaputra (IGB) have been experiencing frequent floods in recent years. These affect their lives, livelihoods, assets, and infrastructure, including houses.

i. **Challenged geographic location:** Bangladesh lies downstream of three major rivers in South Asia – the Ganges, Brahmaputra, and Meghna. The country is one of the most risk-prone to climate-induced disasters in Asia due to its complex geographic location and topography and versatile climate phenomenon (Brammer

2016, Siddiqui et al. 2015, Mechler and Bouwer 2015, Alamgir et al. 2015). It has a complex relief pattern comprising broad and narrow floodplain ridges and linear depressions. Deep rapidly permeable sandy loams and sandy clay loams are predominant in the region. Heavy rains in the main river basins and upstream catchments of India, along with continuous rainfall, trigger flooding in low-lying, vulnerable and densely populated areas. Floods, both flash floods and seasonal long-stay floods are common annual phenomena that inundate an average of 26,000 km2 or 18 percent of the total area of Bangladesh annually (FFWC–GOB, 2015). The northwest part of Bangladesh in fact has been identified as the most vulnerable to extreme climate events of drought (Rahman and Kamal 2016) and floods (Baldocchi 2016).

ii. **Poorest most vulnerable due to sharecropping and habitation:** The poorest and landless share-cropper communities suffer the most. They typically grow only one crop during the dry season. Paddy occasionally sown in early monsoon is quite vulnerable to flash floods and can get entirely wiped out, along with all the investment.

   The poor often live in chars, which are small river islands or sand bars in the middle of rivers and their banks, and hence are more severely affected by seasonal floods, riverbank erosion, thunderstorms, droughts, and heat and cold waves. One such area is Kaunia Upazila (sub-district), located in the northwest district of Rangpur, which is located on a floodplain downstream of the Teesta River[2]. Due to the impermanent nature of these chars, communities build houses which are less resilient to hazards. During floods, these houses get inundated and communities lose their livelihoods and assets, such as food, poultry, livestock, fodder, agricultural produce, and homestead vegetable gardens.

There is thus an urgent need to address the loss of habitation, assets, and livelihoods. Under HI-AWARE, the Bangladesh Centre for Advanced Studies (BCAS) with its partner, C4RE Services Ltd., has piloted and tested CFR housing in two villages, namely Char Dhushmara and Char Haibat Kha in Kaunia Upazila of Rangpur district, which are victims of seasonal floods each year. Char Dhushmara village is situated on the left bank of Teesta River while Char Haibat Kha is on the right bank; both a few kilometers downstream of Teesta bridge at Kaunia.

4.2.2. Pilot solution

Based on extensive literature review and stakeholder consultations at the community, sub-national, and national levels, CFR housing emerged as a potentially effective and applicable adaptation intervention. Participatory piloting and monitoring of CFR houses has revealed that it is finding acceptance as a technology and is socio-culturally appropriate.

The objective behind implementing this pilot has been to create evidence that improved low-cost CFR houses can build community resilience against climate extremes and climate-induced changes such as floods, soil erosion, and heat and cold waves through household-managed disaster risk mitigation and adaptation approaches, in addition to secure and dignified living conditions for the poor.

For the selection of beneficiaries, first, a baseline survey was conducted where socio-economic data of the 10 poorest households from each village was collected; and second, community consultations were conducted where the participants were asked to select the beneficiaries of the CFR houses from among themselves.

The pilot was implemented in two ways:

- Retrofitting existing houses on raised earthen foundations
- Building new, low-cost, portable wooden houses

Both types of interventions have entailed raising the earthen foundations; the use of flood-resilient building material for housing; provisions for homestead gardening, and poultry and livestock rearing; hedge row plantation; and the installation of solar panels for lighting, improved cooking stoves, and sanitary toilets and tube-wells. These provisions have enabled the CFR houses to sustain themselves as safe havens for occupants during floods.

[2]A tributary of the Brahmaputra river

As the houses are built on stilts, the space available below the ground floor can be used for rearing poultry or used as storage. This open space under the house allows floodwaters to flow freely if they reach levels above the elevated plinth of the houses. Four such houses have been constructed in a cluster in Char Haibat Kha village. These houses can also be dismantled within minutes in the event of a flood and carried to another destination if need be. The design of such portable houses has been influenced by the housing models used in the Ganges floodplains of Bangladesh and customized using locally available wood such as eucalyptus and other low-cost woods which are treated to withstand humid weather and floodwaters.

In a bid to build local capacity and encourage the scaling up and sustainability of the tested CFR houses, the intervention also included:

1. Skill-development training provided to women and men on slope protection, homestead gardening, poultry rearing, and handicrafts as small livelihoods options
2. Training provided to local masons and carpenters on building CFR housing structures by carpenters from Munshiganj District in the Ganges floodplains.
3. Hands-on training provided by scientists and technologists from the Bangladesh Forest Research Institute, Chittagong to local carpenters and masons on wood and bamboo preservation techniques to season the building materials
4. Training provided to saw mill operators to saw wood in locally determined dimensions suited to the CFR houses
5. Continuous engagement of BCAS with the Directorate of the Housing and Local Government Department of the Government of Bangladesh to push for the consideration of the CFR house model in their national housing for the poor programmes – *Asrayan* (shelter) and *Ekti Bari-Ekti Khamar* (one home-one farm) projects.

4.2.3. Experiences and lessons learnt

It was crucial to include local knowledge about the highest historical flood levels, summer and winter climate, and other socio-cultural issues so that they could be integrated during the design phase of the pilot intervention. Options to make the housing technology locally feasible were explored and implemented. For example, the portable wooden house model has long been used by communities in the Ganges floodplains of Bangladesh, especially in Shariatpur, Munshiganj, and Faridpur central flood plain districts. The houses normally use *lohakath* (ironwood) *(Xylia dolabriformis)* as pillars, plain iron sheets painted white as walls, and corrugated iron sheets for the roof. As ironwood is quite expensive, locally-available eucalyptus (*Eucalyptus regnans*) or other low-cost woods have been used to make the houses more economical and also able to better withstand humid conditions.

The current cost of building a conventional two-story 3x6 m^2 house made of locally-available woods varies between USD 800 and USD 1,200 if local low-cost, seasoned wood is used. For the CRF houses to be successfully scaled up, their building costs cannot be higher than the costs associated with building conventional houses. Therefore, subsidies are crucial for maintaining further interest from community members in CFR housing. Without subsidies, local people will not be able to afford such housing.

The CFR model piloted by HI-AWARE was brought in from Munshiganj Disctrict in the Ganges floodplains. Carpenters from Munshiganj were brought in to train local carpenters and scientists and technologists from the Bangladesh Forest Research Institute, Chittagong gave groups of local carpenters and masons hands-on trainings on the processes involved in the preservation and seasoning of wood.

