UNIVERSITÀ DEGLI STUDI DI PADOVA

DEPARTMENT OF POLITICAL SCIENCE, LAW,
AND INTERNATIONAL STUDIES

Master's degree in

Human Rights and Multi-level Governance

MICROFINANCE AND CLIMATE CHANGE ADAPTATION: THE CASE STUDY OF ICE STUPAS IN NEPAL

Supervisor: Prof. Alberto Lanzavecchia

Candidate: ALICE MENEGATTI

Matriculation No. 2014989

A.Y. 2022/2023

“I avoid grandiose plans. I start with a small piece that I can do. I go to the root of the problem and then work around it. It's building brick by brick.”

Muhammad Yunus

Table of Contents

Abstract

This work examinates adaptation solutions as a strategy to address climate change at the local level. Initially, it investigates in depth how climate change-related impacts are affecting global human rights records, hindering the capacity of countries to reach 2030 Sustainable Development Goals. Local adaptation strategies are among the responses that countries have identified to counter the detrimental impacts of climate change. Then, this work will focus on Nepal, analysing its increasing climate change-related challenges and the adaptation solutions that have been identified to counter climate change vulnerability. In fact, climate change is putting at risk the livelihoods of many communities, because of extreme weather events that are occurring in the area. In particular, adaptation measures that foster water management will be examined, as Nepal faces recurring periods of drought and water shortages in the Northern area of the country. The last section of the thesis will focus on the case study of "Ice Stupas", which are a local adaptative solutions that can help communities to store winter water, to then use it during the driest months. Ice Stupas have been firstly implemented in the region of the Ladakh Valley, India, through a crowdfunding campaign; then, an ice stupa has been constructed in the Mustang District of Nepal, thanks to a Charity's donation. This thesis hypothesizes the construction of an Ice Stupa in Nepal in the Mustang District, through the adoption of a microfinance-based solution, to help managing water scarcity provoked by climate change's effects. This case study is particularly relevant to show how adaptation could be linked with microfinance, thus becoming a fundamental tool to tackle the already visible effects of the climate crisis and to deal with a changing climate in the years to come.

Introduction

This work examinates how climate change-related challenges are threatening humanity and how they can be addressed through the implementation of local adaptation strategies.

In fact, climate change is already affecting all countries around the world and their geographical position will determine country specific adaptation strategies; the countries that have more resources to cope with the effects of climate change will react faster than others.

We are already assisting to huge natural disasters, such as sea level rise, extreme precipitation and temperatures, wildfires because of climate change. The actions that people, decision-makers and governments will undertake starting from today will determine the quality of life of the next generations.

Due to climate change, many of the goals of the 2030 Agenda of the Sustainable Development Goals (SDG's) will be unlikely to be achieved, since they are strictly related to the already happening hunger, diseases and migration. The impacts of climate change will affect in particular the most vulnerable and deprived communities, as they do not have the necessary resources or knowledge to adapt to the new climatic challenges. Therefore, it is emerging a global need to find solutions and tools that benefit both the most vulnerable segments of the population and the territory they inhabit. In the very recent years climate professionals started working on the idea of building resilience of countries through adaptation and mitigation as climate change solutions.

This work will explore adaptation solutions as a strategy to address climate change at the local level. A case study based in Nepal will be addressed, representing how microfinance can foster adaptation to tackle climate change challenges. The solution that will be analysed in depth is the "Ice Stupa" - a local adaptative solution that can allow the storage of water during winter, to then use it during dry periods for irrigation in the agricultural sector.

In the first part, the thesis will explore the harmful effects of climate change on the global situation of human rights. Then, the concept of climate change resilience will be introduced, and it will be explained how green microfinance could support it. After an

overview of climate conditions in Nepal and how climate change represents a risk for the local population, the thesis will further examine what are the main climate change issues in the North, which solutions are already in place, including adaptation and Loss and Damages and what could be the contribution of microfinance.

The last chapter is dedicated to the case study of ice stupas: a project that helped communities in the Ladakh valley in India; in fact, a water storing method was created in order to irrigate their land. We will explore how this project was transposed for the first time to Nepal thanks to Videh Foundation, a local association operating in the Chitwan region. Lastly, we will critically analyze the interaction between the ice stupas and microfinance, demonstrating that microfinance institutions could build a stable financial model for ice stupas in Nepal.

The aim of this study is to create further knowledge on microfinance and climate change adaptation strategies and in particular on ice stupas as a potential solution to tackle water scarcity for irrigation purposes. A further intention of this thesis is to provide a preliminary feasibility study that could be used to raise funds for a possible practical implementation of ice stupas (SDG 6.A).

CHAPTER 1: Microfinance and the Interest in Climate Change

Introduction

As microfinance targets people at risk and in a situation of vulnerability, it can be considered as a useful tool to address the rising detrimental effects that climate change is having on many regions of the planet. The climate crisis is in fact a new contemporary challenge that billions of people are facing, and microfinance is emerging as a tool to tackle them. Therefore, millions of people potentially affected or affected by climate change are becoming potential clients of Microfinance Institutions. Water shortages, food scarcity, natural disasters, illnesses and inequalities are expected to rise in the years to come, putting at great risk human rights records globally and creating a setback in the Sustainable Development Goals that the world is supposed to reach by 2030. In addition, climate change is having a disproportionate impact on the most vulnerable categories of people, such as Indigenous Peoples, women, children and vulnerable communities and families. Climate resilience, that is the capacity to cope with climate change-related impacts should increase especially in the regions and countries where the climate crisis is already manifesting its effects. Adaptation practices have the particular objective of increasing the resilience of people affected by the consequences of climate change. Many countries that are already experiencing climate change extreme events have therefore the urgent need to put into place adaptation strategies that can help them facing their new life scenarios. Adaptation practices differ from country to country and from region to region, as they adapt to the local context, finding solutions to local climate change-related issues. As adaptation often requires capital to buy sophisticated equipment and machinery, microfinance can be the tool to fill this mismatch, creating income generating activities, that can both create economic opportunities for vulnerable populations and cope with climate change challenges. In this chapter, we will firstly analyse climate change impacts on human rights and Sustainable Development Goals, then we will focus on climate resilient practices that are useful to tackle climate change, and eventually, we will show how microfinance can be a useful tool to serve the green sector, creating solutions to the rising impacts of the climate emergency.

1.1 Climate Change in a Human Rights Perspective

Climate change is one of the biggest challenges of the current generation and the future ones. Since 1950 the world is experiencing extreme climate-related events; some of these impacts have been related to anthropogenic behaviour, including the increase of temperatures, extreme sea level rising and the increasing number of heavy precipitations (IPCC, 2014). The impact of climate change consists both of sudden catastrophic events as well as incremental degradation of resources, such as access to clean water and disruption in agricultural practices. Droughts, floods, and food shortages are becoming more and more common across the world, with great damages to the livelihoods of populations everywhere. As a consequence of climate-related hazards and the subsequent degradation of resources, climate-exposed sectors, such as agriculture, forestry, fishery, energy and tourism are experiencing huge economic damages (IPCC, 2022).

According to the IPCC's Fifth Assessment Report (2014), both current and predicted effects of climate change will negatively impact millions of people, especially in deprived and developing areas, and on the key resources and ecosystems on which their lives depend on. Due to climate change, existing risks will be increased, and new risks will emerge. As far as communities are concerned, risks will affect disadvantaged people in a disproportionate way, irrespectively of their country of living (IPCC, 2014). Many peoples living in poverty have already been exposed to the effects of climate change, because of their "high dependence on climate-sensitive livelihoods, and limited access to or availability of resources to respond to shocks and stresses" (Hamill, A., Matthew, R., McCarther, E., 2008). The climate crisis will be a multiplicator of risks and threats, causing consequences on human and natural environments *(ibid)*. Rural communities are in fact more at risk for shortage of water, food insecurity and agricultural outcomes.

Furthermore, some of the communities will face displacement and migration, due to the changing environment. Reduced habitability of many areas is provoking a high internal displacement and emigration in other countries (IPCC, 2014). The impacts of climate change will contribute to decrease the safeguard attributed to human rights of displaced persons, that often are inhabitant of countries that are most impacted by climate change (UNHCR, 2022). In addition, the intersection of push factors that encourage migrants to flee from their country of origin and climate change, is putting their lives under precarious conditions. Statistics are estimating that "the number of people in need of humanitarian

assistance due to disasters could increase to 200 million annually by the 2050 – twice the current number" (UNHCR, 2021). As highlighted in this paragraph, climate change affects many of the areas of human systems; human rights are experiencing a setback due to the increasing impacts of climate change.

According to the UN Environmental Program's report on Climate change and human rights (UNEP, 2015), anthropogenic climate change represents the largest threat to both the environment and the enjoyment of human rights. According to the Universal Declaration of Human Rights (1948), all human beings are born free and equal in dignity and rights. This international legal framework is the basis for the subsequent International Covenant on Civil and Political Rights (ICCPR) and the International Covenant on Economic, Social and Cultural Rights (ICESCR). These binding instruments constitute the basis for the promotion and protection of human rights, and they entitle individuals to fundamental freedoms and rights, also in relation to climate change (Mahadew, R., 2021). It has been recognized that a "healthy and functional environment" (*ibid.*) is essential for humans to be able to enjoy many basic rights, such as the right to life, to an adequate standard of living, to health and to food (UNEP, 2015). Climate change impacts the rights to self-determination, development, food, water and sanitation and housing (OHCHR, 2015). Also, it has disproportionate effects on categories of individuals that are entitled to specific rights, including women, children and indigenous people (Mahadew, R., 2021). Climate change has been defined by the Office for the High Commissioner of Human Rights (2015) as a "*human rights problem*". Therefore, it can be argued that climate change is a violation of human rights (Mahadew, R., 2021). In the following paragraph, this topic will be furtherly analysed, to show the impact that climate change is having on human rights records at the global level.

1.1.1 The Impact on Human Rights

The Universal Declaration of Human Rights (1948) states: "Everyone has the right to life, liberty and security of person." This principle has been taken by the major legal instrument for the protection of human rights, that is the International Covenant on Civil and Political Rights. Climate change puts at great risk human life; in fact, extreme climate-related hazards will increase, affecting in this way the protection of the right to life. Also, other phenomena that will increasingly occur due to climate change, such as

drought and extreme heat waves, will prevent people from the enjoyment of this right. (OHCHR, 2015). The Right to self-determination is enshrined in different legal instruments, such as the UN Charter, the ICCPR and the ICECR. Climate change is putting at risk the assets peoples need to survive, and it is affecting their livelihoods and their way of living. To mention some examples, small island and least developed countries are experiencing a further increase in temperature of 1.5° as a "*serious threat to their continued existence*" *(ibid)* Climate change is causing effects also on the recently recognized Right to Development. The Declaration on the Right to Development defines it as "*an inalienable human right by virtue of which every human person and all peoples are entitled to participate in, contribute to, and enjoy economic, social, cultural and political development, in which all human rights and fundamental freedoms can be fully realized.*" (General Assembly, 1986). This right is also guaranteed by the ICESCR and the ICCPR. IPCC reports of previous years claim that sustainable development, including the eradication of poverty, can be reached only mitigating the impacts of climate change (OHCHR, 2015).

Article 11 of the ICESCR guarantees the right to food of every human being stating that countries should "*ensure an equitable distribution of world food supplies in relation to need*". Climate change is increasing food insecurity, threatening the right to food in many regions. The impacts of climate change on agriculture and the production of food will affect the right of individuals to have access to food, increasing food insecurity in the years to come *(ibid)*. Climate change does not only impact access to food, but it also increases water insecurity. The access to water will be difficult during the next years both in urban and rural areas. General Comment No.15 of the ICESCR entitles every individual to "*sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use" (ibid).* Furthermore, the climate crisis will affect the right of every person to *"the enjoyment of the higher attainable standard of physical and mental health"* (General Assembly, 1966). The correlation between climate change and the right to health has been identified by many authoritative experts; the increase in food insecurity and the subsequent malnutrition will put human health at risk in many areas (OHCHR, 2015).

The right to housing is protected by Article 11 of the ICESCR and it is put extremely at risk by extreme climate-related events that will be the responsible of the destruction of places where people are living. Phenomena such as drought, erosion and flooding can threaten the right to housing of individuals, forcing them to migrate to look for a better

place to stay that is less impacted by climate change (*ibid*). Children's rights will also suffer a setback; for example, the right to education will be put greatly at risk because of climate change. States will have less instruments to guarantee free education for every child, because they will spend many resources to combat local damages of climate change; the lack of a primary and secondary education system that could reach every child, could also increase the percentage of children subjected to child labour. Also, parents could be less inclined to enrol their children in schools, because of the economic impacts of extreme climate change-related events (*ibid*).

1.1.2 The Impact on SDGs

As far as the Agenda 2030 is concerned, climate change represents a clear danger that will hinder the achievement of different Sustainable Development Goals (SDGs); in particular, it creates setbacks for ending poverty (Goal 1), food security (Goal 2), good health and well-being (Goal 3), decent work and economic growth (Goal 8), reducing inequalities (Goal 10) and peace (Goal 16) (Lanzavecchia, A. et al., 2021). Also, the fight against climate change has been totally incorporated by the Goal 13 of the Sustainable Development Goals ("combating climate change"). Therefore, adopting solutions to contrast climate change is a tool to ensure a *"secure, sustainable, inclusive development that benefits all persons"* (OHCHR, 2015). According to the Special Rapporteur on extreme poverty and human rights to the Human Rights Council (2019), *"Climate Change will exacerbate existing poverty and inequality. It will have the most severe impact in poor countries and regions, and the places poor people live and work. Developing countries will bear an estimated 75-80 percent of the costs of climate change." (ibid).* People living in poverty usually *"live in areas that are more susceptible to extreme weather events, as they lack the instruments and resources to both prevent and recover from their catastrophic impact."* (Lanzavecchia, A. et al., 2021). People in poverty are less resilient to climate extreme events because they do not always have the adequate resources to intervene to counter the effects of climate change and as they get less aid from their financial and political systems. People that have more resources to adapt will be also the most climate resilient ones. The most deprived communities will instead have reduced capacity to cope with climate change, that is causing detrimental

impacts on their livelihoods (Special Rapporteur on extreme poverty and human rights, 2019).

Goal 2 of the Sustainable Development Goals is likely to see a setback in the years to come. In fact, according to the last IPCC Report (IPCC, 2022), extreme climate related events have the responsibility of an increase in the number of people under food insecurity and water insecurity. Water unavailability and water-related hazards are becoming more frequent; this will create challenges for water management in the near, mid and long term, depending on the regions where people are living. As a consequence, malnutrition is increasing in many communities because of the changes in food production and the not always easy access to water. The most affected categories of people will also be the more vulnerable segments of the population, that are Indigenous Peoples, low-income households, children and elderly people *(ibid).*

Climate change will also have an impact on good health and wellbeing, including mental health. The last IPCC Report (2022) stresses the correlation between mental and physical health and climate change. Extreme heat waves have increased mortality and illnesses in many regions and "the occurrence of climate-related food-borne and water-borne diseases has increased" (IPCC, 2022). As far as mental health is concerned, emerging mental problems are related to the increasing temperatures, trauma from climate extreme events and the loss of livelihoods due to climate change. To conclude, when extreme climatic events occur, the health system is less efficient, and it has difficulties to be supportive to the population *(ibid).*

Eventually, peace (Goal 16 of the Sustainable Development Goals) is likely to be affected by climate change. Through the increase of poverty, economic shocks and other drivers of conflicts, climate change is likely to indirectly increase the risks of dispute and disagreement between and within countries (IPCC, 2014).

1.2 Climate Change Resilience

The international community and national governments have already taken actions to address climate change, including the adoption of the Framework Convention on Climate Change (UNFCCC, n.d.) and individual mitigation and adaptation strategies.

Adaptation and mitigation are complementary solutions that help to address the risks and impacts of climate change (IPCC, 2014).

All actions that aim at reducing and preventing emission of greenhouse gases can be defined as Mitigation solutions. To mention concrete examples, climate change Mitigation *"can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour"* (UNEP, n.d.). The decrease in the percentage of emissions can foster effective climate change adaptation and ensure a sustainable development future (IPCC, 2014). According to the IPCC (2014), *"there are multiple mitigation pathways that are likely to limit warming to below 2°C relative to pre-industrial levels".* However, they would need a considerable decrease in greenhouses emissions in the next twenty years and almost zero emissions by the end of year 2100. These objectives would require significant innovation from the technological and socio-economic point of view *(ibid).*

Adaptation is another solution that helps addressing the detrimental impacts of climate change. As the last IPCC report of 2022 highlights, adaptation is one of the key local interventions to increase climate resilient communities (IPCC, 2022). The UN Framework Convention on Climate Change (UNFCCC, n.d.) defines adaptation as *"adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts"* (UNFCCC, n.d.). Adaptation entails modifications that have the aim to diminish the damages of climate change and the creation of innovative solutions to deal with it in the future. Through adaptation measures, states can become more resilient to the upcoming impact of the processes that are already in motion. It can be implemented both in an anticipatory or in a reactive way to climate related hazards (IPCC, 2022). Effective adaptation planning and its implementation are described in detail in Article 7 of the Paris Agreement, that considers adaptation as a global goal to reach. The Article states that the approach to plan and implement adaptative solutions should be *"country-driven, gender-responsive, participatory and fully transparent"* (Agreement, P., 2015). Also, communities that are more vulnerable and natural ecosystems should be taken into account by adaptation actions. Before the implementation and monitoring phases, adaptation should be planned in detail (Agreement, P., 2015). Multilevel action is required, since states must fulfil their international obligations as well as develop National Adaptation Plans. Moreover, private, and individual initiatives are also fundamental for a widespread presence of

adaptation solutions on the territory. Eventually, traditional, and Indigenous knowledge are essential in the process of evaluating and implementing actions to reduce risks derived from climate change (UNFCC, n.d.).