It was encouraging to learn that the HI-AWARE CFR house gave shelter to people during emergencies. During the July and August floods of 2017, more than 530,000 traditional houses and other infrastructure (Reliefweb 2017) were damaged but the CFR houses built were not inundated. Minor damages occurred to one cluster of houses; the hedgerow plantation at Char Dhusmara was partially damaged due to erosion by floodwaters and because members of neighboring inundated households took shelter there with their livestock and poultry. Homestead gardens

Features of climate- and flood-resilient housing

- The plinth of each CFR homestead constructed was raised above the highest historical flood level that community members could remember. Raised tube-wells and sanitary toilets ensured supply of safe drinking water, and health and hygiene even during floods.

- Two clusters were made: One retrofitted with existing houses and the other with prefabricated houses. Both retrofitted and prefabricated houses were built with:
  - Improved facilities chosen by the household members
  - Kitchen re-built with an Improved Cooking Stove (ICS) to minimize health hazards, air pollution, and smoke, and ensure effective use of fuel-wood
  - Solar panels set to power lights and fans
  - Bermuda/Vetiver/Napier grass, hedgerows, and some fruit trees planted at the slope and in the homesteads to protect the plinths from wave erosion

- The prefabricated houses include:
  - Treated/seasoned locally available timber and steel sheet panels
  - 2 trenches – of 20x10 sq. ft. – (like a pond) excavated for soaking/drenching wood for preservation if treated/seasoned timber is not available
  - As the house is built on stilts, the space below it can be used to rear poultry or as storage while this virtually open space on all four sides allows floodwaters to flow freely if levels reach above the elevated plinth of the house
  - The space available upstairs in the two-storied houses may be used during flood events when the water levels are very high

Figure 3: Md. Alam Mia and his family in front of their newly constructed CFR house

are showing good yield with different types of vegetables – okra, eggplant, red amaranth, Indian spinach, water spinach, among others –for regular family consumption.

The system is highly adaptable since locally available low-cost materials can be and have been used. Slope protection from wave erosion using plants can supplement household income. However, successfully scaling up this intervention will depend on the inclination of communities and markets, and support from the government and non-governmental organizations in the form of subsidies or donations. Brainstorming on potential geographical areas for scaling out the pilot in the HKH were identified at a Lima Adaptation Knowledge Initiative (LAKI) satellite event[3] held in December 2017 at ICIMOD's headquarters in Kathmandu, Nepal.

Geography: The most challenging aspect of implementation in this area is its sandy soil, which is washed away each flood season. Sustaining the elevated land is, therefore, still a major challenge if the Bermuda/Vetiver/Napier grass, hedgerows, and fruit trees planted as natural protection are not maintained properly. Additionally, a layer of top soil composed mainly of silty clay is also applied for strengthening the elevated land. However, if silty clay is not available nearby, ferrying them in from great distances can be expensive.

Impermanence of habitation: It has been a daunting challenge for communities to shift frequently – 12–20 times over a lifetime, sometimes every 1–2 years. This is a great challenge and presents high risks that are beyond the scope of small interventions. Large interventions like embankment-cum-spurs can only be constructed by the government.

Wood preservation: Locals are not fully aware of the newly introduced preservation system. Currently, the chemicals used in wood preservation are not available in the local market. Wood preservation requires an extra month and additional money, which may deter people from investing in it. However, if demand increases and local entrepreneurs come forward, the preserved or treated wood may be available in the local market. Reinforced concrete columns (RCCs) which are available in local markets, may present an alternative to wood pillars but more research is needed before this can be recommended.

Inaccessibility: Sandy chars are hard to reach. Access to infrastructure such as roads, power, water, and sanitation is limited and sometimes unavailable. During floods, boats are the primary means of transport available. Infrastructure such as roads, culverts, and school buildings are damaged each monsoon so students cannot go to school for a long time afterwards.

Sandcasting: Due to erosion and sedimentation, farmlands undergo sandcasting[4], which bars farmers from cropping during rabi (winter) season. This may cause people to become disinterested in continuing to reside in chars. This may reduce the autonomous scaling up of the CFR houses.

Inundation of surrounding areas: Areas near the current demonstration site of CFR houses are inundated each year during floods. People whose own homes are unsafe seek shelter with their valuable goods in these structures. This practice may degrade the CFR houses and surroundings, and people may be affected by water-borne diseases due to a crisis of safe drinking water and sanitation.

Basin-level river management is needed: CFR houses are a good solution for inhabitants of 'stable' chars. However, they are not a solution for erosion-prone areas where an integrated basin-level river management would be a better and sustainable solution. Only capital dredging, river training, and embankment and bank protection structures can enhance the water carrying capacity and navigability of the rivers.

Recurring sedimentation and braiding of the river is a huge basin-level problem and mostly driven by dynamic delta processes and human activities in the catchment area. There has to be enough water flow to cater to the increased demand in the upstream and environmental flow of the river. If basin-level river management issues are not addressed holistically with regional programmes covering basin-sharing countries, isolated attempts at river management or CFR housing in Bangladesh will not provide sustainable solutions.

4.2.4. Policy context and recommendations

The concept of 'settlement' for communities on the chars of Bangladesh is not one without complications. It lends itself to the coordination of many different ministries, departments, organizations, etc.

Under the constitutional provision for safe shelter for all citizens, the Government of Bangladesh (GoB) implements housing for the poor in both urban and rural areas. The BCAS–HI-AWARE team continues to work with the GoB so that the CFR housing design parameters are considered in their housing programmes. A Member of Parliament of the constituency visited a CFR house at Char Haibat Kha when he came to know the success of the houses during the

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[3]The theme of the event was 'Repackaging Research for Use in the Hindu Kush Himalaya'.

[4]Sandcasting is when a layer of sand is naturally deposited on the river bank during each large flood in the lower Teesta basin in Bangladesh. Such layers sometimes reach above one meter, and are near impossible to remove to make land cultivable again.

floods. He said that these types of houses need to be built more in the chars of the Brahmaputra basin.

Engagements with the Department of Local Government (DLG); the Directorate of Housing and Local Government Department; the Rural Development Academy, Bogura; and the House Building Research Institute (HBRI) of the GoB are ongoing to get CFR house model parameters considered in their various housing schemes for the poor such as the Asrayan Project and the Ekti Bari-Ekti Khamar Project.

One of the many different climate change adaptation projects that the Bangladesh Forest Department has taken up, for example, is the Char Development and Settlement Project, which completed its fourth and last phase in 2016. The benefit of these projects is their focus on the challenges that make resettlement/rehabilitation of flood-affected and poverty-stricken people difficult. Challenges include unclear land rights, lack of institutions to address issues relating to the development of chars, and lack of appropriate infrastructure to help ease into the motions of life post flood damage, etc.

The Ministry of Land also plays an important role, especially when it comes to the identification and distribution of khas (government owned) land, as does the Ministry of Finance, which has funded the Climate Change Trust Fund and Resilience Fund, the Guchogram and Asrayan Projects in the past.

Thus, the groundwork for an enabling environment exists. This enabling environment is important for solutions and technologies to sustain themselves as beneficial interventions. Therefore, liaising with relevant departments under these ministries can benefit the scaling up of the technological innovations that have been made in the CFR houses in the chars of the Teesta basin.