As we already stated, adaptation reduces climate change-related risks and increases climate resilience of communities, through the implementation of local solutions in existing systems. The necessity of adaptation and its scale depends on the community's vulnerability. Vulnerability and exposure to present climate variability can be reduced through adaptation efforts, that can increase climate resilience (IPCC, 2014). Resilience can be considered as the capacity to *"cope with and recover from, disruptive shocks and trends"* (Hammill, A., Matthew, R., & McCarter, E., 2008). In fact, it is essential to guarantee health and wellbeing of local communities, the safety of resources and livelihoods and the preservation of goods and services. (IPCC, 2014). When people do not have enough assets to deal with contemporary conditions, they could not be in the position of implementing adaptative solution to future climate related consequences; this can be called as "adaptation deficit". Adaptative solutions should have the objective to reduce this gap. For this reason, adaptation should also be complemented by successful development and poverty reduction interventions (Hammill, A. et al., 2008). Adaptation solutions can be useful to reduce peoples' vulnerability, increasing productivity in agriculture, implementing innovative solutions, ensuring health, well-being, food security, livelihood, and biodiversity conservation. (IPCC 2022). In fact, many of the 2030 Agenda Sustainable Development Goals can be addressed through adaptation. IPCC report makes some examples of adaptation strategies that could be helpful to address global challenges.

Fig.1 represents different examples of adaptation options in relation to the 17 SDGs. If the adaptative solution has benefits addressing the respective Sustainable Development Goals the symbol is (+), if it has dis-benefits is (-), while when results are not clear or mixed is indicated in the figure below as (•). We can clearly see that a positive correlation exists between SDGs and adaptation solutions.

Figure 1. Correlation between adaptation and the Sustainable Development Goals (IPCC, 2022).

Figure 1 illustrates some of the different sectors covered by adaptation solutions. Even if they exist in a great number of domains, the effectiveness of their implementation varies from area to area. (IPCC, 2014).

Adaptation solutions related to water management and water impacts are among the most documented ones. As IPCC (2014) states, *"On-farm water management, water storage, soil moisture conservation and irrigation are some of the most common adaptation responses"*. As this thesis will then investigate in further details an adaptative solution to counter the shortage of water caused by increasing droughts, we will now analyse how adaptation can be useful to enhance water management. As far as water management strategies are concerned, some solutions are emerging to help people and natural ecosystems to not be subjected to water insecurity. Because of climate change, rivers, lakes and glaciers are seeing a rapid shrinking and water crisis. Also, droughts and floods are becoming more and more frequent, causing damages and insecurity in the regions where they occur. In addition, the amount of available water is not always managed in an efficient way, as it is often wasted because of old systems of irrigation. Therefore, the

water management sector needs innovative solutions that can respond to the contemporary environmental challenges (Bapna, M., Brandon, C., Chan, C., Patwardhan, A., & Dickson, B., 2019).

Firstly, countries should take advantage of existing water flows, expanding the water infrastructure. Governments should take measures to prevent the ongoing degradation of watersheds such as wetlands and upland forests; such interventions could increase water security. Then, water should be used in a more productive way, to prevent wastes of water. In fact, saving water means addressing the future challenges that climate change will pose to each country. As an example, farmers should use water in a more efficient way; thanks to innovations in agriculture and invented adaptation strategies, the amount of water needed for agricultural reasons can be reduced. Also, the yields coming from crops should be increased. Furthermore, Governments should start planning adaptation for floods and droughts. For example, water should be stored in reservoir by water agencies to prepare for future drought emergencies. Water management should be considered as the top of priorities of many financial investments; in fact, politicians should create policies that can foster a collaboration between institutions, the private sector and civil society organisations. "*The OECD estimates that spending must climb threefold just to meet sustainable development water supply and sanitation goals." (ibid).* Also, investments should be made in *"stormwater management, infrastructure to reduce flood and drought risk, and ecosystem protection" (ibid).*

1.2.1 Limits to Adaptation and Maladaptation

We already have an extended knowledge of existing adaptation options; however, their implementation highly depends on the capacity of institutions to apply these solutions in an effective way. Adaptation gaps are the result of inefficiencies in implementation and not effective policy-making responses. Local solutions that could be able to transform ecosystems and create local opportunities to face climate extreme events, are usually not prioritized by governments and they are substituted by immediate and near-term actions. In fact, adaptation is usually carried on through an approach that the IPCC (2022) considers as *"fragmented, small in scale, incremental, sector-specific, designed to respond to current impacts or near-term risks, and focused more on planning rather than implementation"*. Furthermore, it can be argued that the efficacy in adaptation

depends on regional areas. To mention an example, inequalities affect implementation of adaptive solutions, because of the costs and the capital that need to be allocated to elaborate this kind of solutions. (IPCC, 2022). Also, when the affected population is not properly consulted and included into planning and implementation phases, adaptation can result in maladaptation. Adaptation solutions should in fact take into account *"the complexity of adaptation as a social process"* to produce effective adaptation outcomes (IPCC 2014). To conclude, when climate change has a considerable impact on a specific local community, the effectiveness of adaptation strategies could be limited. For this reason, States should consider long-term adaptative solutions, to increase the possibility to have future options that can respond to climate change challenges and to be prepared for future impacts *(ibid)*.

As far as financial means are concerned, they can become a constraint to adaptation when they are not available in a considerable number. Until now, mitigation options have always been more sustained financially than adaptation ones. The financial resources available to implement adaptation solutions are less than what would be needed. Costs for global adaptation, funding and investment should be analysed more in depth, to create substantial data. Some of the common limits to adaptation are in fact *"limited financial and human resources; limited integration or coordination of governance; uncertainties about projected impacts; different perceptions of risks; competing values; absence of key adaptation leaders and advocates; and limited tools to monitor adaptation effectiveness"*. Maladaptation can eventually increase the vulnerability of present deprived categories of people or produce new experiences of vulnerability in other persons, settings and domains *(ibid)*.

1.2.2 Conditions allowing Adaptation that are essential for Implementation

The very last report of IPCC (2022) describes in detail the conditions under which adaptation can be effectively implemented. According to IPCC, when adaptation is flexible, it covers many domains and it considers the long-term period, adaptation solutions are able to produce effective outcomes in the society in which they are implemented. The engagement of institutions, policies and tools with priorities and objectives that are clear, a deeper knowledge of impacts and solutions, adequate financial resources and an inclusive monitoring and evaluating process are all enabling conditions

that can enhance an effective local adaptation. Also, actions should be coordinated in a network of different stakeholders and at different levels of governance (IPCC, 2022). For example, communities, civil society, universities and research centres, journalists, investors and the private sector should be included in adaptation planning and monitoring (IPCC, 2014). In particular, the private sector should be held accountable for climate change and called to work to implement and sustain different solutions, including adaptation. Big corporations and small businesses should be engaged in the network of actors that work to contrast climate change vulnerability. The private sector should help economically institutions and Governments to deal with climate change related impacts, as costs are high and increasing. Also, businesses can bring to the public sector knowledge, experience and innovation; even if it has not been very much engaged in sustaining adaptation until now, it could bring to the discussion many new competences and initiatives. Institutions should also work to establish partnerships with chambers of commerce and network of businesses to create big platforms of discussion, where smaller actors can have the possibility to bring their contribution and express their opinions (UNDP Climate, 2021).

Also, international, regional, national and local institutions should implement effective policies that consider adaptation as a solution to climate change. Even if adaptative solutions mainly consider the local and the national territory, as they are a local solution to climate change, coordination should be fostered through a joint effort of regional and international cooperation. If all levels of governance succeed to work together, through joint and complementary actions, adaptation can have the possibility to become more effective. At the local level, institutions can manage the actions of local governments and municipalities through the protection of vulnerable communities and categories of persons and *"by providing information, policy and legal frameworks and financial support"* (IPCC, 2014). In fact, it has been proved that local institutions, through the help of the private sector, can more efficiently implement adaptation solutions, as they have a strong impact on the life of individuals, families and civil society and as they are the responsible of prevention and risk information *(ibid).*

This framework of solutions should also be included into national and local spending and the planning of policies. Therefore, adaptation should be included into legal and economic tools that are at disposal of politics. (IPCC, 2022). Effective adaptation outcomes are enabled if institutions, the third sector and the private sector work together

to create policies and actions that consider *"risk reduction, equity and justice"* (IPCC, 2014). In addition, policies that promote the enhancement of the technologic sector and financing tools that support climate change can go hand in hand with effective policies for adaptation to climate change (IPCC, 2014).

These factors create effective adaptation outcomes not only in urban systems, but also in rural ones (IPCC, 2022). In fact, according to IPCC (2022), *"3.4 billion people globally live in rural areas around the world, and many are highly vulnerable to climate change".* Climate change resilience of rural communities can be enhanced through the inclusion of adaptation solutions into social protection programs, such as cash transfers and public work programs (*ibid*). Also, to reduce climate vulnerability of regions and peoples, access to finance should be enhanced. Effective adaptation planning considers each category of the society and opens the adaptation process to the all the actors in a community, including women, young people, indigenous Peoples, traditional communities and minorities (IPCC, 2014). As a consequence of this participatory and inclusive process to adaptation, actions are built on local and traditional knowledge about climate change, that is then put together with national and international consciousness. Climate change resilience can be therefore enhanced thanks to interventions that integrate the local knowledge with global principles, such as inclusion, ethnicity, gender mainstreaming, disability and age. A human rights-centred approach to adaptation can considerably increase climate change resilience*(ibid).* Adaptation measures can also be complementary to mitigative solutions; together, they can create diverse benefits and increase wellbeing of the community and natural environments *(ibid).*

As previously mentioned, mitigation initiatives alone will not be sufficient to reduce the effects of climate change at all levels. In fact, the importance of creating a global climate change adaptation strategy is growing, and it is strictly linked to the inability of States to implement effective mitigation solutions (ESG 360, 2022). COP 27 that is taking place in Egypt from 6 to 18 November 2022, has the objective to *"make urgent progress and to urge all Parties to show the necessary political will to capture and assess our progress in increasing resilience and assist the most vulnerable communities"* that are impacted by climate change (Climate Adapt, 2022). To reach this objective, the Sharm-El-Sheik Adaptation Agenda has been launched during COP27. This international shared plan is extremely important in the context of the global framework of action against climate change, as it is the first adaptation plan that will be adopted at the global level.

The Adaptation Agenda contains 30 adaptation outcomes that should be reached in order to attain the Global Goal on Adaptation, addressing climate vulnerability worldwide and increasing climate resilience of four billion of people at the global level. Each target to be reached is a local solution that needs to be implemented to respond to specific climate change-related challenges that will arise because of the increasing global temperature, such as droughts, floods and extreme heat. The Adaptation Agenda envisages a multistakeholder action plan, where institutions, civil society and the private sector are included among the actors that will have to respect the objectives enlisted in the agenda. The Adaptation Agenda regroups actions related to specific sectors that will be increasingly impacted by climate change during the following years, such as *"food and agriculture, water and nature, coastal and oceans, human settlements, and infrastructure, and including enabling solutions for planning and finance".* (Climate Champions, 2022).

The thirty outcomes of the Sharm-El-Sheik Adaptation Agenda are strictly interlinked with the 2030 Sustainable Development Goals. From 140 to 300 billion dollars are estimated to be transferred to public and private institutions in order to address climate change through adaptative solutions. The Sharm-El-Sheikh Adaptation Agenda intends to foster a shift towards more sustainable and climate resilient agriculture, that can increase yields by 17% and reduce greenhouse gas (GHG) emissions. This type of agriculture should also be more attentive to forms of support for small farmers. Then, the Adaptation Agenda envisages protecting and restoring 400 million hectares of terrestrial and freshwater ecosystems by introducing and fostering the spread of nature-based solutions to improve water security. The plan also aims to steer activities on more than 2 billion hectares of land towards sustainable management. Concerning coasts and oceans, adaptation foresees investments of 4 billion dollars to develop 15 million hectares of mangroves to protect coastal marine environments. Other planned measures include the deployment of technologies and solutions to protect 3 billion people with smart early warning systems. Sameh Shoukry, that is the President of COP27 affirmed during the launch of the Adaptation Agenda: *"It is our aspiration that the Sharm-El-Sheikh Adaptation Agenda represents a significant contribution to enhance global action on adaptation and resilience as an utmost priority. The COP 27 Presidency is keen to develop a governance arrangement to secure continuity in scope, priorities and reporting. Overall progress on implementation will be reported back to COP 28." (ibid).*

The launch of the Adaptation Agenda during the COP27 should be interpreted as a huge step in the direction of multilateral action to plan adaptation solutions at the local level; also, it clearly shows the interest of institutions and the private sector to collaborate at the global level to address increasing climate change challenges.

1.3. Green Microfinance as a tool to address climate change adaptation

Microfinance works through different financial instruments, such as loans, savings, insurances and other services; the target populations to which these services are directed are usually vulnerable communities. Through microfinance, they can invest in income generating businesses, that help them enhancing their livelihoods, building resources, stabilising consumption and protecting them against future damages. Microfinance Institutions fill the gaps created by the existence of traditional Finance Institutions, such as traditional banks and development programs that were not sufficiently capable of giving a source of money and income to the more deprived populations. In fact, vulnerable people are not able to ask for loans to traditional bank services, because they do not have the sufficient assets to secure that they will entirely repay them back. Conversely, Microfinance Institutions reverse this tendency, disbursing loans that require a small amount of capital and asking frequent payments. Clients of MFIs are usually regrouped into a community of payers, and they share the amount of money they have to pay. Each individual is capable of sustaining his own price of the loan, shared between all the different members of the group participating to such investment. Some forms of Microfinance Institutions exist, going from the more regulated ones, such as government-owned institutions or private development banks since "non-bank financial institutions", including credit unions, individual savings, cooperatives and NGOs (Hammill, A., Matthew, R., & McCarter, E., 2008). In addition, financial services of Microfinance Institutions are not the only services delivered; in fact, usually this kind of institutions deliver education, training and healthcare that complement the delivery of loans and other types of financial assistance in order to give an integrated development toolkit to their clients. These services are frequent in urban areas, but also in rural ones *(ibid)*.

Because of the current environmental trends, economic and financial institutions are manifesting their interest in the topic of climate change. In fact, environment and economy are strictly interconnected. Microfinance Institutions have been interested by these last tendencies of the economic sector, creating a specific domain called "Green Microfinance" that will foster ecological process (Forcella, D., Castellani, D., Huybrechs, F., & Allet, M., 2017). Microfinance is transforming its traditional approach into an innovative one that can cope with the challenges of climate change (Lanzavecchia, 2021). Green microfinance tries to efficientize the use of energy and to lower the environmental risk (Forcella et al., 2017), taking advantage from new areas of the financia1 market, where they can operate (SBFN, 2021). The International Finance Corporation *"estimates over $23 trillion in investment opportunities in green and climate-related sectors" (ibid).* Green products give the opportunity to Microfinance Institutions of diversifying their existing services and financial products to compete in the global market. Thanks to Green Microfinance, they have the opportunity to look at new fields of investment, including the rural sector (Forcella et al., 2017).

The advantage of using microfinance as a tool to address climate change may lie in its established access to the people who are economically more deprived, who usually are also the most vulnerable to climate change (Shardul & Carraro, 2010). Green microfinance crosses many domains, including food security, the access to energy, health and wellbeing, adaptation and mitigation, development of rural communities and areas. Only through a human rights-based approach that consider the complexity of problems, such as poverty and vulnerability, green microfinance would be able to address these challenges (Hammill, A., et al., 2008). Green microfinance aims at modifying environmental problems in socio-economic returns (Forcella, et al., 2017) and it can play an important role in the alleviation of poverty (Lanzavecchia A. et al., 2021) and in the enforcement of resilience among the affected communities (Dowla, 2009). In the near future microfinance institutions will have to prepare a reliable plan in relation to climate change adaptation (Fenton, 2015).

Clients of Microfinance Institutions can deal with the impacts of the changing climate thanks to a new set of actions, services and products (Forcella, et al., 2017). Microfinance services have the capability to increase the number of livelihoods through effects on the direct revenue, impacts on the indirect revenue thanks to education pathways and non-pecuniary effects, such as building stronger networks with the community and a greater

sense of trust. (Hammill, A. et al., 2008). Finding other financial actors, such as the government, private banks or specific funds, that can play an important role in the disaster recovery (Dowla, 2009) can back up the loans people at risk will not be able to repay or help the microfinance institutions recover from serious effects of natural disasters. Also, microfinance institutions may rethink their conditions for microcredit, offering more flexibility to their clients when exceptional events occur. To mention some examples, green microcredit can be provided for renewable energy (RE), energy efficiency (EE), or for environmentally sustainable practices (ESP) and climate change adaptation (CCA). Green microcredit aims at generating income in a sustainable way, making sure that the financed projects are helpful to cope with the impacts of climate change (Uddin, 2021). Loans must be provided by MFIs to their clients with the condition that the proposed activities or businesses will be in line with the green growth standards. Some examples in which green microfinance serves to contrast climate change are in-house green microfinancing, with the focus of maintaining the atmosphere clean, green building, replanting trees on (Uddin, 2021) and business financing such as investing in renewable energy, biogas and bio-fertilizers plants (Giulia, 2016).

Many Microfinance Products can be employed to increase resources of Microfinance Institutions' clients, thus reducing their vulnerability to climate change. Firstly, through microcredit, Microfinance Institutions lend money to the more vulnerable people, to create an income generating activity; therefore, they have the capacity of diversifying and building resources. Revenues coming from the first loan are then spent, saved or reinvested. Then, microinsurance is another product offered by Microfinance Institutions. People pay a regular small sum of money to be protected against climate extreme events. For this reason, people have an incentive in investing in assets and resources, even if they are scared of losing them during extreme events, such as injuries, deaths and natural events. Microsavings help people saving and storing their money; clients can use microsavings whenever they require them, and they can be considered both as a source of investment and as a personal insurance. Eventually, disaster risk reduction microfinance can help people dealing with extreme events; as an example, people can be offered loans to rebuild or repair parts of their house, walls, and physical assets they own that would be at particular risk during extreme climate-related events, such as droughts, floods and storms. It is a form of insurance that people possess in case of the loss of their livelihoods. As an example, in some areas frequently subjected to floodings and

hurricanes, microinsurance might be the only solution to address local climate change-related impacts (Hammill, A. et al., 2008).

All these microfinance products are more likely to be successful in the lives of microfinance institutions' clients when they are integrated through the delivery of training to increase non-cognitive skills, *"such as literacy, health and hygiene (e.g. disease prevention, nutrition during pregnancy), financial management (e.g. bookkeeping, investment, decision-making) and specific technical/entrepreneurial skills"* (*ibid*). Thanks to these trainings, people are capable of undertaking financial decisions, manage their own capital and be aware of the risks, including those posed by climate extreme events *(ibid)*. Therefore, microfinance products can sustain the more vulnerable people and help them building climate change adaptation strategies through long-term and financial tools; households are in this way able to cope with climate change and to build assets that protect them against eventual stresses and shocks *(ibid)*. Microfinance services give them the possibility of diversifying their livelihoods, so that they are not dependent just on one of their assets *(ibid)*. The objectives of Microfinance Institutions introducing these new services are to increase climate resilience of their clients, to reduce vulnerability to environmental stress, to improve livelihoods of people subjected to climate related hazards and to preserve natural ecosystems (Forcella, et al., 2017).

Nevertheless, lack of data and information on existing practices of green microfinance represents a major challenge for Microfinance Institutions, the investors and the clients' commitment (Forcella, D. et al., 2017). Also, it is not always easy to invest in Green Microfinance as these solutions depend on other factors such as incentives, previous knowledge and skills and availability of resources (Fankhauser, Smith, & Tol, 1999). Many studies also underline that the contribution of microfinance may not be sufficient to make households resilient to climate change in situations of extreme vulnerability. For this reason, there is the need for better and coordinated approaches, which may incorporate microfinance interventions. When using microfinance to finance adaptative solutions for climate change, we should also consider implementing measures that do not create maladaptive outcomes which have the opposite effect of improving resilience (Fenton et al., 2015). In order to deal with climate change and green microfinance, Microfinance Institutions should gain experience, define products and services and establish networks with energy suppliers or with organisations for development that have specific Technical Assistance and fundings; they should also be capable of engaging

clients, the administration and loan officers in this new financial sector (Forcella, D. et al., 2017). Despite the recent positive developments, the Green Microfinance sector remains a minor part of the total microfinance initiatives. Also, Microfinance Institutions' *"average environmental performance level remains low compared to their social or financial performance level" (ibid).* Further data should be collected to deepen the studies on this subject that prove the efficacy of this completely new green financial sector (*ibid*).

As a result, it is today recognized that green microfinance has the ability to address climate change vulnerability and increasing poverty. However, some further steps need to be undertaken to expand this emerging sector. Advocating with governments to implement green policies, monitoring Microfinance Institutions and educating individuals to save energy and resources are all factors that can accelerate the growth of the green microfinance sector.

Conclusion

To conclude, Microfinance Institutions are exploring emerging domains and markets, to find new clients and opportunities. As their action has always been oriented to the building of tools for the most vulnerable communities, microfinance is now shaping its role to address climate change, a contemporary and future challenge that is having detrimental impacts on the population. Microfinance can be thus considered as a tool creating opportunities to raise capital that can contribute to advance adaptative solutions in the community. Through the interconnection between microfinance and adaptation solutions, clients of microfinance institutions can empower themselves thanks to the economic returns, but they can also adapt to the emerging obstacles that the climate emergency is posing worldwide. Microfinance can be the tool to implement efficient adaptation strategies that consider the long-term period and that cover many different domains. Multi-level actors at the local, regional, national and international levels should be included in the process of planning and coordination of different adaptation strategies; institutions, organisations and the private sector are all fundamental elements to render efficient the outcome of this process. As this chapter demonstrates, climate change poses at great risk Human Rights and hinders our capacity to reach the Sustainable Development Goals. When microfinance becomes instrumental to finance adaptation practices, climate

change can be locally addressed, creating solutions for local challenges that populations will have to face in the years to come, because of the changing environment.

CHAPTER 2: Climate Change in Nepal: Between Challenges and Solutions

Introduction

Nepal belongs to a region that regroups many other countries, named the Hindu Kush Himalayas. This area is characterised by common meteorological and climatic features; climate change is having a detrimental impact on the entire territory, exacerbating its climate characteristics. Indeed, mountain zones are more subjected to sporadic precipitation rates, causing recurring droughts and water unavailability during winter months. On the other hand, summer rainfalls have increased during the monsoon season, thus putting plain areas at risk of flash floods. Another consequence of climate change is the growing demand of water from the community, and the incapacity of the region to satisfy the water's request. In fact, climate change is hindering the capacity of employing water for irrigation and domestic activities. Water is an important resource in the area, as many populations, especially those living in the most rural areas of the region, are still basing their livelihoods on agricultural yields. As far as Nepal is concerned, it possesses the same climate characteristics of the Hindu Kush Himalayan region; however, it presents at the same time very high mountain areas and plains, resulting in different *"ecological belts"* (Bista, R., 2019), with very distinct weathers and climate change consequences from area to area. Nepal is highly vulnerable to natural disasters and its vulnerability continues to grow due to the impact of climate change (UNDP). In 2020, the country was ranked as *"the nine's most vulnerable country in the world"* on the Global Climate Vulnerability Index. Some adaptation solutions and actions to manage water have been implemented in the Hindu Kush Himalayas; however, it remains difficult to coordinate all efforts at the regional level, thus resulting in individual initiatives of each country. As far as Nepal is concerned, many instruments have been adopted to face climate change, including adaptation measures, Loss and Damages and green microfinance initiatives. These sectors are expanding; nevertheless, the chapter will illustrate that further steps need to be taken in order to produce an effective and coordinated response to rising climate change challenges.

2.1 The Environmental Context of the Hindu Kush Himalayan Region

The Hindu Kush Himalayan area regroups 18% of all mountainous regions of the globe. Eight countries make part of this territory, respectively Nepal, Bhutan, Afghanistan, Bangladesh, China, India, Myanmar and Pakistan (Dhimal, M., et al., 2021). This entire area hosts 3 billion people (Singh, S. P. et al., 2011) and it is the source of ten great river basins that provide everyday water and other products to its communities (Dhimal, M., et al., 2021). Climate change is already having impacts on this area of the world, that is one of the most delicate ecosystems on Earth for its geographical and geological characteristics, as it is characterised by very young mountains. Hence, it is often subjected to phenomena such as earthquakes, landslides and erosion. The area is geologically vulnerable to a high incidence of climate-related extreme events and climate change will exacerbate its propensity for climate-related hazards. In fact, the frequency and severity of extreme weather events have already started to increase during the last years. Also, temperatures have been affected by global warming, as they are rising *"at a higher rate than the global average"* (Dhimal, M., et al., 2021). As far as precipitations are concerned, the entire Hindu Kush Himalayan area is subjected to a rising variability of the yearly number of rainfalls, but there are significant differences between mountains and plains. Indeed, reduced snowfalls have been identified in upstream, while floods are more frequent in mid and downstream of water basins. Also, floods are occurring more frequently in each country during the monsoon season, while drought is more severe during winter. To conclude, the consequences of the climate emergency are having a detrimental impact on many different economic sectors, such as "hydrology, agriculture, biodiversity and human health" (ibid). These meteorological characteristics are becoming more evident, and they are being exacerbating, as a consequence of climate change (Dilshad, T. et al., 2019).

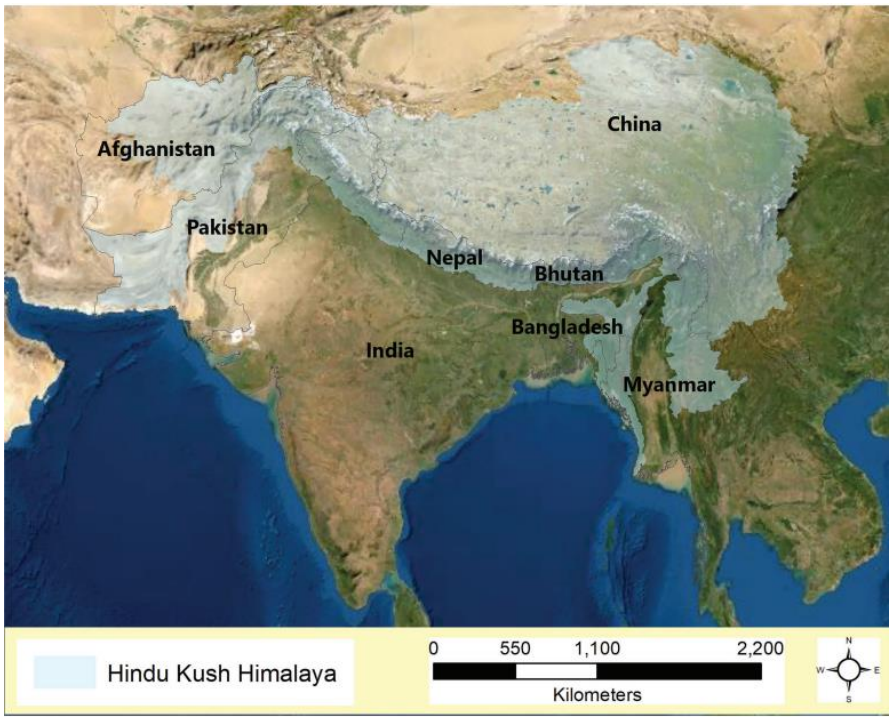

Figure 2. Representation of the extension of the Hindu Kush Himalayan region (Dhimal, M., et al., 2021)

2.1.1 The Importance of Water in the Region

It is critical to comprehend the current and future availability of water in the region of Hindu Kush Himalayas, given the meaning this resource has in providing livelihoods to its own population. Climate change is affecting the capacity of people to have access to the water supplies they need, thus increasing their climate change vulnerability. The region will face an increase in water resources during specific seasons, while it will be negatively impacted by water shortages during the driest months (Singh, S. P. et al., 2011). Some common characteristics of the region can be identified. Firstly, climate change is expected to increase the number of precipitations, particularly during the monsoon period (IPCC, 2022). More than 80% of the total amount of precipitations is in fact produced during the monsoon season (Molden, D. J. et al., 2014). More sporadic and heavy precipitations during monsoons will be the result of a shift in weather conditions in the whole Hindu Kush Himalayan region (IPCC, 2022). Warmer temperatures, caused by global warming, will rise evaporation rates, that in turn will rise the total number of rainfalls. This variability in precipitations *"will affect soil moisture, groundwater*

reserves, and the frequency of flood and drought episodes" (Singh, S. P. et al., 2011). In fact, the amount of water that is stored under the ground and the water's runoff, highly depend on soil moisture. If this increases, the capacity to sustain rivers' flows is reduced and floodings are more likely to happen *(ibid),* creating damages and destruction in plain regions (Molden, D. J. et al., 2014). Also, the probability of flood disasters in summer is increased by the melting of glaciers, that produces enormous amounts of water (Singh, S. P. et al., 2011).

Secondly, during the dry season, populations are often used to face water scarcity. Sporadic precipitations in the region are causing economic and environmental issues, such as difficult access to water during the driest months. This reduces its application in the irrigation and navigation sectors. To mention an example, the Indian city of Cherrapunjee, that has the highest rate of yearly precipitations, is also occasionally named "the wet desert", as a consequence of water shortages that occur during the driest months. Also, basins "*like the Ganges, Brahmaputra, Salween and Irrawaddy, are considered economically water scarce"* (Molden, D. J. et al., 2014). Rivers become water scarce, hindering the capacity of communities to use water for their activities in the agricultural, industrial and domestic sector *(ibid).* Climate change is exacerbating these weather characteristics of the region, creating damages and detrimental impacts on assets and livelihoods (IPCC, 2022).

Eventually, climate change is negatively affecting water supply of the cryosphere, causing many damages to people living in the area and to natural environments (IPCC, 2022). In fact, glaciers, snow and permafrost produce important water flows for the rivers that are located in the Hindu Kush Himalayan region (Molden, D. J. et al., 2014), making the cryosphere a significant water supply (IPCC, 2022). Livelihoods and ecosystems of the entire area depend mainly by the freshwater created in the mountains *(ibid).* The Himalayas constitute 30% of the global glaciers on Earth, with more than 50.000 glaciers, providing water in the surrounding regions. As glaciers' melting is increasing and causing detrimental consequences on populations and ecosystems, Himalayas are in a state of constant observation (Molden, D. J. et al., 2014).

Climate change and its impact on water management and the cryosphere, strongly affect agricultural activities worldwide. In fact, water coming from mountains' springs has always underpinned the agricultural domain in many regions. Populations living in rural

areas that base their subsistence on agriculture, highly depend on irrigation water coming from glaciers and snow melting, as they affect soil moisture during the sowing period. In the Hindu Kush Himalayan area*, "agriculture in upstream region is mostly subsistence and has high significance for food and nutritional security of the people living in the harsh mountain terrain"* (Dilshad, T. et al., 2019). Agriculture is the main mean of subsistence also for communities that are living in plains. Agricultural practices have been negatively impacted by the reduction of the streams and rivers' flow, that have been caused by glaciers' retreat and lowered snow cover (IPCC, 2022). Communities living in plain areas are becoming more vulnerable to floodings and water-induced disasters, that are hindering the seasonal agricultural cycle and crops' agricultural outcomes (Dilshad, T. et al., 2019). Irrigation of plains neighbouring to rivers and streams has been highly affected by this phenomenon that caused a decrease in agricultural yields. Also, global warming has increased temperature at the soil level, rising the percentage of crop evapotranspiration and the request of water to produce crops (IPCC, 2022).

Agriculture has been strongly affected by consequences of climate change, provoking challenges for the communities living in the Hindu Kush Himalayan area. To mention some examples, regions that benefit from the Indus' water are likely to be subjected to floods and droughts, more than in the previous years. Farmers living in this area described the weather changes during the last ten years saying that wheat was cultivated between October and November, while now it is planted in December to follow emerging changes in the climate pattern. Also, winter rainfalls that used to happen in January and February are now occurring in March. In the bottom part of Indus*, "farmers reported 100% of crop loss during last three years due to unwanted rain spell in March."* (Dilshad, T. et al., 2019). Furthermore, in mid-stream of Teesta, unexpected precipitations and hailstorms are causing an impact on plantations of maize, fruits, vegetables, and cardamom. Inhabitants of the intermediate area of the Teesta River lost from 70 to 98% of spring discharges that caused drought and water unavailability for agricultural practices; the result is a loss between 60 to 90% of the total outcome of crops. As agriculture needs to face new climate-related challenges, it has also become a less profitable activity as a livelihood. (Dilshad, T. et al., 2019). During the last period, agriculture is decreasing its importance on the income of a family in the Hindu Kush Himalayan region*; "the percentage of income from farming, in recent years, declined from over 90% in the late 1980s to 30-40% of the household income"* (Bhatta, L.D. et al., 2019).

Eventually, drought and floodings are disproportionately affecting communities and households, as they have a major detrimental impact on the most deprived and vulnerable categories, that do not possess enough assets to cope with climate change-related extreme events. In fact, their livelihoods highly depend on shared cropping and daily wages. During drought, in many cases households that cannot cover the cost of a water pump do not have access to water; this is responsible of increasing the workload of women that need to look for water in other areas and the migration of men that cannot base their subsistence on agriculture. Water insecurity and its consequences on agriculture are also having a disproportionate impact on women; in fact, farming in the Hindu Kush Himalayan region is a *"woman centric activity in mountainous regions and demands a major contribution from females throughout the year" (ibid).* Forced migration of men and migration of youth in search of better employment opportunities are some of the reasons of the rising burden of women in the agricultural sector. Also, some lands have been abandoned, because of the migration phenomenon that has been increased by the consequences of climate change (Bhatta, L.D. et al., 2019).