4.3. Flood-resilient habitat

4.3.1. Context

Bihar is frequently ravaged by floods and is in fact the most flood-affected state in India. North Bihar in particular is home to eight major tributaries of the Ganges that make 77 percent of the region vulnerable to floods. If building climate resilience among communities vulnerable to floods has to be meaningful, then the concept of flood-resilient habitat is inevitable. The following issues can be clearly identified:

i. **Annual financial burden of repair and maintenance:** Similar to the situation in Bangladesh, expenses on annual repairs that need to be undertaken due to the damage caused to houses by recurring floods keep poor and flood-affected communities in a vicious cycle of poverty. A habitat framework has to incorporate safe drinking water and appropriate sanitation as its components apart from taking into account the existing local coping mechanisms of floods.

ii. **Groundwater contamination due to specific hydrogeology:** The shallow water tables in north Bihar do not provide the necessary thickness of the vadose zone[5] required for mitigating contaminants. The rudimentary hand pumps (*chapakals*) installed by a majority of the rural population in north Bihar allow the direct movement of water from the surface to the aquifers through poorly constructed heads. Thus, impure water bypasses the vadose zone without any kind of reduction in pollutants and contaminates groundwater. During floods, hand pumps, which are the primary source of water for drinking and domestic use, get submerged in water, silted up, or damaged by the gushing waters. There is also a perceptible fall in the quality of water from these sources during floods. People's access to safe drinking water during floods gets severely compromised especially under marooned conditions as they have to depend on unclean flood and river water, which otherwise is used for multiple purposes – defecation, immersing dead persons and animals, etc.

iii. **Inappropriate sanitation technology:** The most commonly used toilets in north Bihar are 'soak pit toilets' and septic tanks that collect human faeces and urine over a long duration allowing the concentration of contaminants, especially nitrates and bacteria, in the pits and tanks. The soak pits are designed to contain the solids while allowing the leaching out of liquids while the septic tanks collect everything till they are cleaned regularly. The shallow water tables lead to the permanent presence of moisture in the subsurface above the water table, which prevents complete leaching out of liquids from the soak pits. The contaminants that do leach out from the pits reach the water table rather quickly and spread to other regions of the aquifer. Such models, with their tank structures underground, also prove futile in flood-prone regions since they are rendered unusable during floods, which present the most challenging times. It is also of concern that under India's flagship scheme on sanitation – the Swachh Bharat Abhiyan (Clean India Campaign) – its Bihar counterpart, the Lohiya Swachh Bihar Abhiyan (LSBA) is promoting the twin leach-pit model at a massive scale throughout the state regardless of suitability to terrain and ecological peculiarities.

iv. **Access to secure sanitation is aggravated during floods:** In marooned conditions, lack of access to space and privacy – especially for women and adolescent girls – becomes a major contributor to the physical and psychological stress faced by them. These issues are aggravated in challenged terrains such as those within embankments and regions in flash flood zones.

Evidently, sanitation is not just about the construction of toilets. An incompatible design of a sanitation scheme that does not consider hydrogeology may lead to the deterioration of groundwater quality. It is in this context that the 'Phaydemand Shauchalay' (beneficial toilet) or Ecological Sanitation (EcoSan) toilets is an alternative sanitation technology that has the potential to be adapted to the alluvial flood plains of Bihar with different groundwater regimes.

ICIMOD and MPA, under HI-AWARE, have piloted flood-resilient sanitation and drinking water systems in Naya Tola Bishambharpur under the larger framework of flood-resilient habitat to alleviate the effects of lack of information on water quality and contamination in drinking water, and poor sanitation in general, especially during floods.

4.3.2. Pilot solution

Naya Tola Bishambharpur in the district of Pashchim (West) Champaran, north Bihar, is a village located inside the Gandak River's embankment. Such areas inside the embankment are generally referred to as the 'riverside' and communities located in these regions are not only vulnerable to regular flooding but also – as in the particular case of Naya Tola Bishambharpur – face problems such as a lack of access to sanitation facilities and safe drinking water, coupled with the lack of information on water quality and contamination within the village. It is a hamlet of 103 households that comprises multiple caste groups[6] and families that have been displaced from their original lands by the Gandak River's siltation and erosion. They are currently situated within the embankment along the Gandak and are still highly vulnerable to annual riverine floods. According to its residents, August 2017 witnessed the worst flood seen in the past 25 years in Naya Tola.

A flood-resilient habitat in these vulnerable areas comprises four components – ensuring safe drinking water, secure and appropriate sanitation, resilient housing, and learning patterns of co-existence with floods. Therefore, piloting is as much about being a process-driven approach as it is just a "technological intervention". The technical – in this case, technologies for safe drinking water and sanitation like Phaydemand Shauchalay – is only one part of the whole. It is important to recognize the significance of informed interactions that seek to demystify technologies and challenges that are at play in the process of eliciting collective action and the steps taken to meet them.

4.3.3. Experiences and lessons learnt

Most toilets that are being built in north Bihar under the national government's flagship Swachh Bharat Abhiyan are twin leach-pit latrines. Given the region's flood-prone alluvial plains and high water-table levels, widespread and conventional technologies such as pit latrines are not likely to work in the long-run. For one, they are likely to go

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[5]While transferring water from the surface to the aquifer, the vadose zone performs the vital function of purifying water by processes such as filtration and the adsorption of biological contaminants among other pollutants.

[6]Musahar, Harijan, Been, Mallah, Yadav, and Rajput

underwater during floods, the season when, above all, access to secure sanitation becomes the primary concern for flood-affected communities. Secondly, there is a very grave threat of faecal contamination of groundwater aquifers, which tend to be both the source of drinking water and also sinks for any leachate including contaminants and pollutants. Various statistics from the state and central governments show that rural north Bihar's drinking water needs are almost entirely met through groundwater accessed individually via hand pumps. Bacteriological contamination is omnipresent in these sources and sanitation schemes are therefore being promoted at a very large scale.

Given the above-mentioned factors, contextually appropriate sanitation technology such as the Phaydemand Shauchalay are more suited to the landscape when compared to other technologies. They are urine diverting dry toilets designed not only to withstand floods and ensure secure access to sanitation during floods, but also to provide additional benefits such as conservation of water, protection of groundwater and surface water from faecal contamination, and provision of fertilizers substitutes in the form of 'humanure'. Waste management is possible within the sanitation unit itself, eliminating the need for other structures for sewage treatment. Furthermore, Dasgupta

Features of the EcoSan unit – Phaydemand Shauchalay

One of the salient features of the Phaydemand Shauchalay is that the entire structure is above ground. It comprises three structural parts:

a. Foundation and raised plinth (or column, if structure raised on columns): Along the required dimensions, a foundation is dug to a depth of 1 to 1.5 feet and compacted with brick bats, after which the plinth is raised. In flood-prone areas, the plinth level is raised to 1 to 1.5 feet above the highest flood level recorded in the past 20 years. After the construction of the foundation and plinth, it is filled with soil and compacted. An RCC band is laid over the plinth to strengthen it. The substructure is built over this.

b. Sub-structure: This includes the two faecal chambers, and the squatting pan which is 1.5 feet wide and stretches the length of the toilet. The pan has one opening that connects to the urine chamber outside the toilet, and two more for the back wash, each of which drains the wash water through pipes to plantations adjacent to the toilets. This pan is constructed on-site by masons using locally available materials such as bricks, sand, cement, iron rods, and stone chips. The walls of the sub-structure are raised 2.5 feet above the plinth and a wall splits the sub-structure into two faecal chambers. The base of the chambers is compacted using bricks bats and the walls of the chambers and the base are plastered with sand and cement so there are no cracks. The faecal chambers have openings for the removal of 'humanure' after it decomposes. Ash or rice husk/hull is put into the excreta chamber after each use. Adding dried neem leaves helps kill pathogens, if any. The gases formed in the faecal chambers during decomposition find an outlet via gas pipes fitted into the back wall of the structure. After 6–8 months (depending upon the season), the faeces decomposes completely and can be used in agricultural fields as 'humanure'.

c. Super structure: The physical structure built on top of the chambers, complete with small openings for ventilation.