2.1.2 Adaptation Solutions, Water Management and Water Governance

As the entire region has not allocated during previous years considerable financial means to sustain water infrastructures, today it has a hindered capacity of matching the increasing water request with adequate supply, of mitigating the consequences of climate-related impacts such as floodings and droughts and of creating effective local adaptation solutions to face emerging climate change challenges (Molden, D. J. et al., 2014). As mentioned in the previous paragraph, water shortages and emerging changes in the variability of precipitations are affecting agriculture and daily use of water (Vaidya, R. A., 2015). For this reason, high mountain areas need integrated water management strategies for all activities that imply the use of water; in particular, adaptation strategies are needed in fields such as energy, agriculture and drinking water availability. As mentioned in the previous chapter, the efficiency of adaptation solutions depends on the capacity to conduct a joint and inclusive process where all actors of the community are engaged, as well as on the allocation of sufficient financial means. Also, indigenous know-how should be complemented with scientific knowledge in order to build effective responses to climate-related extreme events (IPCC, 2022).

Some adaptation strategies have already been implemented in the most recent years, to face the growing demand of wate and to adapt to the emerging trends and future scenarios (IPCC, 2022). Solutions storing water *"through initiatives such as wetlands conservation and watershed management in the hills and mountains, groundwater aquifer recharge through infiltration ponds and others in the foothills, and even the creation of small artificial glaciers"* have been already implemented in the Hindu Kush Himalayan region (Vaidya, R. A., 2015). Some artificial systems have been built to store water, such as water tanks and ponds that are capable of accumulating water coming from rainfalls. Integrating natural characteristics of each country and territory with artificial techniques means creating efficient storing methods that can meet the water necessities of the community. Storing water can help the community to be less vulnerable during drought periods *(ibid).* According to IPCC (2022*), "Release and storage of water from reservoirs according to sectoral needs (agriculture, drinking water, ecosystems) has reduced the impact of seasonal variability on runoff"*. By storing water, communities can also manage its distribution and they are able to cultivate the fields even when rainfalls are not sufficient. To mention some examples, many communities are storing water that melted from the glaciers of the region. Water is stocked during the night in a tank, and it is distributed through exit channels during the day. Another effective storing solution that has been implemented in Western Himalayas is the canalisation of water streams coming from the mountains to bring water to communities living in the hills, that can use it for agricultural practices (Vaidya, R. A., 2015). Despite these virtuous examples, most of adaptation strategies implemented in the region are independent initiatives, while just few are programmed and implemented through a multilateral effort of all stakeholders involved in the region. Adaptation strategies in the agricultural sector in mountain regions often have characteristics that hinder the extent of these actions, such as a lack of understanding of finance and technical tools, a scarce capacity of adaptation of the local populations, a low-level equipment of national organisations and an absent support from institutions (IPCC, 2022).

In addition, water governance is an important component of the adaptation process, as it creates coordinated and planned response to emerging climate-related hazards, and it considers all the stakeholders involved in the community (IPCC, 2022). The Hindu Kush Himalayan region has a water management system that is mainly formed by *"hybrid formal-informal regimes with a prevalence of informal institutions at the local level and*

formal state institutions at national and regional levels". Often, these actors are not interacting to produce a joint effort. National institutions are not really involved in management of water, as State presence is weak in many areas of the region. However, at the local level, informal networks of water management exist and deal with current water crisis. Local networks are sustained by formal institutions "through the provision of energy and technology for harnessing and managing water supply as well as through investments in infrastructure for irrigation and energy" (Wester, P., 2019). As far as regional agreements are concerned, the Hindu Kush Himalayan area has a very restricted number of joint water-governance structures; also, the main organisations operating in the area, SAARC (South Asian Association for Regional Cooperation) and ICIMOD (International Centre for Integrated Mountain Development) are not engaged in the management of water in the region. The almost inexistent regional water governance makes that each country creates its own system to deal with water shortages and water insecurity; thus, water availability differs greatly from country to country. *"States have often taken unilateral action on water-management decisions, leading to fragmented management of transboundary resources, narrow focus on national interests, and negative consequences for neighbouring riparian countries and communities" (ibid).* Climate change is going to exacerbate the existing inequalities on water access in the region *(ibid).*

Usually, the majority of the requests for water in the region are satisfied by groundwater coming from sources, handpumps and wells. At the local level, agriculture and households match their water demand by water coming from mountains' springs. An effective coordination of water resources coming from spring basins and river basins is the best approach to deal with *"surface and groundwater resource management" (ibid).* Eventually, research and common water projects should be actions to undertake, involving different countries and stakeholders. The positive effects of this joint collaboration can result in better arrangement of infrastructure design, lowering impacts on assets, households and natural environments. Eventually, the sharing of data collection could improve the capacity of each country to take knowledge from the best practices that have been implemented in the area, to look for strategies that can reduce climate change vulnerability at the community level *(ibid).*

2.2 The Environmental Context of Nepal

The entire territory of Nepal is part of the Hindu Kush Himalayan region (ICIMOD, 2020), located between the countries of India and China. Nepal possesses a rich natural ecosystem, as it has many natural supplies, such as the cryosphere, rivers, rainfalls, that constitute 2,27% of the world's water resources. Water coming from the Nepali mountains nourishes the most important rivers of the country, such as Koshi, Gandaki and Karnali (Bista, R., 2019). It possesses among the highest mountainous areas in the world - including Mount Everest (8.848 metres). However, the Southern territories are composed by plain areas, with an altitude of not more than 100 metres. The climate of the country highly depends on the season and on space, as well as on altitude (World Bank Climate Change Knowledge Portal, n.d.). As far as seasons are concerned, Nepal has specific meteorological conditions that are similar in all the Hindu Kush Himalayan territory. Seasons affect weather events, including precipitations and temperature. Temperature is high in summer, but it turns to very low rates during winter. The rates of precipitations during the periods that precede and that follow the monsoon season are low, that are from March to May and from October to November. The annual rainfalls are condensed during the monsoon period, as in the other parts of the Hindu Kush region; in fact, 80% of the yearly number of precipitations happens during the monsoon season, while 3,1% of rainfalls are concentrated during winter, 4,6% after monsoon season and 12,4% preceding it (Bista, R., 2019).

Concerning Nepal's geography, several climate areas exist, depending on altitude (World Bank Climate Change Knowledge Portal, n.d.); the three main areas in which Nepali territory can be divided are *"Mountain (high altitude), Hill (medium altitude) and Terai (lower altitude)"*. Altitude is inversely proportional to precipitations and temperature (Bista, R., 2019). In the southern part of Nepal, temperatures are around 24°C, while in high mountain areas in the north it goes also to sub-zero during the same season. Precipitations vary from territory to territory; in fact, in high-altitude areas the annual mean of rainfalls is around 1.000 mm, while in plain and hill areas they reach higher rates (World Bank Climate Change Knowledge Portal, n.d.). The Trans-Himalayan region in west Nepal extends from 3600 m to 6400 m in altitude. It lies to the north of the Great Himalayas and includes many inner valleys of Nepal, such as those of Ganesh Himal towards west, Humla, Jumla, Manang, Mustang, Khumbu, Kaligandaki, Bheri and Mugu

(Donner, 1968; Jackson, 1994; Negi, 1994). This zone has very long, and cold seasons and it is characterized by alpine, arid and semi-desert valleys originated by a rain shadow, which stops the monsoonal rainfalls and, consequently, the precipitation does not exceed 160 mm (Dahal, R. K et al., 2008). Also, depending on the *"ecological belt"* (Bista, R., 2019), climate is different within the territory. In mountain areas climate is arctic or alpine, in the hills it is mixed ranging from cool to warm, while in the Terai plains the climate presents tropical or sub-tropical characteristics *(ibid).* The result is that during the same seasons, Nepal presents different climate and features within the same country.

2.2.1 Impacts of Climate Change in Nepal

As it has already been highlighted in the chapter, Nepal is one of the countries that have been more impacted by climate change (Central Bureau of Statistics, 2017). Nepali communities reported a rise in extreme climate-related events such as *"soil erosion, landslides, flash floods and droughts"*, during the last years, causing a detrimental impact on the lives and activities of many populations (World Bank Climate Change Knowledge Portal, n.d.), following the general trend of the Hindu Kush Himalayan region.

Climate Induced Hazards/Disasters	Observed Changes (%)			Total
	Yes	No	Not applicable	
Drought	90.06	9.84	0.10	100.00
Fire (in forest)	30.23	51.34	18.43	100.00
Fire (in settlement)	27.30	69.39	3.32	100.00
Flood	36.77	54.04	9.18	100.00
Inundation	14.12	56.21	29.67	100.00
Windstorm	38.38	56.35	5.27	100.00
Thunderstorm	44.16	54.87	0.97	100.00
Hailstorm	54.72	44.78	0.49	100.00
Heavy rain	24.67	73.30	2.03	100.00
Sporadic rain	41.82	56.39	1.79	100.00
Soil erosion	16.27	64.17	19.56	100.00
Landslide	23.08	39.02	37.90	100.00
Snowstorm	0.74	21.35	77.92	100.00
Avalanche	0.06	20.03	79.91	100.00
GLOF	0.03	19.18	80.79	100.00
Heat wave	9.51	45.26	45.23	100.00
Cold wave	39.60	32.11	28.28	100.00
Disease/insect	73.74	23.05	3.21	100.00

Table 1. Distribution of interviewed people that identified changes on the amount of climate-related extreme events during the last 25 years (Central Bureau of Statistics, 2017)

Table 1 regroups the perception of the Nepali population of the changes that occurred in climate-related extreme events during the past 25 years. Drought has been identified as the most recurring climate-related extreme hazard; 90,06% of the people that have been interviewed by this study of the Central Bureau of Statistics (2017), have reported an increase in this phenomenon during the last 25 years. According to the same survey, all households in the subalpine zone observed an increase in droughts. Around 57% of households perceived the dried up of surface water sources in the last 25 years and 92 % of them were from the far-western mountain and mid-western mountain regions *(ibid)*. The projected increase of aridity and drought is expected to endanger agricultural productions and they will have serious implications on the functioning of drinking water supply systems. Cultivations are becoming more dependent on snow melts and streams of irrigation rather than rainfalls, as an effect of the increasing rates of drought. The increase in the drought's frequency and intensity will also raise the forest fires' risk. Forest fires have several consequences, including the loss of local livelihood, the melting of glaciers and snow in the mountains, the production of higher sediment loads, the difficulty in planting non-timber forest products' seedlings and the loss of water sources' integrity (Qamer & Matin, 2019). These two phenomena constitute a problem because, along with poor irrigation systems and old technologies, water scarcity will put at risk cultivations and provoke food insecurity. In fact, among all households facing food scarcity due to climate change-related disasters in the last 5 years, almost 33% of them affirmed that this was due to drought (Central Bureau of Statistics, 2017).

In addition, Nepal is crossed by more than 6000 rivers and streams, that provide water for agriculture to communities living in the country. However, they also devastate entire lands and fields when these rivers overflow, putting at serious risk the population's livelihood, as it is a recurring natural phenomenon in the country. Climate change, causing a rainfall's intensification during the monsoon season, has contributed to increase the risks of flooding, erosion and landslides (Lanzavecchia, A. et al., 2021). Communities living in the Terai region observed that flash floods are the main climate-related extreme event in the area (Central Bureau of Statistics, 2017). As far as temperatures are concerned, they will be subjected to a general increase, that will be higher in areas in the North of the country, compared to temperatures in the South. Precipitations instead will increase during the monsoon period, while there will be a decrease during the winter season (Singh, S. et al., 2011). In fact, climate change has altered the already frail existing

conditions, on one side changing the frequency, intensity and duration of monsoon and on the other causing an increase of the temperature, which, in turns, fastens the melting of the snow and glaciers (Lanzavecchia, A. et al., 2021).

Many economic domains such as *"energy, agriculture, water resources, forestry and biodiversity and health"* (Asian Development Bank, 2021) are experiencing the consequences of climate change; in fact, the Asian Development Bank (2021) estimated a loss on the yearly GDP of a percentage of 2,2% by 2050, because of the climate crisis *(ibid)*. Almost 80% of the population of Nepal is living in rural areas (Statista, 2022), where agriculture is an important component of families' households (Lanzavecchia et al., 2021). However, in 2019, agriculture counted just the 25% of the country's GDP, as major part of the people are employed in the service sector (Statista, 2022). The impact of climate change on agriculture has been very relevant on the lives of many rural communities in Nepal, that were basing their livelihoods on this activity. Farmers that are basing their means of subsistence on agricultural activities are more likely to experience climate-related hazards; in fact, their income generating activity extremely rely on the total amount of precipitations and on their variability (Central Bureau of Statistics, 2017). Also, water availability is reduced during the dry season, because of recurring drought phenomena (Wester P. et al., 2019), hindering the capacity of farmers to cultivate their fields during the driest seasons. Farmers in Nepal are often managing and maintaining methods of irrigation through their individual initiative; in fact, the government is not responsible of managing irrigation systems (Wester P., et al., 2019). For this reason, irrigation for agricultural reasons is strictly linked to rainfalls and their variability, meaning that communities are more vulnerable to events such as droughts, floods and landslides that hinder their capacity of having good agricultural yields (Central Bureau of Statistics, 2017; Wester P. et al., 2019).

Because of all the aforementioned reasons, it is necessary to find adequate, affordable and effective solutions to counter these problems in order to ensure livelihoods for all.

2.3 Existing Strategies and Solutions to Cope with Climate Change in Nepal

The high vulnerability of Nepal led to several efforts aimed at enhancing the preparedness and at minimizing the impacts. On the side of the adaptation strategies, there are two types of adaptation: *autonomous* – individual actions to reduce vulnerability regardless of national policies – and *strategic* – policies and strategies planned at national level. In Nepal, the former is much more developed on a daily basis, but it is a poorly documented informal sector. Thus, it is difficult to extrapolate clear data about all the collective responses implemented by local actors. Among them there may be changes in technologies, financial opportunities such as micro-insurance, micro-credit, and diversification of livelihood systems (Bartlett, R.& Co, 2010). As far as agriculture is concerned, some adaptation measures have already been applied, such as *"diversifying crop species, rotating crops and seasons, best selection of seeds for the changing agricultural land properties, altering planting time, adopting chemical fertilizers, promoting mixed cropping systems"* and greenhouses (Adhikari, D. et al., 2021; IPCC, 2022). Also, to cope with water unavailability, some innovative technologies regarding irrigation have already been implemented, to manage and store water (IPCC, 2022).

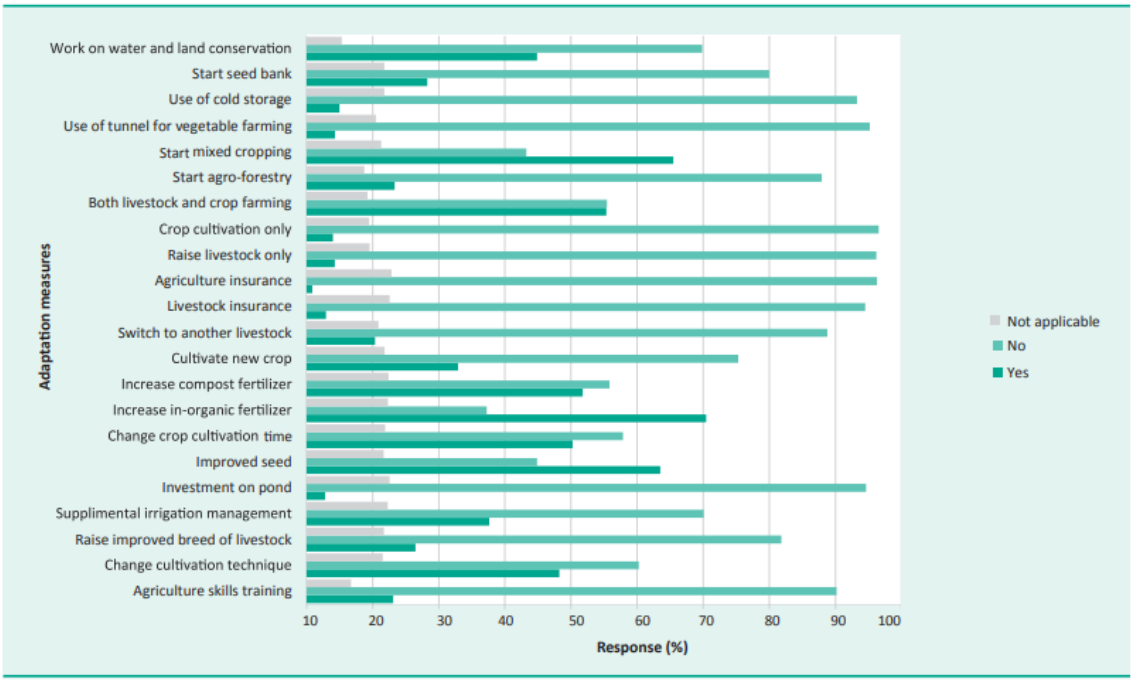

Table 2. Adaptation measures for agriculture that have been implemented during the last 25 years (Central Bureau of Statistics, 2017)

The CBS study (2017) conducted in Nepal reveals that many adaptation solutions have been implemented in the country in the last 25 years. The most implemented solutions have been the employment of inorganic fertilisers, the agricultural solution of mixing crops and the use of improved and new yields (CBS, 2017).