Figure 4: Gita Devi in front of her Phaydemand Shauchalay

Therefore, this facility ensures above-ground excreta management and sustained use before, during, and after floods as well as in waterlogged areas. It is precisely these kinds of knowledge and process inputs that play a role in bringing out informed understanding and clarity among stakeholders, and enable choice and decision making in an informed and efficient manner.

(2016) concludes in a study on sanitation as adaptation options that "the cumulative averted costs over the life span of the toilet, both in terms of health benefits and convenience are higher for EcoSan toilets" (in comparison to the double pit latrines). Rural flood-affected communities can therefore also view it as an asset.

Customization and process orientation: A key component of this intervention is the customization of processes of generating data, information sharing, and alternative technologies suited to the landscape. For example, flood-resilient sanitation was developed as a pilot that would be adaptable to the agro-climatic zone, its communities, and households. Chiefly, the methodology of engaging with the community at different levels – households, tola-wise (hamlet specific), and larger inter-group interactions wherever possible through exposure visits, etc – has served to encourage as much participation as possible from the community such that they remain the decision-makers. The focus has been on developing women-sensitive and centric processes, arguments, and technologies for the long-term sustainability of the interventions.

Different EcoSan design models are available. These are decided on the basis of location, land availability, and financial resources. Typically, the location should be close to the house/kitchen garden, and receive direct sunlight. In flood-prone regions, the toilets should be elevated, keeping in mind the highest flood levels recorded in the past 20 years. The dimensions of the toilets too are determined by the space available for construction, the size of the family, and the financial capacity of the household. For a family of eight or less members, the dimensions can be 8 feet by 5 feet, and for more than 8 members, the preferred size is 9 feet by 6 feet. The removal of compost or 'humanure' formed in these toilets does not require specially skilled labourers or machines and can be done by family members themselves for direct use in agricultural fields and kitchen gardens. This prevents any additional financial burden on the households.

Locating, evolving, and establishing social-technical solutions in a sound framework to be used in similar ecologically challenged locations in alluvial flood plains can be beneficial in the long-run.

Knowledge sharing, participation, and peer interaction spur change: Sharing of knowledge and information on the lateral separation between drinking water source and sanitation utility helped in readying the community. The exposure visits organized for women and training of local masons in building the EcoSan toilets have encouraged the community to demand construction of toilets, while providing their inputs to the design. At the same time, knowledge and information was also sought from the community, especially women, on drinking water quality and sanitation issues in the community to encourage greater participation. Therefore, the implementation of a technology became the implementation of a process of change.

Peer interaction: The interest that is being generated with respect to the Phaydemand Shauchalay is, in part, a result of peer interactions within and outside the village. Enquiries are coming in not just from other households within Naya Tola but also from neighbouring villages like Mangalpur Kala. The ripple effect led to design innovations as well. One household tried to incorporate the raised plinth aspect of the Phaydemand Shauchalay design in a twin leach-pit toilet model. However, the crucial aspect of the tank being above ground was not imitated.

Establishing trust: Continuous and consistent engagement with the community even during the most difficult time – that of the August 2017 floods – helped in establishing trust among the community members.

Engaging relevant stakeholders: Constant communication with the Bihar Rural Livelihood Mission – JEEViKA has paid back in terms of access for women beneficiaries to low-interest credit from the Sanitation, Health, and Nutrition (SHAN) fund. This positive recognition of efforts has also encouraged women to construct toilets for their households. JEEViKA has provided low-interest credit to women from the SHAN fund for construction of the EcoSan toilets.

Enabling environment: The sustainability of an intervention is largely dependent on an enabling environment consisting of, among other things, the availability of resources locally (skilled human resource, access to financial and administrative institutions, etc), and ownership of the intervention by the community. For example, interactions with JEEViKA have shown they have been open to alternative sanitation designs. There was a lack of availability of skilled masons, however, since most masons migrate for work.

Local-level partnership and collaborations must be formed for the institutionalization and advocacy of the intervention so as to enable it to be scaled up and scaled out and hence sustain itself in the long run.

This process of the conceptualization and implementation of the pilot has also seen some challenges. The institutional arrangements under JEEViKA were such that not all households, especially ones that were not part of any self help groups, were eligible to access the SHAN fund to construct toilets. The stress on sanitation from the government is ensuring fast spread of technologies that are cheaper, but not necessarily suited to the hydrogeological setup of North Bihar. The Phaydemand Shauchalay is hence competing with toilets under government schemes, and its high capital cost[7] could further slowdown the process of adoption and implementation. It is therefore important to have sufficient funds allocated for pilot implementation in a research project. For instance, the revolving fund[8] set up did not sufficiently meet everyone's demands. This was partially met by the SHAN fund allocation by JEEViKA.

The floods in August 2017 seriously hindered the implementation process. Even though the foundation of some structures under construction were able to withstand the floods (which are said to be the highest floods ever seen by the community), future uncertainty with regards to flood levels remains.

If this exercise could be repeated again, the pilot would further engage in awareness raising through more cultural programmes in addition to door-to-door contact and group discussions (which have been the primary modus operandi).

4.3.4. Policy context and recommendations

The EcoSan toilet is a good example of addressing the issue of sanitation and water quality in flood conditions in its totality. With the possibility of customizing the design to suit local settings and the resources available, it offers a valuable technology for scaling up and scaling out. The concept of the EcoSan toilet ties in well with the intent of the Swachh Bharat Mission Gramin – SBM(G) – a government programme which focuses not just on achieving Open Defecation Free (ODF) status for India by 2019, but also on building a culture of sanitation through behavioural changes, communication, and facilities that cater to solid and liquid waste management.

The SBM (G) falls under the purview of the Ministry of Drinking Water and Sanitation (MDWS). Since sanitation is a state subject, states can differ in the way they approach implementation of the programme while following the overarching national-level principles and objectives. This enables acknowledging and providing for the socio-cultural diversity that varies across states. The Government of Bihar, through its Lohia Swachh Bihar Abhiyan (LSBA), has helped to promote ecological sanitation in flood-prone areas by ensuring loans to the beneficiaries from JEEViKA through the SHAN fund.