Adaptation has been increasingly seen as a tool to cope with actual and expected climatic effects and impacts in terms of social, ecological, and economic systems. It is a mean aimed to achieve resilience by focusing on the elements that constitute the robustness of the whole system subjected to vulnerability: communications, transportation, finance, economic diversification, education, organization and representation, knowledge generation, planning, and learning (Asif, D, 2009). Insofar to the worsening of the situation, adaptation is insufficient to prevent negative impacts produced by climate change. Therefore, actors at international and national level have started to consider the existence and application of a different approach, through the adoption of Loss and Damages instruments.

2.3.1 Beyond Adaptation, Loss & Damages Instruments

The core of the concept of Loss and Damages is that some risks are residual and related damages are unavoidable. It is aimed to go beyond the adaptation approach, meanwhile it is based on risk tolerance. Loss and Damages provides for the implementation of efficient measures to strengthen the capacity building of affected local communities. Therefore, risk assessment abilities of those facing climate negative impacts need to be powered. However, the financial efforts invested in this instrument is scarce and this is pushing the most vulnerable states to search for alternative solutions (Pradeep, B., & Prabin, M. S, 2020). L&D is controversial and continuously discussed within international climate change negotiations. For the purpose of this thesis this aspect is not deepened, but it is relevant to state that there have been identified three main guidelines*: a) Polluter-Pays, b) No Harm Rules, c) Common differentiated responsibilities and respective capabilities* (Lanzavecchia A. et al., 2021). However, the financial efforts invested in this instrument is scarce and this is pushing the most vulnerable states to search for alternative solutions (Pradeep, B., & Prabin, M. S, 2020). However, Loss and Damages is linked to human rights obligations. Therefore, a human

rights-based approach is needed for addressing Loss and Damages. It means that Loss and Damages should be tailored within the framework of international human rights law. This corresponds to a preventative approach that is more efficient since it avoids human rights violations (Lanzavecchia A. et al., 2021).

On the side of the Loss and Damages instruments, there have been some instruments configured such as the Early Warning System, embankments construction, safe shelters, and elevated drinking water taps (Bartlett, R.& Co, 2010). However, the concept of Loss and Damages has been recently considered in the policy of Nepal. The National Climate Change Policy 2019 indicates further climate-induced losses in the future. It primarily focuses on mitigation and adaptation, which is limiting if one takes into account the considerations mentioned above. In addition, it is difficult to understand if measures already taken such as insurance, social security, post-disaster resettlement and reconstruction have been targeted to build adaptation or to go beyond it, thus addressing Loss and Damages. This policy only mentioned the need for regular assessment and maintenance of a database showing financial and non-financial loss and damages. Other choices possibly taken within this framework are the 2017 Disaster Risk Reduction and Management and the 2018 Disaster Risk Reduction National Policy. Similarly, in 2017 the Local Government Operation Act 2017 defined the roles and responsibilities of local governments. Yet, an institutional system has been set up in order to assign roles and responsibilities to different levels of national governance (Pradeep, B., & Prabin, M., 2020).

So far, there have been identified *a) tools used by climate change adaptation communities* and *b) tools used by disaster risk reduction communities*

Among “(a)" there are vulnerability and Risk Assessment Framework, National Framework for Local Adaptation Plan of Action, Climate Vulnerability and Capacity Assessment.

Among “b)” there are Local Disaster and Climate Resilience Plan, Initial Rapid Assessment, Multi-Cluster Initial Rapid Assessment, Cluster Specified Detailed Assessment, Post-disaster Needs Assessment (Practical Action, 2021).

A further instrument within the framework of Loss and Damages is that of insurance. In Nepal, there are two types: indemnity insurance and index-based parametric insurance, providing compensation for Loss and Damages. The most used is the first type and it

covers the pre-agreed hazards and multiple risks. Among the climate-based hazards, the following are those officially acknowledged: fire and thunderstorms, floods, inundation and drought, landslide and erosion, windstorms, hailstorms, snowfall and frosts, insects, and diseases. These hazards have been identified specifically within the Agriculture and Livestock Insurance Programme (2013) (Practical Action, 2021). Overall, solutions based on Loss and Damages are insufficient and there is no clearness on how slow onset events are assessed. The existing methods do not distinguish acceptable, tolerable, and intolerable risks. They mainly focus on adaptation and disaster risk reduction. Hence, the principle to go beyond adaptation is not assessed. Similarly, tools do not explain the modality through which addressing residual risks. In addition, insurance schemes are limited and non-comprehensive in terms of climate change impacts. Definitively, Loss and Damages in Nepal lack financial resources in order to be developed.

2.3.2 The Role of Microfinance as a Climate Change Oriented Tool

Microfinance products useful to address climate change and facilitate adaptation include microcredit, micro deposit, and microinsurance, which may be integrated to some degree with non-financial services (health and education). This paragraph will illustrate existing microfinance solutions to climate change in Nepal, addressing the advantages and the shortcomings of such strategies.

In Nepal, microfinance is divided into three main segments: formal, semi formal, and informal. The formal one is made up of commercial banks, development banks, finance companies and rural microfinance banks. The semi formal category is populated mainly by Small Farmers Cooperative and Savings and Credit Cooperatives (SACCOSs) and NGOs. The informal category is given by informal savings and credit associations, money lenders and cohort groups. Among them, the informal sector is the most used meanwhile microfinance through formal institutions such as banks is the least developed (The Banking with the Poor Network SEEP Network & SEEP Network, 2009). The financial system of Nepal and the availability of financing tools are basic. The range of products and services at disposal of possible clients is limited and loans consider the short and the mid-term (Köhn, 2012). By a study conducted in 2017 (CBS, 2017), 51,31% of individuals did not belong to any cooperative association or savings groups. As far as different ecologic belts are concerned, households living in the mountains are those who

mostly belong to cooperative and saving groups. Many communities that are highly vulnerable to climate change hazards are not member of any Microfinance Institution (almost 50% of people living in these areas) *(ibid).* As already mentioned, the majority of Nepali population lives in rural areas and gets its subsistence through farming. Therefore, they have the possibility of being strongly impacted by climate change-related negative impacts such as floods and droughts. Microfinance Institutions should set up risk management strategies, as a considerable quota of capital to be prepared for possible major natural disasters (Lanzavecchia, A. et al., 2021).

Green microfinance is at an early stage in Nepal. Green loans are the sustainable financial instrument used by the banks and financial institutions (BFIs) in adopting green lending practices (Agrawala, S., et al. 2010). Recently, BFI's have decided to incorporate climate risks and assess sustainability of the projects when lending money (Nepal Economic Forum). Some microfinance products exist to intervene and face risks posed by climate change. *Microinsurance* is one of the tools used by Microfinance Institutions to face climate change and increase climate resilience. Microinsurance products already exist in Nepal and they are offering protection in form of emergency funds to clients of Microfinance Institutions for many risks that vulnerable people could face such as *"death, death of the spouse or close family members, losses due to damages to the housing because of hazardous natural disasters"* (The Professional Consortium, 2017). They are already offering tools such as *"Social Protection Fund products, life, credit/life, healthcare, accident/disability, livestock and crop insurance"*. Furthermore, few disaster management and disaster reliefs programs are provided by different Microfinance Institutions. The Development Bank (in connection with Oxfam GB) offers a River Basin Program in the Sindhuli province, often impacted by floods. Among their objectives, they increase awareness and knowledge on how to be prepared for disasters of this kind and they coordinate stakeholders and people impacted by floods during and after the disaster. Another example of a disaster management program is the Emergency Loan program, provided by a Credit Cooperative, specifically related to addressing climate change disasters (Agrawala, S., et al. 2010).

Microfinance programs existing in Nepal are addressing different problems affecting the population, such as the shortage of water resources, sanitation and agriculture. However, microfinance activities and products existing on the Nepali territory are not directly addressing vulnerability to climate change. Nevertheless, these activities can have an impact on a poor segment of the population, which is also impacted by climate change,

thus indirectly addressing climate change vulnerability. The result is that 41% of programs in Nepal are completely not linked with adaptation. In fact, the existing products are mostly development activities, which have few or no objective to create climate-resilient communities, but that indirectly address populations sensitive to dangers created by climate change. Existing solutions could therefore be expanded and enhanced to create this missing link with the creation of resilience to climate change (Agrawala, S., et al. 2010). Another recurring problem when talking about existing solutions to diminish climate change related vulnerability is the geographical distribution of microfinance projects; in fact, many regions are less populated than others and many people live in remote areas (Nepal Rastra Bank, 2013). The lack of infrastructures, the limited access to other markets and the isolation of segments of the population are factors that have contributed to not equally developing microfinance programs in every part of Nepal (Lund-Thomsen et al., 2019). The result is that the portfolio of existing projects in these areas is limited (Agrawala, S., et al. 2010). and the existing activities are in the informal financial market which cause small-size, short-term transactions and higher interest rates (Lund-Thomsen et al., 2019).

As far as microinsurance is concerned, products are at disposal of clients both in urban and rural areas of Nepal; however, hill and mountain areas are not entirely covered by microinsurance (The Professional Consortium, 2017). To mention an example, the Koshi Tappu floodplain located in the South-Eastern area of Nepal, is usually hit by floods and other major events; the absence of microfinance services as microinsurance in this area of Nepal makes poor people even more vulnerable. In this case, microinsurance would protect their belongings against natural disasters. Vulnerability is therefore increased by the incapacity of poor people to have access to microfinance. (Dula et al., 2010). Eventually, microfinance is not always the useful tool to address adaptation on a large scale. In the specific case of microinsurance, the range of choice of different existing microinsurance products is still restricted and their effectiveness is not certain; in fact, monitoring and administrative procedures of microinsurance are very expensive. However, expanding this perspective to other microfinance projects, we can consider that most of the adaptations need financial means and technical knowledge that overcome the potential of microfinance; in fact, international donors and national governments should be the first entities in charge of setting up this type of projects. Despite this, microfinance could be important to expand the portfolio of existing activities, support the work of

international donors and government and create smaller-scale solutions and community-based interventions (Agrawala, S., et al. 2010).

Conclusion

This chapter provided an overview of the climate characteristics of the Hindu Kush Himalayan region, narrowing the focus on Nepal. Climate change is having different impacts on the country, pushing communities to find new tools to cope with the contemporary challenges, that put greatly at risk resources, natural environments and supplies. Adaptation has emerged as an instrument that can be helpful to create climate resilience in communities affected by the detrimental impacts of the climate crisis. Nepal still does not possess the sufficient financial means to develop Loss and Damages instruments, that could go furtherly beyond the concept of adaptation, being based on risk tolerance. In addition, adaptation solutions exist and have already been implemented, but they are mostly individual and autonomous initiatives that are not supported through concrete funding possibilities and efficient national adaptation plans. Green microfinance could have a role in Nepal to reduce climate change risks and cope with its impacts, however it is still not efficiently developed in the country. In fact, many microfinance products of Nepali Microfinance Institutions are not linked with adaptation solutions. However, microfinance in this context could be helpful to create local adaptation solutions and to deal with climate change at the community level.

Having considered these premises, the purpose of the thesis is to illustrate a possible project within a framework where microfinance could potentially take the role of climate change-oriented tool. Specifically, the project proposal that will be enshrined in the next chapter took inspiration from a part of India that shares common morphological and geographical features with the mountainous region of Nepal.

CHAPTER 3: Ice Stupas in Nepal as a Climate Change Adaptation Strategy

Introduction

As underlined in chapter 2, Nepal is facing many climate challenges that are occurring in the entire Hindu Kush Himalayan area - such as floods, droughts, and landslides. Following these premises, this chapter will analyse how microfinance could be used to tackle climate change challenges at the local level, through the implementation of adaptation strategies. In particular, it will focus on a specific adaptative solution, namely the "Ice Stupa".

Ice stupas are artificial ice structures that can store water during the winter season. In spring, water melting from the ice structure becomes available for the community, allowing villages to face increasing drought and water shortages challenges. The first prototype of an ice stupa has been implemented in the Ladakh Valley, in India, conducting to a successful management of water resources. This solution has been implemented in other areas of the world, to face climate conditions that were similar to those in Ladakh. In particular, Nepal is among the countries that adopted ice stupas to face the increasing drought occurring in the North, that is putting at risk livelihoods of several communities living in high mountain areas.

This chapter will further examine this first implementation in Nepal, assessing whether or not it has been successfully and useful to the community, and how microfinance could be helpful in addressing the limitations encountered, promoting community engagement and a sense of ownership of the asset. Through the examination of the specific case study of ice stupas in Nepal, the chapter will investigate how microfinance can be used as a tool to promote climate change adaptation at the local level.

3.1 Ice Stupas: An Overview

The first prototype of an ice stupa was invented by an engineer living in the Ladakh Valley. The hostile conditions of the area where he is living brought him to find a solution to increase water availability during the spring season, that is the period when communities living in Ladakh do not have sufficient resources to irrigate their lands. In fact, Ladakh is located in one of the driest areas of the Hindu Kush Himalayan region. According to data of 2018, only 28% of the population was taking advantage of agriculture as their first means of subsistence. Indeed, many persons have started diversifying their livelihoods, migrating to other areas to find better jobs during specific periods of the year. However, an existent rural community is still living in the Ladakh region, resisting to the extremely harsh weather conditions. People living in the area have been strongly impacted by the translocality of many households. In fact, "*these trends pose risks for households who lack financial assets and a workforce and rely on reciprocal labour*" (Dame, J., 2018). The inventor of ice stupas has the desire to create the conditions that allow people to continue living in the mountainous region of Ladakh, adapting to a changing climate, to the increasing weather challenges and continuing to rely on agricultural practices, as means of subsistence.

3.1.1 Climate Change in the Ladakh Valley and Water Management Strategies

The Ladakh Valley is a 470 km valley between the Himalayan and Karakoram Mountain ranges in Northern India, where 300,000 people live up to 4,000 meters above sea level (Clouse, 2016). It can be considered as a high-altitude desert and the westernmost area of the Tibetan Plateau (Nüsser, M. et al., 2019). Its geographical position, that is among Himalayas, makes the Ladakh valley one of the driest and coldest mountainous areas in the world. Rainfalls occur mainly during the monsoon season, as in the rest of the Hindu Kush Himalayan region, and the annual snowfall rate rarely exceeds 100 milliliters (Clouse, 2016). As far as glaciers are concerned, the general observation

is that they are retreating since the 1960s (IPCC, 2022). In fact, due to climate change almost 20% of the glaciers in the area have been lost in the last 50 years (DW News, 2019). As rainfalls are lowering during winter and summer, and glaciers are diminishing their area, water shortages are occurring. In the Ladakhi desert, water coming from glaciers and rainfalls is an essential component of the survival of agricultural activities. Irrigation channels are often used to have access to the water that is coming from glaciers that are positioned above the communities (Sharma, A., 2019). The result is that many populations rely on streams to irrigate the crops in spring and summer (IPCC, 2022). In this area, the survival of rural communities depends on the diversion of meltwater from glaciers used to irrigate crops (Clouse, 2016). *"Seasonal snow cover characterized by uneven distribution and duration contributes significantly to the runoff in spring"*, that subsequently affects water availability for the community (Nüsser, M. et al., 2019). Given the further decrease in rainfalls in the cold desert due to the action of climate change, the rural communities living in this area suffer a great lack of water used by households and for the irrigation of crops (Clouse, 2017). As water shortages are affecting many agricultural practices, different cities and villages in Ladakh are being abandoned (Times of India, 2020). In fact, recurring droughts have put at risk life quality of populations living in the villages.

Some adaptation strategies have been implemented to face the growing challenges posed by climate change. Some of them "*involve snow and ice, employing frozen design intervention that exploit annual freeze-thaw cycles to increase water catchment for farming*". Therefore, water storage is the solution that has been mainly implemented to face water scarcity. Adaptation practices adopted by the community are the result of a combination of traditional know-how and innovative techniques, that allow a better management of water resources (Clouse, C., 2016). In particular, communities living in Ladakh used four tools of artificial ice storing methods, that are "basins, cascades, diversions and a form known locally as ice stupas" (IPCC, 2022). These adaptative measures store water during the autumn and winter season, allowing the transformation of water in ice, due to low temperatures; then, they release the entire amount of stored water in April and May, when ice starts melting. These practices can be extremely useful to irrigate the crops during spring. Through the management of the amount of water that would not be used during the autumn and winter season, communities can address water shortages during the remaining seasons of the year. The first ice storing method is the

frozen basin; it is built thanks to water that "*is conveyed across a slope through channels and check dams to shaded surface depressions near the villages*" *(ibid)*. Concerning cascades and diversions, they convey water to stone walls; hence, the flow is slowed down, and water can be transformed into ice. Eventually, ice stupas allow water to freeze during winter in a cone structure, that will then melt during spring, when the population demonstrates an extreme necessity of water to irrigate their lands. According to the IPCC (2022), ice stupas are an effective method to face drought and water shortages periods. The advantages of these storing ice methods are a greater availability of water during April-May, an improved access to water and the reduction of failure in agricultural yields *(ibid)*. In the Ladakhi desert, ice stupas are the example of a new model for climate adaptive design thinking. In fact, the region's dwindling supply of meltwater led to the creation of a new water management strategy. Providing a reservoir of water for agricultural use, Ladakh's ice stupas reveal a sophisticated response to the environmental constraints (Clouse, 2017).