The recognition of EcoSan toilets as an alternative technology in flood prone areas of Bihar by the LSBA has led to a statewide study on disaster-resilient sanitation and ecologically sustainable technologies, to be undertaken by MPA and supported by United Nations Children's Fund (UNICEF), Bihar. The construction and continuous use of EcoSan can potentially facilitate a transformation in the predominant popular mindset from open defecation to open defecation free.

It is imperative to develop a narrative around disaster resilience and ecologically sustainable sanitation systems within Bihar given its close linkages with drinking water security, especially in high water table conditions. The District Collector's Office is as an important entity to engage with when pitching the Phaydemand Shauchaly as the most suitable sanitation technology, especially for flood–prone areas[9] of Bihar, Assam, and Uttar Pradesh.

By preventing contamination of groundwater sources, the EcoSan toilet aids the purpose of the National Rural Drinking Water Programme as well, another initiative of the MDWS and one that focuses on source sustainability,

[7]Despite the relatively higher cost of construction of EcoSan toilets, beneficiaries of Phaydemand Shauchalay have been willing to invest and have not faltered once begun.

[8]The amount from the revolving fund given out to each beneficiary meets roughly around 1/6th or 1/7th of the total cost of structure.

among other objectives. Since sanitation is a national priority, convergence is sought between SBA (G) and other development programmes and initiatives such as ones on prioritizing piped water supply for villages that have attained ODF status.

Therefore, focusing on sanitation right now has benefits not just for adapting to impacts of a changing climate or health and hygiene but also affiliated benefits in relation to other development programmes, particularly ones that pertain to drinking water, (such as the Saat Nischay (seven points) Scheme of the state government, one of which pertains to installing taps in every house for water provisioning). The HI-AWARE pilot, through focused work on sanitation and prevention of groundwater contamination, provides a model that has the potential for extrapolation to areas with similar hydrogeological and agro-climatic setting. The current policy environment provides an opportune time for the same.

4.4. Heat stress management in resettlement areas in the Savda Ghevra area – on the periphery of Delhi

4.4.1. Context

Cities the world over are growing at rapid rates. Urban expanses are currently accommodating more than half of the world's population. Urban populations area expected to grow further, with the rate of urbanization increasing to 67 percent in 2050 as opposed to 52 percent in 2011. A majority of this growth is to be witnessed in the less developed regions (United Nations 2012). Here, unplanned and rapid growth of cities is raising serious questions about the vulnerabilities it might create and its overall sustainability. Extreme events, attributed to climate change or otherwise, will lead to exacerbated impact in these urbanized zones, considering the exposure levels.

Urban heat islands coupled with extreme heat events pose a grave risk to human health in these growing cities. The vulnerability of communities to such extreme heat events has been highlighted during many instances – in New York and St Louis (Schuman 1972), Europe (Beniston 2003) and (Dong et al. 2016), and Russia (Dole et al. 2011). A more recent example is the extended 2015 heat wave event in India which resulted in massive casualties and was attributed as being exacerbated by anthropogenic climate change (Wehner et al. 2016).

Pre-existing drivers of vulnerabilities, especially in the less developed regions, like skewed demographic trends and "urbanization of the poor" (Ravallion, Chen, and Sangraula 2007), will aggravate current exposure levels, resulting in a multiplier effect. Considering these forms of vulnerabilities, it becomes imperative for policies to address the immediate and underlying vulnerabilities effectively and in a targeted manner to alleviate threats. In the past, local institutions have incorporated proactive measures through Heat Action Plans (Martinez, Imai, and Masumo 2011, Knowlton et al. 2014) to prevent and tackle heat stress related health concerns, while Murari et al. (2015) have noted the need for deliberate action on mitigating heat stress impacts.

Techniques such as improved building design, making better use of reflective materials, ventilation and isolation – applying both traditional knowledge and new innovations – and taking into account people's behaviour as well, can be amongst the many effective ways to reduce the impact of heat stress. Other strategies are based on improving environmental conditions: street corridors can be designed as ventilation paths; vegetation cools through shade and evapotranspiration; open water brings relief, if refreshed; and water bodies may be used as heat/cold storage facilities. Many of these actions require fundamental changes in the way cities are planned and continue to grow in the Global South, which would involve transitioning away from malignant growth in the urbanscapes: characterized by rapid, uncontrolled, and unplanned growth. However, to reduce the immediate vulnerabilities of people in the growing cities of the Global South, especially South Asia, there is a need for soft and hard measures targeted at the least fortunate and most vulnerable – the urban poor.

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[9]Moreover, it can also be adapted to water-scarce regions where the lack of availability of water may serve as a disincentive for not constructing/ not using existing water-intensive toilets. In the EcoSan model, the only water required is that for wash post use.

Under HI-AWARE, Wageningen University and Research (WUR) and TERI, in partnership with Mahila Housing Sewa Trust, have piloted and tested the Modified Roofs – a structural modification in the roofing of low-income houses which currently have corrugated cement or metal sheets as roofs. This exercise was carried out in Delhi's Sawda Ghevra, a resettlement colony on the fringes of Delhi. The pilot had targeted the urban poor for the very premise that was already established above.

4.4.2. Pilot solution

This action research aimed at generating evidence on current indoor heat exposure in growing South Asian cities, and subsequently experiment with probable solutions that would aid in tackling indoor heat exposure, leading to safer and healthier livelihoods.

The pilot was implemented in two phases:

- Phase one involved data collection that helped developing an understanding of the current indoor temperature patterns in 135 houses in three cities in South Asia (Dhaka, Faisalabad, and New Delhi) with the help of partners at BCAS, PARC, TERI, and WUR, and assessment of real-life variations in heat exposure and thermal comfort. This was then compared with the outdoor temperatures in different neighbourhoods. It was found that richer neighbourhoods with more green spaces tend to be cooler, though the effect is relatively modest – about 2-3 degrees, mainly during nighttime. Promising options in houses were found to be shading roofs, smart roofs, and wall structures and various ventilation options, for which we found heat reducing effects of up to around 5 degrees.
- Phase two of this research involved assessing the potential to improve thermal comfort of a specific measure, the modified roofs (ModRoofs) system for slum houses under the climatic conditions of Delhi. The pilot took place in an urban, low-income neighbourhood of Delhi, India. This city was chosen because it is located in the Indo-Gangetic plain (the domain of the HI-AWARE project), a highly populated region in an ecological zone with prolonged high and extreme temperatures. Conditions will thus be representative for a large part of the South Asian population. Delhi, being the national capital, also carries high political relevance.

ModRoofs, developed by ReMaterials[9] and promoted by Mahila Housing Sewa Trust (MHT[10]) in Delhi, are especially designed to replace corrugated cement/metal sheet roofs in poor-income neighborhoods and are a way of insulating the roof with co-benefits. A ModRoof is a modular roofing system for slum and village homes in the developing world. The main component of the roofing system is composed of blue panels that are custom manufactured from packaging and agricultural waste. To address the challenges of operating in the developing world, ReMaterials designed the roofing system to be modular, allowing easy shipment, installation, and replacement of individual panels.

ModRoofs are made out of recycled materials and are water resistant. They have been especially developed for the marginalized living in slum houses. The test site where this intervention was carried out was Savda Ghevra, located in the extreme east of Delhi, close to the eastern border between Delhi and Haryana. The locality is home to the largest resettlement zone, consisting of houses with mainly cement/metal sheeted roofs. These roofs were installed in five pilots houses, with ten houses acting as a control for testing the efficacy of the roofs in a real-time setting.

With a thermal conductivity k-value of 0.1 W/mK, the manufacturer ReMaterials, claim that it is 5–6°C cooler below ModRoofs during day time and afternoons than under cement sheets, and 8–9°C cooler than under metal sheets. MHT was interested, however, in a thorough continuous analysis of indoor temperature reduction under real-life conditions. Specific, local circumstances like limited ventilation or low-insulation capacity of walls, in combination with the impact of behaviour (walking in and out, many people in one room, and the use of evaporative coolers) are likely to influence the potential cooling effects.

[10]http://re-materials.com

[11]http://epaperbeta.timesofindia.com/Article.aspx?eid=31808&articlexml=A-cool-idea-on-the-roof-can-bring-09102016010030

Figure 5: Installation of a ModRoof

Heat stress management with modified roofs (ModRoofs)

Certain properties of the ModRoof as provided by the manufacturer, ReMaterials, are given below:

- Strength testing: 50 kg/cm2 cross-breaking strength roof can support multiple people walking on it, doing their daily chores; it can withstand monkey jumps
- Thermal conductivity: K-value of 0.1 W/mK; manufacturers suggest room temperature is 5–6°C cooler in the afternoons than under cement sheets, and 8–9°C cooler than metal sheets
- Determination of thermal stability: 0.92 percent expansion, and contraction due to temperature change is minimal; chances of cracking are reduced
- Test for flammability: Self-extinguishing in case of fire; the roof will not spread fire
- Water absorption test: Full submersion test conducted for 48 hours, no weight gain; roofing panels are fully waterproofed
- Expected life: 15–20 years

4.4.3. Experiences and lessons learnt

Our research highlighted that the urban poor, who are the most vulnerable, lack resources to make structural changes to the houses they reside in, to make it "green" and more hospitable in extreme heat. Moreover, affording active cooling is beyond their means. It was therefore crucial for us to identify strategies that are affordable yet effective (or claimed to be), for us to test their viability further – this is where modified roofs came in.

While new owners of ModRoofs were very positive about the heat reducing capacity of the roof, and with the designers claiming indoor temperatures to be up to 9°C lower than in houses without a ModRoof, our measurements in these 15 houses (5 test and 10 control houses) do not point towards such conclusive results. For the large part, this inconclusiveness is due to difficulties encountered in maintaining a representative dataset; the instruments placed inside the households for constant monitoring were sometimes tampered with, people moved out instantaneously, leaving the house locked permanently, or loggers simply failed. These operational difficulties, much more severe than during Phase 1, resulted in an incomplete dataset, with as little as 6 out of 15 houses monitored during the hottest period. This considerably reduced the ability of the research team to make conclusive comments on the efficacy of modified roofs. With the loggers that did provide consistent data, we did not find significant cooler conditions in ModRoof houses, and certainly not in the order of magnitude of 9°C. In addition, it might be relevant to note that in Phase 1, in which we evaluated the effect of a range of building characteristics on indoor temperatures, none had an effect as large as 9°C, with one of the most effective measures – switching on an evaporative cooler – providing cooling more in the range of 3°C. Further testing, with a larger set of houses would be required to give a robust conclusion.

Another important consideration and learning from the pilot's implementation was the diversity in behaviour that might influence the observations, especially the role of unpredictable door and window opening patterns and the use of evaporative coolers in the houses, which could have skewed the measurements. Window and door opening patterns might considerably influence indoor temperatures and provide for ventilation, which is essential in keeping the indoors cooler, especially during night time. The same accounts for the usage of evaporative coolers, which some households possessed. As stated earlier, they can considerably cool down indoor temperature. However, while we recorded the way they were used in general, we did not know exactly when dwellers switched these devices on or off.

Given these considerations and the discrepancy between the very positive responses of ModRoof owners and the insights from the very limited observations, we suggest that piloting at a much greater level (probably involving tens of houses with such roofing systems), and preferably in combination with one or two other low-costs solutions, like painting roofs white, is needed to provide conclusive results. Anything that could hold huge potential in transforming the living of the urban poor is worth a controlled trial.

4.4.4. Policy context and recommendations

The way we plan cities, needless to say, has to change, and a range of soft and hard measures through definite policy directives have to be undertaken to not just protect cities from heat stress, but various other climatic threats. However, as a first step, the most vulnerable need to be targeted to alleviate the immediate vulnerabilities they are currently facing. The most daunting task in this was to find a viable solution to reduce indoor heat exposure amongst low-income households. A plethora of options at a city-level have already been successfully implemented. These, however, are aligned towards a disaster management perspective, and do not dwell much on preventive measures and the chronic heat exposure this population group experiences year after year.

There is overall very limited research on heat related health implications in South Asia (WHO 2014). There is not only a need to better understand which population groups are vulnerable, and which individual, cultural, and environmental factors contribute to vulnerability (Haines et al. 2013, White-Newsome et al. 2012, Kovats and Hajat 2008), but also explore what adaptation measures could support resilience. Most epidemiological studies which establish a relation between health outcomes and extreme heat rely on meteorological data from standardized weather stations outside of city limits. These are not able to provide good reflection of heat exposure in residential areas such as inner-city slums (Basu 2009). Our research aimed at filling-in this gap by establishing an understanding on the spatio-temporal variations in indoor temperature amongst a typology of houses, dominated by single bedroom houses/one-room houses representative of low-income households.

Furthermore, HI-AWARE research shows there is scope to reduce temperatures indoors and outdoors. Single solutions will not be sufficient, though. Improved house construction, behavioural adjustments, and smart city design need to go hand in hand. Additionally, contrary to initial field measurements, ModRoofs are perceived to be reducing indoor household temperatures strongly, and this is why the monitoring of temperatures in these houses to assess for effectiveness is being continued. Potential linkages with the Delhi Urban Shelter Improvement Board, Ministry of Rural Development, and the Ministry of Housing and Urban Development are being explored. Mahila Housing SEWA Trust, an implementation partner in the pilot, has already piloted micro-finance for greater proliferation of the technology in Ahmedabad, and such schemes could also be scaled out to meet demands in other field sites. Irrespective of this, policies addressing cities need to push for transformational change in the growth of the urban landscape, and policies should explicitly target the low-income and informal settlements/buildings. Such settlements often face greater indoor temperatures, owing to their minimal ventilation/insulation or means to have active cooling, and often face the brunt of severe heat waves with the communities residing in these buildings continuing to be under extreme duress owing to lack of resources to help mitigate the impact of extreme temperatures.