3.1.2 The First Implementation of an Ice Stupa

Ice stupas are man-made glaciers that allow to store winter water for use in the dry months when meltwater is scarce. This storing method is created by freezing vertically the water coming from a stream, onto a structure that has the form of a high ice cone of about 30-50 meters that looks very similar to local sacred structures called Stupa or Chorten (Maheshwari et al., 2019). This solution is not completely new, as it can be traced back to the ancient practice of "glacier grafting", used by the ancestors and to the more recent building of "artificial glaciers". Before the ice stupas, the planar ice reservoir is the most widespread type, acting as a frozen lake. However, this system had several drawbacks: it requires very high-altitude locations, which sometimes make difficult maintaining the frozen lake in a north-facing valley that can shade it from the spring sun. To address these challenges, an Indian engineer named Wangchuk started learning techniques such as 'glacier grafting', which attempt to artificially grow glaciers. He also followed the activities of the Ladakhi civil engineer Chenwang Nortphel, who had worked to store glaciers' water in vast ice fields (Griffin, 29 December 2014). After having noted the presence of ice under a bridge in May in Ladakh during summer at a

low altitude, the engineer Wangchuk realized that ice could last for a longer time if it is not exposed to the direct sunlight. Since it was not possible to provide shade to large bodies of water, Wangchuk freezed and stored the water in the form of a cone, a geometric shape that offers minimal surface to sun exposure and allows for the collection of a large volume of water (Maheshwary et al., 2019). During one of his interviews, he affirmed*: "High school math told me that a cone was the simple answer"*. (Winkler, A., 2022).

In October 2013, Wangchuk - in collaboration with the SECMOL Alternative Institute - built the first prototype of an ice stupa 6 meters high in a month, freezing 150,000 liters of water in the Indian city of Leh, without any protection from sunlight. To demonstrate that the prototype would work in any environmental condition in Ladakh, they chose a spot fully exposed to sunlight and placed it at the lowest possible altitude of the entire Ladakh valley (Maheshwary et al., 2019). The ice cone was fed by a supply pipe, which had its headwork roughly 15 meters above the spot; the pipes were put in the stream, and they conducted water to the place where the ice stupa was constructed (Rolex Awards for Enterprise, 2016). A water flow was diverted from the mountain by exploiting the gravity force with no use of electricity or any other kinds of machinery to pump the water. Also, the pipes were buried six feet underground to prevent freezing (Maheshwary et al., 2019). Once the water reached the site, it came out from the pipe because of gravity and pressure (Rolex Awards for Enterprise, 2016). In that moment, the fountain on top broke the water into tiny droplets which, froze to form ice and snow because of below 0 temperatures, becoming a high mountain of ice and forming the ice stupa (Maheshwary et al., 2019). The head of pressure forced water to sprinkle (DW News, 2019). The ice stupa did not completely melt until May 18th, -even when the temperature was above 20° C- and still provided water to the land, exceeding the most optimistic expectations. In fact, 1st May was considered as the ultimate due date to judge the experiment successful. At the end of the project cycle in 2014, the team that collaborated to the Ice Stupa Project shared their findings and observations with the Ladakh's communities and all the key actors involved, through conferences, reports and sharing moments (Clouse, C., 2017). After this success, the first ice stupa was inaugurated in March 2015 near Leh. The project costed 100,000 dollars that were obtained through a crowdfunding campaign, and it allowed to store two million litres of water. This ice stupa started to melt in April 2017, allowing to irrigate an entire poplar plantation (Maheshwary et al., 2019).

Wangchuk has been refining and teaching the concept of the ice stupa at the environmental mountain school for the last years. In one of his interviews, he affirmed: *"I want to engage youth in schools to be sensitive to the environment in the mountains, so that the world can go in safe hands"* (DW News, 2019). In this moment Wangchuk is planning to build 50 ice stupas in the region; each ice stupa will produce *"10 million litres of water a year irrigate 25 acres of land"* (Strochlic, N. 2021). Thanks to his innovations, Wangchuk won a prize from the Rolex company in 2016 of the value of £80,000 (Brian, H., 2021); his desire is to use the prize to build a university focused on research and environmental problems in the Himalayas *(ibid).* In fact, the area where Ladakh is located does not possess a university and many young people migrate to farther main cities in search of a better academic pathway. Wangchuk would like to find local solutions for climate change adaptation, so that the next generations could be in the condition to remain in their territory dealing with its harsh conditions. He is strongly convinced that adaptation can be a winning practice in the region, claiming: "*Things that work in New York or New Delhi do not work in the mountains. We have to find our own solutions for our problems*" (Strochlic, N. 2021). The intensive work of entrepreneurs in the region, volunteers and people engaged in the Civil Society have influenced the perception of the community face to problems caused by climate change. Now the community wants to take part in the mitigation and management of the water crisis occurring in their region (Kumar, S., 2019). In fact, today ice stupas are accepted by the community that would like to invest in this solution, but it has also become a touristic attraction for the people that visit India (Clouse, C., 2017).

The community had a great benefit from the construction of the ice stupa; indeed, it was built right on the outskirts of villages, close to the fields where water is needed (Rolex Awards for Enterprise, 2016). During summertime, populations can usually benefit from water that is melting from the glaciers. However, farmers are extremely in need of water during the months of April and May, when glaciers are not yet providing meltwater to the community; for this reason, water scarcities usually occur in spring. These weather conditions are being exacerbated by the impacts of climate change, that is responsible of more recurring drought periods. Water stored by the ice stupa is particularly useful during the driest periods of the year. In fact, the ice stupa allows the melting of winter water exactly during the months in which farmers have an extreme necessity of water for crops' irrigation. Therefore, it can be argued that ice stupas allow people to use the water stored

by the ice stupa for the timely irrigation of their fields (DW News, 2019). Ice stupas that are built at a lower altitude melt more rapidly than ice stupas built at high altitudes. As a consequence, farmers can better manage water flows in the months of April and May to irrigate their lands (Sharma, A., 2019). Ice stupas could bring additional useful water to many communities that need to employ it in the agricultural sector. As the first implementation in Ladakh demonstrated, the construction of an ice stupa can create the possibility irrigate the lands and to grow some new trees in areas that are completely dry and desertic (Clouse, C., 2017).

The design of the ice stupa is critical for its own success; in fact, it must provide a minimum surface area to provide a maximum protection from the sun, in order to survive until spring. If the ice stupa was a flat glacier, it would melt too fast. By building it in the form of a cone, and with a minimum surface area, 2 million litres of water can be stored into the ice stupa (DW News, 2019). The supporting structure is a geodesic dome, which gives structural stability and conical shape to the ice stupa. Construction of the dome is done using randomly stacked sea buckthorn twigs (Maheshwary et al., 2019). Thanks to their size and shape, these structures are particularly efficient - releasing millions of liters of water every year - easy to maintain and with less effort and cost (DW News, 2019). The hope is to reglaciate what has been lost because of glaciers' retreat and adapt to a changing climate (Rolex Awards for Enterprise, 2016). Although ice stupas allow communities to manage existing water resources, they cannot create new supplies when they will disappear. This is extremely concerning as natural glaciers are retreating to a higher rate and it will be more and more complex to construct and preserve artificial ones. In fact, other solutions including mitigation and adaptation practices should be implemented at the global level to address glaciers' retreat, that will also impact on the capacity of people to manage water in the long-term (Clouse, C., 2016). According to the Himalayan Institute of Alternative Ladakh, water flows produced by glaciers will be sufficient just for 10 years in the best-case scenario; therefore, this adaptative solution should be also complemented by mitigation actions (Kumar, S., 2019).

To conclude, ice stupas are accessible and affordable methods to address climate change at the local level; in fact, they are constructed using local supplies and materials, indigenous knowledge and local workforce (Clouse, C. 2016). The Ladakh region is now hosting 25 ice stupas (DW News, 2019). Nevertheless, their characteristics make that ice

stupas could be recreated in many different environments of the world. They can be built in any village, community or area that freezes during the winter season and in any type of ground providing a channelled water stream (Clouse, 2016). This adaptative strategy could be scaled up to be employed in similar contexts that are dealing with water shortages during specific seasons and that rely on agriculture. Even if this solution has been planned for the Ladakh context, it could be transferred at the global scale and implemented in other parts of the world where climate conditions are similar. Ice stupas in Ladakh can be transposed in other countries to address climate change challenges, *"eliciting creative responses and exploring survival strategies on a changing planet"* (Clouse, C., 2016).

3.1.3 The Ice Stupa as a Scalable Solution Worldwide

The innovation of Ice Stupas of Ladakh has reached other parts of the world, thanks to social media and information spreading. Many international newspapers and media have already started talking about this innovative solution, as a local form of adaptation to climate change, including The New York Post, National Geographic and The Guardian (Sharma, A., 2019). Information and dissemination have also reached academics and researchers, that decided to reproduce this solution to tackle climate change-related problems that were similar to those in the Ladakh region, such as water shortages and drought periods. They have been mainly individual initiatives, but the scalability of ice stupas should be considered as a great success, especially considering future possibilities and applications of this local-based solution.

Firstly, Chile has collaborated with the team of the Ice Stupa Project in Ladakh to build the Nilus ice stupa, addressing water shortages of Andes and securing water in the region. The idea of Ladakh has been replicated in Chile by a multidisciplinary group of more than 40 people made of glaciologists, geologists, hydraulic engineers and computer scientists. They Nilus project was born as a response to the water crisis, caused by the changing climate. In the winter months of 2020, the first pilot of the Nilus project has been implemented in Parque Arena, an area of the Cajon del Maipo that is close to Santiago de Chile. It is located in one of the valleys of the Andes Mountains; precisely

there, this team initiated a process of water storage, which was redirected downhill. The project team was able to create an ice stupa approximately six meters high, which is the equivalent of 50 cube metres of stored water. The team would like to scale the pilot project to implement it in other locations of Chile, creating the first water park of the country. Ideally, it would be composed by 50 ice stupas of approximately 20 meters high. The construction team estimated that 50 ice stupas could provide water for almost 12,000 people (Núñez, R., 2022). As in Ladakh, water stored by the ice stupas would be used mainly in the agricultural sector (Simfruit, n.d.). Enrique Gellona, that is the project manager of Nilus Ice Stupa affirmed: "*Nilus seeks to help resolve the huge water crisis that we are facing both in Chile and the world*". The area of Parque Arena is facing the same climate-related impacts of Ladakh, as glaciers in the Andes are increasingly retreating (Reuters, 2021). Today Chile is hosting more than 24,000 glaciers; however, only three of the total number continue to grow every year. Ice stupas can be considered as an alternative to the accelerated retreat of glaciers in Chile, as they enhance water availability and water access during water scarce periods (Simfruit, n.d.).

Picture 1. The Nilus ice stupa in Chile (Reuters, 2021).

Ice stupas have been reproduced also in the European region, in particular in Switzerland in the Oberengadin area, where mountains can reach up to 4000 metres. The team in Switzerland strictly collaborated with engineers, technicians and project managers in the Ice Stupa Project of Ladakh to recreate it in their territory. The first ice stupa of Europe has been built in 2018 in Val Roseg, in the middle of Swiss Alps, at an altitude of 2000 metres and it was 12 metres high. After the learnings of the first implementation in Val Roseg, many ice stupas were constructed in Val Morteratsch (Oerlemans, J., et al. 2021). The project aims to draw attention to glaciers' retreat and to offer a solution on how to conserve water. Meltwater coming from the ice stupas during spring was eventually used to irrigate the lands in the region (Academia Engiadina, n.d.). The collaboration between the team of the Ice Stupa Project in Ladakh and experts from Switzerland brought to the development of Ice Stupa International, that is an international branch of the Ice Stupa Project in Ladakh. The two teams are now spreading conferences and dissemination events, to raise awareness around the globe about this possible adaptation method. Swedish experts and scientists are now collaborating with the Himalayan Institute of Alternatives trying to implement this solution in their territory (Kumar, S., 2019).

3.2 The Construction of an Ice Stupa in Nepal

Nepal presents climate characteristics that resemble to those in the Ladakh Valley. In fact, climate change is hindering the capacity to have access to water for irrigation and domestic use during all the seasons of the year. A Nepali association based in Kawasoti, named Videh Foundation, contacted the team of the Ice Stupa Project in Ladakh with the aim of implementing a similar solution in the territory of Nepal. Thanks to a joint action with the experts of the Ice Stupa Project in Ladakh, they succeeded to build the first ice stupa of Nepal. The area of construction of the ice stupa is the Mustang District, a region having climate features that are similar to those in Ladakh and that is facing the exact same climate change-related challenges, such as increasing drought, migration of the population due to hostile climate conditions and the difficulty to carry agricultural activities. Many villages have already been abandoned, and the area is becoming a great desertic land. However, some communities continue living on the Mustang territory,

dealing with extremely hostile climate characteristics and carrying forward traditions of this this high mountain area. Therefore, ice Stupa has been identified as an effective solution that could help the communities living in this region to deal with the increasingly harsh conditions and climate change-related impacts.

3.2.1 Impacts of the Water Crisis in Mustang

The Mustang District is located in the Gandaki Province. It is considered one of the most inaccessible areas of Nepal, as it is positioned in the middle of Himalayas. In fact, Inhabitants of Mustang villages have insufficient essential services, because of the remoteness of the district (Khattri, M. B. et al., 2021).

Figure 3. Representation of the location of Mustang in a map of Nepal (Rijal, H. B., 2021).

Figure 3 clearly represents the location of Mustang, which is in the Northern part of Nepal, in the Himalayan region.

The difficulty in reaching Mustang and its remoteness make that this area of Nepal is concerned by a few numbers of research and studies. However, the climate features of Mustang and its changing weather conditions can be identified, thanks to the few available data (Khattri, M. B. et al., 2021). Mustang is located in the Trans Himalayas,

in the rainfall shadow of the Dhaulagiri Mountain and Annapurna; these mountains hinder the passage of the clouds that are responsible of precipitations. Consequently, Mustang is one of the driest areas of the country; in fact, it has an extremely low yearly rate of rainfalls, with an average of two hundred millimetres per year (Dudock, Y., 2022). The exact place where the first ice stupa of Nepal has been implemented is the Chhoser Village, where the annual rate of rainfalls is 200.8 mm. The area can be clearly identified in Fig.4, in the Eastern part of the map. As the entire Mustang District experiences a dry climate, the number of cultivated fields is not high; however, territories that are being cultivated, are *"managed almost as fertile oasis"* (Khattri, M. B. et al., 2021). In fact, the name 'Mustang' comes from the dialect of the area, meaning 'fertile plain'. Agriculture is one of the main sources of livelihood in this area, along with tourism and seasonal activities. Harvesting only takes place during spring, which is the reason why harvests and yields do not vary greatly. Also, "*there is quite short, but peak sowing and harvesting periods*" (ibid). Hence, water is not always available for timely irrigation. Changing weather conditions strongly affect the abilities of communities to have the necessary livelihoods. Therefore, when temperatures are highly below zero, many people from the communities living in Mustang migrate to towns and regions that are located further to the South of the country.

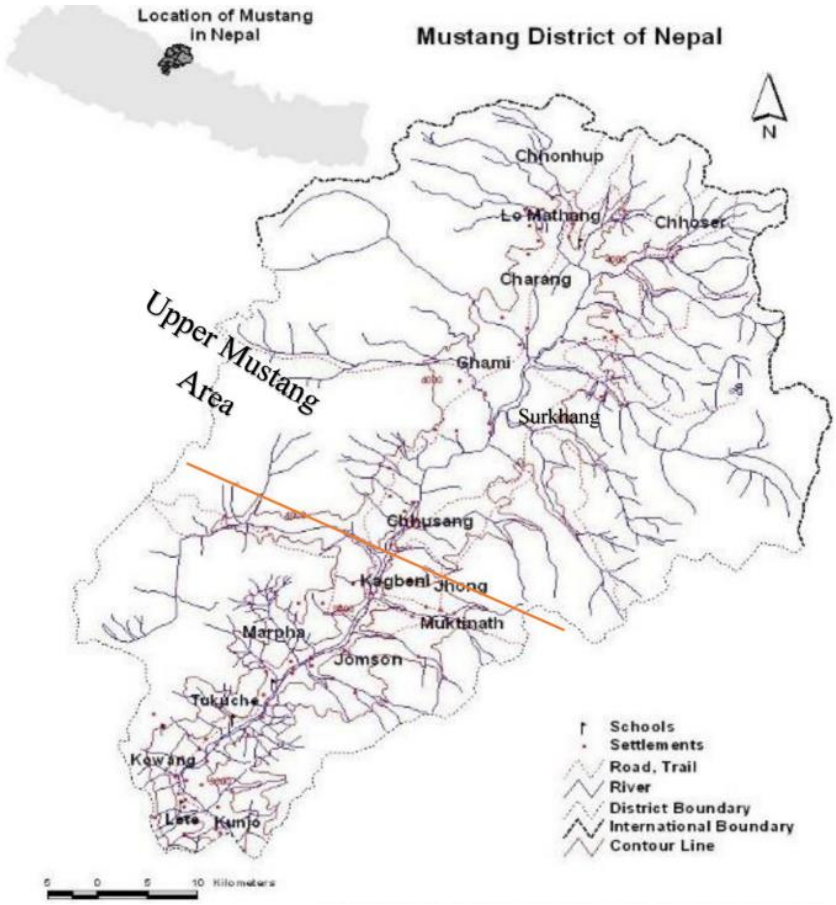

Figure 4. Map of different settlements and municipalities in Upper Mustang (Khattri, M. B. et al., 2021)

Climate change is exacerbating the characteristics of this remote place. Due to changing climate conditions, the number of precipitations and the temperature have increased in Mustang. However, rainfalls rates remain low. As far as temperature is concerned, it is rising at a rate which is up to five times the world average (Dudock, Y., 2022). The temperature's increase is causing a melting of snow during the winter season that has become faster, resulting in a growing runoff and in a lowered amount of stored water in the area (Khattri, M. B. et al., 2021). Precipitations also varied their usual pattern, causing unpredictability in the agricultural sector (Khattri, M. B. et al., 2021). A person from the Loba community living in Upper Mustang has been interviewed by a Holland journalist; he affirmed: "*Farming is a tradition; we have been supporting ourselves this way for centuries. Everything we have is given to us by nature. We know it well and are spiritually attached to it. My parents work the land every day, growing wheat, barley, buckwheat and potatoes. We also have two horses and a few cows. With the milk we make butter and*

cheese. We use the manure as fertiliser or dry it to burn in the stove. It is a hard and simple life." (Dudock, Y., 2022). Loba community is living in the municipality of Lomanthang, that can be identified on fig.4 in the Northern part of the map. According to him, the water that is supposed to be used by his community to irrigate the fields disappears even before sowing. Therefore, many plants do not even have the possibility to germinate. In addition to struggling with the lack of water, the Loba community also must contend with pests that attack the crops and with weeds that steal valuable moisture from the soil. Droughts and extreme rainfalls are occurring with an increased intensity. Traditional methods that have always been used to irrigate the fields, through channel systems, do not work when water shortages and floods occur. In fact, infrastructure in Upper Mustang was not built with the objective of facing these always growing climate change-related extreme events. Loba community claimed that the land does not provide anymore the sufficient reserves to face winter and survival is becoming every year increasingly difficult. Some villages have already been abandoned by the community, that cannot practice anymore agriculture in a complete desertic region. Many people would like to find solutions to remain and cultivate their traditions and the Loba culture, preserving the natural ecosystem where they live *(ibid)*.