An immediate need, therefore, is to reevaluate urban planning to ensure both inclusivity and sustainability across scales, to manage with a rising influx of people, especially the informal labour population, who have limited access to resources, and are forced to reside in structures that could perpetuate their vulnerabilities. The focus of current heat action plans is predominantly to provide emergency response to and management of short-duration stress-periods, such as alarming heat waves. This ignores the hidden risk and impact of prolonged high temperatures, especially during nighttime. This calls for more radical and fundamental changes, and prioritizing possible innovations to climate proof low-income housing as cities in the Global South continue to grow in both size and inequalities.

5. Key messages and way forward

The lessons learnt from experiences so far are valuable as that can help improve the design and management of pilot implementation exercises further. Many organizations are reaching out to HI-AWARE partners and showing interest in coming onboard to build on technologies and pilot interventions to take them to scale. In summary, we can say the following about adaptation pilot interventions designed as part of research projects:

Adaptation is a multi-sectoral challenge; interventions should be designed accordingly: Typically, development interventions are implemented in their sectoral silos but climate change impacts are experienced across sectors, at the same time. This brings out inter-sectoral linkages and vulnerabilities. Therefore, adaptation interventions require different sectors to speak to each other. For example, water and sanitation, or water, agriculture and climate change, etc.

Understand project capacity: The pilots areas were selected based on the confidence that the research teams and strategic partners had with respect to affecting change.

Acknowledge and address gender dimensions of climate change impacts: Climate change impacts are experienced differently by women and men through varying levels of vulnerability. Where possible, the HI-AWARE pilots have taken the specific requirements of women into account by ensuring that they understand the technological aspects of the intervention as well.

Customization is key: The pilots have taken a flexible approach to implementation. They have gone beyond focusing merely on the technical solution to account for specific socio-economic, cultural, and political cues in particular contexts. Accordingly, the most appropriate strategies to intervene were designed, in terms of awareness raising, engaging with communities, and introducing the pilots and taking their inputs to in turn customize the technology as per their specific needs and the resources available.

Sustainability of adaptation interventions requires community buy-in and government support:

- The co-designing, planning and testing of various technologies with communities and other stakeholders is the most critical factor for successful pilots in the HKH region.
- Engagements with relevant stakeholders took place and are taking place at different levels including government, INGOs, etc. to familiarize them with the work on the pilots and how they are addressing vulnerability stemming from climate change impacts.
- Establishing trust with the community is extremely important as that will determine whether or not they are invested in the narrative around the adaptation intervention brought forth by research projects. In the case of the EcoSan toilet, for example, members of MPA continued to visit Naya Tola Bishambharpur despite it being inundated during the floods of 2017. This helped convey the seriousness of their intent.

Enable both inter- and intra-community learning:

- Farmer-to-farmer or community-to-community transfer of information, opinions, and experiences with interventions are a very effective way of communication since it provides more motivation to adopt and use a particular intervention, as opposed to a top-down approach. Farmers and individuals become carriers of communications and this may aid mobilization, scaling up, and scaling out.
- Making pilot sites training and learning sites, as is the case in Chakri, Pakistan, also makes them an active entity in spreading information and enabling scaling up and scaling out. In Naya Tola, Bihar, India as well, community members were taken on exposure visits to Kairi village where EcoSan toilets were already being used. This aided their decision of constructing such toilets for their families as well.

Ensure that work on adaptation pilots starts along with research:

Work on the pilots began in earnest only in the last two years of HI-AWARE. The following lessons were learnt:

- The inability to allocate enough time and financial resources to the pilot interventions constrained the full implementation of all the processes and steps that were planned in the beginning. This will have consequences for the effectiveness of the pilots if measured within the project period. This has also meant that the unit of piloting has been very small. Therefore, the scaling up of the pilots will rely heavily on government support. This would be extremely helpful in showcasing results.

- Perhaps research projects should aim for demonstrations as opposed to full-fledged large-scale pilots, given the scope of research and as a way to use research for action. This, combined with interaction with different stakeholders, can set the ball rolling for larger-scale adaptation interventions.

- Allocate time to build/engage M&E capacity at the community level. This is needed to get actual situational and ground contextual analysis. However, the time allocated for M&E engagement at the community-level was not sufficient.

References

Alvarez, Sophie, Boru Douthwaite, Graham Thiele, Ronald Mackay, Diana Cordoba, and Katherine Tehelen. 2010. "Participatory Impact Pathways Analysis: A Practical Method for Project Planning and Evaluation." Development in Practice 20 (8). doi:https://doi.org/10.1080/09614524.2010.513723.

Basu, R. 2009. High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. Environmental Health, 8, 40-40.

Beniston, Martin. 2003. "Climatic Change in Mountain Regions: A Review of Possible Impacts." Climatic Change 59: 5–31. doi:10.1023/A:1024458411589.

CDMP-II. (2014). Trend and impact analysis of internal displacement due to the impacts of disaster and climate change. Retrieved January 29, 2018, from Comprehensive Didaster Management Programme, phase II (CDMP-II), Ministry of Disaster Management and Relief, Government of Bangladesh. Retrieved from http://www.bd.undp.org/content/bangladesh/en/home/library/crisis_prevention_and_recovery/trend-and-impact-analysis-of-internal-displacement-due-to-the-im.html

Chambwera, M., Heal, G., Dubeux, C., Hallegatte, S., Leclerc, L., Markandya, A., … Neumann, J. E. (2014). Economics of Adaptation. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 945–977. Retrieved from https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap17_FINAL.pdf

Chaudhry, Q. (2017). Climate Change Profile of Pakistan [Ebook]. Manila: Asian Development Bank. Retrieved from https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf

Coony, J. (2016). Scaling innovation for climate change. Retrieved from http://blogs.worldbank.org/climatechange/scaling-innovation-climate-change

DAC Criteria for Evaluating Development Assistance - OECD. Retrieved from http://www.oecd.org/dac/evaluation/daccriteriaforevaluatingdevelopmentassistance.htm

Dasgupta, P. (2016). Assessing Costs and Benefits of Climate Change Adaptation [Ebook]. Kathmandu: HI-AWARE Working Paper 3. Retrieved from http://lib.icimod.org/record/32321/files/hiawareCCA-WP3-016.pdf

Dole, Randall, Martin Hoerling, Judith Perlwitz, Jon Eischeid, Philip Pegion, Tao Zhang, Xiao Wei Quan, Taiyi Xu, and Donald Murray. 2011. "Was There a Basis for Anticipating the 2010 Russian Heat Wave?" Geophysical Research Letters 38 (6): 1–5. doi:10.1029/2010GL046582.

Dong, Buwen, Rowan Sutton, Len Shaffrey, and Laura Wilcox. 2016. "The 2015 European Heat Wave." In Explaining Extreme Events of 2015 from a Climate Perspective, S57–62. Bulletin of American Meteorological Society. doi:10.1175/BAMS-D-16-0140.1.