3.2.2 Videh Foundation and the Transposition to Nepal

The Northern region of Nepal is entirely occupied by the world's highest mountain range, the Himalayas. As it has already been mentioned, this area is endangered by aridity and drought, which negatively impact not only the functioning of drinking supply systems but also the agricultural and socioeconomic systems. Many similarities in climate features and climate change-related extreme events can be identified between Mustang and Ladakh valley, where an ice stupa was implemented to address climate change-related impacts. Videh Foundation is the association that firstly identified similarities in weather conditions between Ladakh and Mustang; it is based in the municipality of Kawasoti in Nepal. I contacted the association in March 2022, after I discovered via Instagram that they constructed the first ice stupa of Nepal in the region of Mustang. After the first meeting with the Co-Founder, Raghav Pratap Thakur, it was immediately clear that the ice stupa had been efficiently constructed, but it had not been useful for water

management for the community living in the area, because of reasons that will be furtherly analysed throughout this paragraph. From March 2022 to October 2022, I collaborated with the association, thanks to the availability of my contact person inside the association, that is the Co-Founder. During this period, I had several meetings with Raghav Pratap Thakur to investigate the possibility of implementing a completely efficient ice stupa in Nepal. All information contained in this paragraph about ice stupa construction in Mustang has been taken by the continuous flow of information that Videh Foundation shared with me after the implementation phase of the ice stupa in Mustang.

Videh Foundation was created in 2007 to implement women empowering programs for marginalized communities living in Nepal; advocacy, trainings and workshops were delivered to enhance their autonomy and their life skills. Some of the projects of the association enhance education opportunities for the most marginalised children of Kawasoti. For example, they created in 2021 the "Happy School", which is a Montessorian school *teaching "moral values, respect for diversity and responsibility for the environment"*. The association has a strong collaboration with a German Charity, named Charity Clubber, that is financing many of their projects. The main areas of intervention are education, entrepreneurship and environment. Concerning climate change, they "envision to make the individual and the community as the green accountable citizens". [1] The construction of an ice stupa in Mustang, is based on this principle. Several actors were involved in the construction process of the ice stupa in Mustang. A joint triangular action among three teams in Germany, India and Nepal brought to the construction of this adaptative solution. In fact, Videh Foundation collaborated with Charity Clubber that contributed to the financing of the project and with HIAL in Ladakh, that mainly helped through technical support. After several meetings in which they evaluated a possible implementation of an ice stupa in the Mustang District of Nepal, they decided to implement this solution in the Chhoser Village at 4100 metres (fig. 4). The place was chosen as similar climate features and climate change-related extreme events were identified in both Ladakh and Chhoser. Also, the construction team considered Chhoser village as a place where local support from the community could be easily obtained. The very nice cooperation with the local government of the Lomanthang Rural Municipality was essential to implement this adaptative solution in the region. *"The*

[1] Further information can be checked at: https://www.videhfoundation.org/environment

local government seemed very satisfied with the whole project, and it is ready to invest their money in future ice stupas" (Videh Foundation, 2021).

The construction team firstly visited the site in May 2021 to verify the conditions of the terrain and to consider the feasibility of an ice stupa. Upper Mustang was found to be an ideal area of implementation, as many fields have become completely arid because of recurring droughts. After the site visit, engineers from Ladakh and experts and Videh Foundation's expert created a detailed survey. Also, Ladakh engineers provided the association with information on the equipment and resources required for the construction of the ice stupa. The source altitude was identified at 4094 metres and the ice stupa location at 4016 metres; therefore, the vertical offset was about 78 metres; the water flow was 4.3 litres per second during the first visit of the site. However, it was expected to drop down to 2.5-3 litres per second during winter. As the ice stupa needs to be implemented during winter season when temperature goes below zero, they considered this last measurement. The construction was supposed to start in November 2021; however, construction work has started during the first week of December 2021. During the site visit, the implementation team decided to take water from a source that was completely frozen when they returned on the area during the construction phase. For this reason, they identified a different water source, that was mainly composed by a mixture of spring and stream.

Picture 2. Water source at 4094 metres (Videh Foundation, 2022)

The ice stupa was constructed by the volunteers of Videh Foundation, the engineers from the HIAL and youth living in Chhoser village. The team walked to the water source, to carry water through pipes to the location of the ice stupa, which was about 78 metres below.

Picture 3. Making of Zing (pond) from the water source (Videh Foundation, 2022)

Then, they made a pond at the water source altitude; the pond is constantly filled up with water coming from the spring and the stream.

Picture 4. The construction team is bringing the pipes to the construction site of the ice stupa (Videh Foundation, 2022)

Pipes were brought to the ice stupa spot, to bring water to the place where ice stupa needed to be built. The Ladakh team of engineers provided Videh Foundation with instructions on the type of pipes required. In fact, a HDPE pipe is needed, that is a highly impermeable and flexible plastic pipe. The pipe should be in optimal conditions and 500 metres long. Compression couplers are needed if the HDPE pipe length is not 500 metres. They should be used if any other length is used, as winters can have an adverse impact on the equipment, and it often breaks. Compression adapters can be useful to join pipes of different diameters.

Picture 5. Different phases of construction of the ice stupa (Videh Foundation, 2022)

The construction of the dome went through several stages.

Firstly (in the 1st image), the backbone of the ice stupa has been constructed, and it is called tripod. The tripod was made by Galvanised Iron Pipes; it has the function to transport the siphoned water and to spray it over the geodesic dome structure. Galvanised Iron Pipes sprinkle water on the top of the ice stupa structure. On the base of the tripod, all other structures of the dome are built. The tripod is placed inside the dome, that can be made of various materials, such as wooden sticks (short and long), metal, PVC pipes etc.

The second picture follows the process of construction. In fact, Videh Foundation used a specific type of local tree to construct the dome that is available on that region of Nepal at a high altitude. This structure is used to support the tripod. During the construction phase of the wooden structure, the team had to ensure that there were just few gaps among the wooden sticks, so that it could support the weight of the frozen water.

The third picture represents the roof of the wooden structure; a fishing net was applied to the domed structure in order to increase the freezing surface of the ice to freeze quickly and achieve a base for the ice stupa during the early days of construction. The team used a biodegradable fishing net available on the local market, to increase the sustainability of the project. In addition, the fishing net was found to retain ice and snow for a longer period of time than plastic materials. Eventually, the Ladakh team provided the Nepali team with sprinklers designed by the team of the Ice Stupa Project.

The last picture shows the final phase of the construction of the ice stupa; when all equipment is set, water can sprinkle through the pipe and when it reaches below 0 temperatures, it freezes.

3.2.3 Learnings from the Construction of the Ice Stupa in Chhoser

The entire structure of the ice stupa was successfully created in four days. In April 2022, 80% of the ice stupa had already melt. Nevertheless, during the rainfalls' season, the pipes and the pond were largely impacted. In fact, around 40% of the pipes was damaged by a flood and the pond was dismissed. Also, some challenges emerged at the community level. Although the ice stupa provided a great amount of water in spring, the

villagers did not take advantage from the stored water to carry their agricultural activities. In fact, during the construction phase, few members of the community participated, and many of them were not completely involved in the process. Also, people who inhabited the area during the period of construction were few, as many of them usually migrate to Southern areas of Nepal because of the very hostile conditions during winter. Eventually, the villagers did not have any previous knowledge about the possible advantages of an ice stupa, and they had been reluctant to use it to carry their agricultural practices.

The lesson learnt here is the crucial role of engagement of the community as an essential part of the project, since it affects the construction, maintenance, and conservation phases. In fact, a plan for community engagement and participation process should be realised before starting the operations of construction of the ice stupa (Clouse, C., 2016). "*Since the village communities are the main stakeholders and know the area and its dynamic thoroughly, the first step is to mobilise them and to hold intensive discussions with them*" (Clouse, C., 2016; Norphel, 2012). This process helps the community to retain ownership on the construction of the ice stupa and on its maintenance and to provide essential information to technical experts that will help them implementing this adaptation solution. The lack of community participation in the project could in fact hinder the capacity of the ice stupa to really serve the needs of the villagers and the farmers *(ibid),* as in the case of the ice stupa in Chhoser. However, even if the community was not fully aware of the agricultural benefits of an ice stupa, it became an opportunity to enhance green tourism in the area. In fact, ice stupa became an attraction for tourists that were hosted in the hotels that are located in the village. Local hotels inserted the name of the ice stupa inside their list of sites seeing areas.

After this first implementation, I had several meetings with Raghav Pratap Thakur to understand how the learnings of their construction could be useful to implement another ice stupa in the Mustang region. The Co-Founder of Videh defined the first experiment in Chhoser as a "learning by doing" project, that built solid knowledge for future possible implementations. By these final learnings that emerged after the implementation, he identified some elements that are essential for an effective construction of an ice stupa. Firstly, the natural environment and the technical characteristics of the place of construction need to be adequate; the measurement of the weather, altitude, the water source and the flow of water need to correspond to the criteria that were underlined in the previous section. These characteristics allow the construction team to understand if the

ice stupa would work from a technical point of view and if the lands would have the possibility to be irrigated by the stored water. Secondly, as already mentioned, the team should investigate if the community has the desire to carry activities in the agricultural sector, to understand if they could be able to take advantages from this solution. The necessities of the population living in the area of construction can be investigated through surveys and interviews. Lastly, seeds that will be irrigated with the stored water of the ice stupa should be considered as appealing by the farmers; hence, they would have a return from their agricultural activities. These three factors should be matched, in order to build an effective solution that could be useful as a local adaptation strategy.

As far as the climate features and technical characteristics are concerned, the location where Videh Foundation decided to build its first ice stupa was ideal.

	Nepal, Mustang	**India, Ladakh Valley**
Location of the Ice Stupa	4016 metres	3200 metres
Use	Green tourism	Agriculture and green tourism
Temperature	**Winter:** about 0 to 5 °C. It drops from -25 to -20 °C at night **Spring**: during the days, the average temperature ranges from 15 to 21 °C[2]	**Winter:** The coldest month is January, with an average temperature of -3°C during the day and an average temperature of -15°C during the night. Peaks of 30°C are registered at night. **Spring:** ranging between 15 and 20°C during the day[3]
Season of construction of the Ice Stupa	December	November
Climate	Dry and cold	Dry and cold
Annual Rate of Rainfalls	200 mm[4]	100 mm[5]

Table 3. Comparison between ice stupa in Ladakh and ice stupa in Mustang

[2] https://nepalecoadventure.com/mustang-nepal-weather-and-temperature/
[3] http://icestupa.org/
[4] Dudock, Y., 2022
[5] http://icestupa.org/

In fact, Figure 5 demonstrates that from a geographical and technical point of view, the conditions of Mustang are very similar to those in Ladakh Valley, where water coming from the ice stupa was used to irrigate the fields in the area. Both places possess a dry and cold climate, they have an annual rate of rainfalls that ranges among 100 and 200 mm and they are both located above 3000 m. Also, temperatures are below the zero point during winter, while they become warmer in spring. These are the adequate conditions that allow the freezing of the stupa in winter, its melting during spring and the possibility to store water to irrigate the surrounding lands that are usually subjected to recurring droughts. Therefore, from a climatic point of view, the construction of an ice stupa of Nepal could potentially serve the agricultural scope. According to Videh Foundation, water stored by the ice stupa could be collected in a water tank to manage the amount of water for a longer period. Hence, the ice stupa could be transformed into a more long-term solution. Also, they identified that more pipes were needed, in order to build a higher ice stupa that could last until March, and that will not melt as fast as the previous one. Eventually, an important learning was that pipes, the plastics and ropes of the pond should be removed during the rainy season to prevent them from damages. Then, the equipment for the formation of the ice stupa could be reinstalled between October and November to reinitiate the slow formation of the Ice Stupa.

Concerning the community, the population now appreciates the value of the construction of the ice stupa, recognising its potential in adapting to a changing climate. Villagers would like to be involved in another process of construction in order to store water that could serve agricultural scopes. In fact, the community has realised that making an ice stupa in their area would not be a burden, as it would not require a great financial investment, and technical equipment and skills. During one of the last site visits that the working team of Videh Foundation conducted in Chhoser, the villagers manifested their necessity to grow potatoes in the area, that could be irrigated by the water coming from the ice stupa. Potato farming is often implemented in dry areas, as potatoes have a very high rate of harvest. Compared to other types of fruits or vegetables, potatoes are easier to grow, as they have very high agricultural outcomes. According to Raghav Pratap Thakur and his research findings, potato farming in the region would produce 70-80% outcome from the planted seeds. As reduced water availability resulted in lowered agricultural yields of potatoes (IPCC, 2022), ice stupa could be an effective solution to address these climate change-related challenges and to satisfy a great demand for this crop in the region. The planting of potatoes could be easily carried in a big barren land

area that would be located close to the ice stupa. Karma Dhindu, that is a local villager of Chhoser said during one of the interviews conducted by Videh Foundation: "*We really look forward to constructing a better ice stupa this year along with the support from local government and other donors. We are more excited to use it for irrigation this time, so that the locals would have more interest towards the Ice Stupa*." (Videh Foundation, 2022).

3.3 Ice Stupas and Microfinance: a Critical Analysis

Thanks to the learnings of the first implementation of an ice stupa in Nepal by Videh Foundation, this work aims to reveal that a microfinance-based solution could be adopted to build an efficient ice stupa in Chhoser village, that could clearly address climate change-related impacts. In fact, microfinance would be helpful to address the main issue that emerged during the first implementation by Videh Foundation, that is the lack of community's engagement in the process of construction and maintenance of the ice stupa. The project implementation in Chhoser was possible through the funding delivered by the German charity Charity Clubber, that allowed the purchase of all the equipment that was necessary for the ice stupa's construction. Instead, in Ladakh, the engineer Sonam Wangchuk raised 125,000 US dollars through a US-based crowdfunding website; around 330 contributors from 31 countries donated for the cause. Nevertheless, it can be argued that the funding based on crowdfunding endeavours and voluntary donations is an unstable financial model that could destabilize the system in the long run. Also, international donations that were provided to Videh Foundation to locally implement the project do not favour a long-term sense of ownership of the asset by the community.

In fact, international aid can be considered as a short-term measure, as claimed by Dambisa Moyo in her book "Dead Aid" (Della Faille, D., 2010). Moyo (2009) links the negative impacts of international donations to the dependency they create into societies that receive fundings. In fact, when projects end and funding stops, greater part of activities finish. According to her, international aid should be considered as a short-term intervention, as communities never become independent from external donations (Moyo, D., 2009). In one of her interviews, she affirmed that "*aid can provide a short-term*

solution, but it cannot deliver a long-term growth". Conversely, microfinance creates a logic of self-help that reduces vulnerability, creating financial independency (Swain, R. B. et al., 2010). Microfinance Institutions, in collaboration with associations, can deliver the technical equipment and technical skills trainings that communities need in order to undertake entrepreneurial activities and small businesses. The population invests a part of its capital in the asset, developing a sense of ownership on the resource that allow maintenance in the long run. Therefore, it can be argued that microfinance favours long-term solutions, and it should be considered as a valid alternative to crowdfunding-based and international donation-based projects.