FFWC-GOB. (2015). Annual Flood Report 2014. Retrieved June 15, 2017, from Flood Forecasting & Warning Centre, Bangladesh Water Development Board, Ministry of Water Resources, Government of Bangladesh http://www.ffwc.gov.bd/images/annual14.pdf

Haines, A., Bruce, N., Cairncross, S., Davies, M., Greenland, K., Hiscox, A., Lindsay, S., Lindsay, T., Satterthwaite, D. & Wilkinson, P. 2013. Promoting Health and Advancing Development through Improved Housing in Low-Income Settings. Journal of Urban Health, 90, 810-831.

Hartmann, Arntraud, and Johannes F Linn. 2008. "Scaling Up a Framework and Lessons for Development Effectiveness From Literature and Practice," no. October. www.brookings.edu/global.

International Centre for Integrated Mountain Development (ICIMOD) 2009. Local Responses to Too Much and Too Little Water in the Greater Himalayan Region. Kathmandu.

IPCC. (2013). Climate change 2013: The physical science basis: Contribution of working group I. In T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P. M. Midgley (Eds.), Fifth assessment report (pp. 1535). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA: Intergovernmental Panel on Climate Change.

Knowlton, Kim, Suhas Kulkarni, Gulrez Azhar, Dileep Mavalankar, Anjali Jaiswal, Meredith Connolly, Amruta Nori-Sarma, et al. 2014. "Development and Implementation of South Asia's First Heat-Health Action Plan in Ahmedabad (Gujarat, India)." International Journal of Environmental Research and Public Health 11 (4). Multidisciplinary Digital Publishing Institute: 3473–92. doi:10.3390/ijerph110403473.

Kovats, R. S. & Hajat, S. 2008. Heat stress and public health: a critical review. Annu. Rev. Public Health, 29, 41-55.

Kraaijenbrink, P. D.A., M. F.P. Bierkens, A. F. Lutz, and W. W. Immerzeel. 2017. "Impact of a Global Temperature Rise of 1.5 Degrees Celsius on Asia's Glaciers." Nature 549 (7671). Nature Publishing Group: 257–60. doi:10.1038/nature23878.

Martinez, Gerardo Sanchez, Chisato Imai, and Kanako Masumo. 2011. "Local Heat Stroke Prevention Plans in Japan: Characteristics and Elements for Public Health Adaptation to Climate Change." International Journal of Environmental Research and Public Health 8 (12). Molecular Diversity Preservation International: 4563–81. doi:10.3390/ijerph8124563.

McEvoy, D., Fünfgeld, H., & Bosomworth, K. (2013). Resilience and Climate Change Adaptation: The Importance of Framing. Planning Practice & Research, 280-293.

Murari, Kamal Kumar, Subimal Ghosh, Anand Patwardhan, Edoardo Daly, and Kaustubh Salvi. 2015. "Intensification of Future Severe Heat Waves in India and Their Effect on Heat Stress and Mortality." Regional Environmental Change 15 (4): 569–79. doi:10.1007/s10113-014-0660-6.

Nayar, R., Saleh, A., & Minj, A. (2016). Scaling Up Innovations With Government. Scaling Social Innovation in South Asia, pp. 5-6.

Pakistan among most vulnerable countries to climate change: HSBC report. (2018). Retrieved from https://www.pakistantoday.com.pk/2018/03/20/pakistan-among-most-vulnerable-countries-to-climate-change-hsbc-report/

Pelling, Mark. 2011. Adaptation to Climate Change: From Resilience to Transformation. Routledge . http://talos.unicauca.edu.co/gea/sites/default/files/Adaptation to Climate Change From Resilience to Transformation.pdf.

Ravallion, Martin, Shaohua Chen, and Prem Sangraula. 2007. "New Evidence on the Urbanization of Global Poverty." World Bank Policy Research Working Paper. 4199. doi:10.1111/j.1728-4457.2007.00193.x.

Sarker, A., Abed, S., & Seelos, C. (2016). Lessons in Scaling and Failing. Scaling Social Innovation in South Asia, pp. 14-15.

Schuman, Stanley H. 1972. "Patterns of Urban Heat-Wave Deaths and Implications for Prevention: Data from New York and St. Louis during July, 1966." Environmental Research 5 (1): 59–75. doi:10.1016/0013-9351(72)90020-5.

Singh, Surender P, Isabella Bassignana-Khadka, Bhaskar S Karky, and Eklabya Sharma. 2011. "Climate Change in the Hindu Kush-Himalayas: The State of Current Knowledge." Icimod, 88.

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R., … Skinner, M. (2001). Adaptation to Climate Change in the Context of Sustainable Development and Equity. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Working Group II Contribution to the Third Assessment Report of the Intergovernmental Panel on Climate Change, 879–906. Retrieved from https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap17_FINAL.pdf

Smits, S., Moriarty, P., & Sijbesm, C. (2007). Learning Alliances: Scaling up innovations in water, sanitation and hygiene. Delft, the Netherlands: IRC International Water and Sanitation Centre. Retrieved from http://www.bvsde.paho.org/bvsacd/cd67/TP47_LA_07.pdf

Spicer, N., Bhattacharya, D., Dimka, R., Fanta, F., Mangham-Jefferies, L., Schellenberg, J., . . . Wickremasinghe, D. (2014). 'Scaling-up is a craft not a science': Catalysing scale-up of health innovations in Ethiopia, India and Nigeria. Social Science and Medicine, 121, 30-38. doi:https://doi.org/10.1016/j.socscimed.2014.09.046

UNFCCC. (2017). Opportunities and options for integrating Climate Change Adaptation with the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction 2015–2030. UNFCCC/Tp/2017/3, GE.17-1846(October), 1–29. Retrieved from http://unfccc.int/resource/docs/2017/tp/03.pdf

UNISDR. (2013). 2013 floods a "turning point". Retrieved January 29, 2018, from United Nations International Strategy for Disaster Reduction (UNISDR) http://www.unisdr.org/archive/33693

United Nations. 2012. "World Urbanization Prospects: The 2011 Revision." doi:10.2307/2808041.

Wehner, Michael, Daithi Stone, Hari Krishnan, Krishna Achuta Rao, and Federico Castillo. 2016. "The Deadly Combination of Heat and Humidity in India and Pakistan in Summer 2015." In Explaining Extreme Events of 2015 from a Climate Perspective, S81–86. Bulletin of American Meteorological Society. doi:10.1175/BAMS-D-16-0145.1.

White-Newsome, J. L., Sánchez, B. N., Jolliet, O., Zhang, Z., Parker, E. A., Timothy Dvonch, J. & O'neill, M. S. 2012. Climate change and health: Indoor heat exposure in vulnerable populations. Environmental Research, 112, 20-27.

WHO 2014. Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. In: Simon Hales, S. K., Simon Lloyd, Diarmid Campbell-Lendrum (ed.). Switzerland.

Himalayan Adaptation, Water and Resilience (HI-AWARE) Research
c/o ICIMOD
GPO Box 3226, Kathmandu, Nepal
Tel +977 1 5275222
Email: hi-aware@icimod.org
Web: www.hi-aware.org

ISBN 978 92 9115 6887 (electronic)