Hence, this work is based under the assumption that microfinance could be useful to increase ownership and engagement of the community in all the construction and maintenance processes of the ice stupa, while at the same time decreasing climate change vulnerability.

3.3.1 Searching for an Income-Generating Activity

As already mentioned, the hypothesis of this thesis is that microfinance could be adopted as the tool to build a second and efficient ice stupa in Mustang, addressing water shortages occurring in the area. In order to use microfinance as a tool to finance the construction of the ice stupa, the ice stupa should produce an income generating activity, that will allow the community to repay the initial costs of equipment and human resources. Businesses activities that can arise from the construction of an ice stupa are many. As Wangchuk and Raghav Pratap Thakur both underlined, the construction of ice stupas is extremely economical and offers a maximum profit. The implementation in Ladakh is a very good example on how an ice stupa can produce a revenue. In fact, the community took advantage from the sale of the trees that were irrigated by the water stored in the ice stupa. According to Wangchuk, each tree can be sold at Rs 7,000. He claimed that "with good care, they attain their complete size in just five years. We planted roughly 5,000 trees at the ice stupa site. By this economics, even if only 2,500 survive they will be worth Rs. 17,500,000 in five years. What is interesting is that this amount alone is more than double the Rs. 7,800,000 raised by the ice stupa project through crowdfunding this winter" (Ice Stupas Project). Therefore, Ice Stupa Project in Ladakh demonstrated the possibility to use an ice stupa as an income generating activity.

Income can be generated in many other different ways. At the small scale, this has happened in the Gya Meeru village, where a café was built inside of an ice stupa, becoming a centre of attraction for both locals and tourists (ANI News Official, 2019). The ice café is located 75 km away from Leh's village, at 14,000 feet above the sea. It provides hot drinking beverages and some food to the visitors. The ice café was constructed by three young people Sonam Chosdup, Nawang Phunstog and Jigmet Tundup for a local contest that was initiated by Sonam Wangchuk in 2018, with his own team of the Ice Stupa Project. "*The objective of this competition was to build the highest ice stupa and to spread awareness about this artificial glacier technology, besides sensitising the masses about water scarcity*." The ice stupa in Gya Meeru won the second prize (Wangchuk, R. N., 2019).

Picture 6. Sonam Wangchuk and awarded innovators of Gya Meeru village (Wangchuk, R.N., 2019)

Sonam Chosdup affirmed: "*We figured that the corridor of ice leading up the dome could be used as a café, provided we extend it a bit and put chairs there. After a few tweaks, we opened the café in the first week of February, serving ginger lemon tea, masala tea,*

coffee, local butter tea and even Maggi". The number of people that visit the ice café during weekdays is around 100; however, the number of visitors increases up to 700 during the weekends. The ice café was closed in April, when the ice stupa started to melt; water that had been stored was then employed to irrigate the surrounding lands (Wangchuk, R. N., 2019).

Picture 7. Picture of the ice café in Gya Meeru village (Dainik Bhaskar, 2020)

The trees plantation in Ladakh and the ice café in Gya Meeru village are just few of the examples about the possible income's generating activities that an ice stupa could produce.

3.3.2 Potato Farming as an Income-Generating Activity

This subparagraph will investigate the potentiality of potato farming as an income generating activity that will repay the initial costs of the ice stupa. Chhoser village identified potato farming to be a possible activity where farmers can employ water coming from the ice stupa. Therefore, an ice stupa could potentially irrigate a plantation

of potatoes in Chhoser, addressing climate change-related challenges and water shortages occurring in the Mustang District. A possible model that would appear to be the most suitable for this project is the Cooperative Model. Cooperative Models are implemented by the Saving and Credit Cooperatives (SACCOs), under which a wide range of savings and loan products are provided to the members. This model targets all members of a community, regardless of their social and economic status. However, these organizations usually focus on services to disadvantaged populations. These cooperatives take savings deposits from their members and whoever wants to put savings in the cooperative becomes an extended member. The SCC generally demands compulsory savings from their members. These cooperatives are ruled by laws on cooperatives and should be self-regulated. Nevertheless, some cooperatives are regulated by the Nepal Rastra Bank for what concerns the bank services. The SCC works in all districts of Nepal. However, since it provides both savings and financial services to members in a more familiar setting, the SACCO is considered a financial model more suitable for those communities living in hills and mountain regions. Considering the low-cost operations, the interest rates as well are lower than those imposed by other financial institutions (NIBL ACE CAPITAL). The cooperative could apply for funding from a bank, such as the Rural Self Reliance Fund (RSRF). The RSRF has been set up to provide loans to NGOs and SACCOs for lending to the rural poor: it provides credit based on total regular savings or share capital. The Fund provides a small loan of up to Rs 30,000 per borrower, with only 8% of interest charged to the credit. It is worth mentioning that they will get back 75% of the interest in case of timely repayment of instalment of their loans. The credit approved is disbursed for up to 3 years in instalments. Furthermore, the Fund observes whether the loan is properly used (Dhakal & Panthi, 2002).

In order to assess whether the investment that will finance the construction of the ice stupa could be supported and feasible by the hypothetical members of the cooperative, some conditions need to be ensured. Firstly, the product that will result from the income generating activity should encounter a demand on the local market. In the case of potato farming, the community expressively manifested the desire of growing potatoes, but they are also requested in the entire surrounding area. Then, it should be questioned whether the profits coming from potato cultivation would be sufficient to repay the loan, considering the total costs of equipment and human resources. Hence, the total costs of the equipment and human resources will be firstly considered, and then this subparagraph

will analyse whether the profits from potato cultivation will cover the loan requested for the construction of an ice stupa.

The first ice stupa in Chhoser required a very small investment of 8,500 euro; in fact, the equipment for the construction of the ice stupa's structure consisted of many materials and resources that could be found locally. Also, the implementation of an ice stupa should be considered as a one-time investment. Materials should be removed during the monsoon season to prevent damages, and they can be reinstalled the following autumn or winter to rebuild the ice stupa. Indeed, equipment is purchased once, and it is reusable several times.

Videh Foundation has drawn up a new estimate for the construction of an ice stupa on the same site, thanks to lessons learned from their first implementation. The costs cover the price of further equipment, but also human resources, including an irrigation expert and a plumber who have specific technical skills. Also, a press conference is planned to occur after the implementation. The costs also comprise the construction of a water tank, to create an ice stupa that can store water on a longer period, compared to the first implementation.

Tentative Cost Breakdown

SN	Particulars	Details	Amount (NPR)
1	Pipes with Delivery Charges	HDPE and GI Pipes	250,000
2	Fittings and other tools/equipment(s)	Joiners, Couplers, Valves and other tools	75,000
3	Construction of Xing/Pond	(Plastic, Ropes, labor cost etc.)	100,000
4	Construction of Water Tank for Irrigation	Cement bags, Stones, Bricks etc.	200,000
5	Plumber's Fee and Labor Charges	Lump sum	50,000
6	Irrigation Expert's Fees	Lump sum	50,000
7	Travel Costs, Food and Accommodation	(2 Visits- Before Construction/ After Construction)	200,000
8	Press Conference (after the completion)	Lump sum	100,000
9	Fencing of the Ice Stupa and Water Tank Area	Support from Local Government	200,000
TOTAL			1,225,000

Table 4. Estimated costs of the construction of a new ice stupa in the Chhoser Village (Videh Foundation, 2022).

Through improved data and knowledge, they estimated a cost of 1,225,000 NPRs that would be 9,387.39 euro at the current rate. The hypothesis of the thesis is that a loan could be asked to raise the capital that will be necessary for the ice stupa's construction; the water produced by the ice stupa will irrigate cultivations of potatoes. The sale of potatoes will generate an income that will entirely repay the loan asked for the construction of the ice stupa.

We will now analyse the number of potatoes that an ice stupa is capable to produce in a year. These are the premises. Usually, 60 tonnes of water are capable to produce 1 tonne of potatoes (Buckley, D. et al., 2012). Considering that 60 tonnes of water correspond to 60,000 litres, we can then argue that 60,000 litres of water will produce 1000 kg of potatoes. From existing data, it is known that 2 million litres of water can be stored into a normal sized ice stupa (DW News, 2019).

By these premises, the number of potatoes that an ice stupa can produce in a year can be calculated:

$$2{,}000{,}000l : 60{,}000l = x : 1{,}000\ kg$$

Where:

- 2,000,000 *l* of water stored by the ice stupa in one year
- 60,000 *l* of water needed to produce 1 kg of potatoes
- 1,000 kg of potatoes produced by 60,000 *l* of water

Therefore, the amount in kg of potatoes produced by the possible implementation of an ice stupa in a year is:

$$x = \frac{2{,}000{,}000 * 1{,}000}{6{,}000} = 33{,}333.33\ kg$$

Considering that 1 kg of potatoes might be sold in 2022 for 40 NPRs (on average), that corresponds to 0.35 euro at the current rate:

$$33{,}333.33\ kg * 0.35\ € = 11\ 666.7€$$

Therefore, 11 666.7€ is the total revenue generated in one year by a cultivation of potatoes that has been irrigated by the ice stupa.

As equipment to build the ice stupa is reusable and the community has the technical skills to rebuild it each year, it can be argued that the ice stupa is a long-term solution and a completely affordable and remunerative investment. In fact, the total costs of the equipment can be already repaid during the first year of instalment. The total revenue of one year after the construction of the ice stupa is:

$$11{,}666.7\ € - 9{,}387.39€ = 2{,}279.3\ €$$

Where:

- 11,666.7 € is the total revenue from the sale of potatoes
- 9,387.39 € is the up-front capital expenditure for the equipment and the labour cost to built-up the ice stupa.

In a 3-year horizon, considering that implementation costs must be paid just only once, the community will expect a total revenue of:

$$2{,}279 + 11{,}667 + 11{,}667 = 25{,}613\ €$$

These calculations shows that the community will be able to repay back the initial loan during the second year. As $33{,}333.33\ kg$ of potatoes are produced each year, the ice stupa will be capable not only to pay back the loan, but also to match the request of potatoes arising from the community. Although the agricultural outcome of the planted potato's seeds may not be of a 100% percentage, the revenue gained by the sale of the produced potatoes in three years is still sufficient to have considerable economical returns.

As far as the maintenance of the ice stupa is concerned, the community will be able to self-manage the asset. In fact, Videh Foundation identified some active members of the village that participated during the first implementation in Chhoser. These villagers already have the skills to take care of the ice stupa's maintenance and preservation. Also, they would be capable to reinstall the equipment every year, after that it had been dismantled during the rainfalls period to preserve the structure. Nevertheless, a training

to enhance financial, technical and entrepreneurial skills of the entire community could increase the rate of success of the project. As already explained in the first chapter of this thesis, microfinance products are likely to be successful in communities where they are integrated with trainings on financial management and technical skills.

To conclude, an ice stupa in Chhoser village could be useful to create a local business of potato farming that will generate a considerable income for the community; at the same time, the stored water is useful to address the challenges that farmers encounter in agriculture, allowing the local population to rely on agriculture as a livelihood and increasing the possibilities to continue living in the area. Therefore, the hostile conditions of Mustang, that are exacerbating because of climate change-related impacts, can be addressed through this local adaptation strategy.

3.4 Limitations and Future Implementations of Ice Stupas

Ice stupas are now globally recognised as an efficient adaptative solution to effectively manage water during periods of shortage and unavailability. Although ice stupas have been considered as efficient methods to counter climate change at the local level, few researchers have argued that they are not likely to function as an adaptative solution to effectively contrast climate change-related impacts. These studies are motivated by the assumption that ice stupas highly depend "upon winter runoff and freeze-thaw cycles". Despite their capacity to reduce water shortages during spring, they are highly impacted by weather conditions. In fact, some research considers ice stupas as "site-specific water conservation strategies, rather than climate change adaptation" solutions (Nüsser, M. et al., 2019). As far as data are concerned, it must be foretold that while the prototype of Ice Stupa project has been considered a success as a promising alternative to harvest water in dry desert regions, very little data exists to substantiate, quantify or contradict the project claims (Clouse C., 2017). From a technical point of view, some obstacles have emerged during different construction initiatives, such as blockages in the pipes due to very low temperatures, and the waste of water that occurs during the first phase of the ice stupa's construction (Kumar, S., 2019). Furthermore, it can be argued that the ice stupa requires a significant investment in terms of energy,

annual maintenance, regular attention, and a skilled workforce to monitor the pipes and the dome which must be constantly supervised (Kumar, S., 2019).

Eventually, as already pointed out in this chapter, the strong involvement of local communities should be an essential part of the entire process of construction, maintenance and preservation of the ice stupa. Hence, it could be argued that the cooperative model without a sense of accountability that I hypothesised for a new construction of an ice stupa in Chhoser might be considered insufficient.

Participation of local communities should be encouraged by disseminating the scientific knowledge and technical know-how that are at the basis of the construction of the ice stupa. Workshops with local populations and trainings about climate change's effects could be useful to raise awareness in the area and increase the sense of community's engagement. Villagers should be the main beneficiaries of this project, but they should also participate in trainings about ice stupa maintenance in order to be held accountable for its functioning and preservation. (Clouse C., 2017).

Although a general lack of data about ice stupas and some limitations can be identified, ice stupas have been recognised globally as a successful adaptation strategy that could enhance water management at the local level. The international visibility that the Ice Stupa Project of Ladakh raised, proves that the world is intentioned to learn more about this solution and to adopt it to counter local challenges. Although my thesis hypothesis has been based on data and information about the Chhoser area, this adaptative solution could be implemented and transposed in many other regions with climate characteristics that are similar to those in the Hindu Kush Himalayas. Potentially, mountain areas with temperatures ranging below 0°C during winter and with warmer temperatures during spring are ideal places of ice stupa's construction. In particular, they are useful in regions of the world where climate change is hindering the capacity of people to have access to water for domestic and agricultural uses. Therefore, ice stupas could be transposed to other areas of the globe to support communities during drought periods.

As far as Nepal is concerned, the Co-Founder of Videh Foundation affirmed that many other areas in the country are ideal places where ice stupas could be implemented; however, it should be taken into consideration that many areas in Nepal are still difficult to reach because of their remoteness and the inefficiency of transport services. Therefore, mobilising resources, bringing the equipment and engaging the community could be very

difficult in some areas of Nepal for possible future implementations. Nevertheless, Videh Foundation has already identified some Districts where a practical implementation of the ice stupa could be possible, to store water and deal with the winter water crisis, that are Gurka, Dulka and the Eastern part of Nepal. To conclude, Videh Foundation manifested the intention to implement this solution in 2023 in Chhoser Village, after the learnings of their first construction.

The aim of this work is also to demonstrate that an ice stupa could be constructed for the second time in the Mustang District, through the help of microfinance. According to this thesis, a microfinance-based solution could have a great impact in terms of economical returns, but it could also develop a sense of ownership of the asset in the community living in the construction site of the ice stupa. Microfinance products can be the tool to counter climate change at the local level in every context where the construction of an ice stupa can be linked with any kind of local business or economic activity, such as agriculture and tourism. Eventually, the community should be engaged from the first phases of the construction, so that the ice stupa can become a real climate change adaptation solution for the population.

Conclusion

After giving an overview of the first implementation of an ice stupa in the Ladakh Valley, this chapter analysed the ice stupa that has been constructed by Videh Foundation in Nepal, in the region of Mustang. The two locations share similar climate features and encounter common climate change-related issues, such as water shortages and recurring drought periods. The construction of the ice stupa in Chhoser was completely successful from a technical point of view. However, Videh Foundation had many learnings from the first construction of the ice stupa. In fact, equipment could be enhanced through the construction of a water tank and an increased number of pipes, thus creating a higher ice stupa that will last on a longer period. Also, at the local level the solution was not useful to irrigate the surrounding lands as the community was not entirely engaged in the whole process of construction and maintenance. Nevertheless, after the melting of the ice stupa, the community manifested the necessity of cultivating potatoes in the area. Chhoser

village identified potato farming as an activity where to use water coming from the ice stupa. Water unavailability for agricultural practices could be then addressed thanks to the ice stupa. The final part of the chapter demonstrated that microfinance could be adopted as a tool that could effectively engage the community; from an identified deficiency, that is the necessity of potatoes, an income generating activity could be created through the water coming from the ice stupa. Therefore, the villagers will be capable of repaying the loan they asked for the construction of the ice stupa, through the sale of potatoes that will be the outcome of the harvest irrigated by the ice stupa's water. Therefore, the use of microfinance to request the loan to Microfinance Institutions, will generate economical returns, while at the same time increasing the sense of ownership that the community will have face to the ice stupa. Therefore, if efficiently managed, microfinance products could be used as tools to effectively foster climate change adaptation.

Limitations of the Study

The microfinance-based solution analysed in this research revealed the economical returns from the potato farming activity that are sufficient to payback the investment for the construction of an ice stupa. As such, ice stupas could be used as a viable solution to address local climate change-related challenges.

Nevertheless, some critical issues in the study shall be pointed out. Firstly, although microfinance has been recognised as an effective tool to contrast climate change at the local level, we should take into account some typical features of Nepal (e.g. remoteness, heterogeneous groups, cultural diversity) that have hindered the equal distribution of microfinance tools in the entire territory of the country. It is important to elaborate a microcredit delivery mechanism better suited for people living in hills and mountains and to redesign the existing programs of the MFIs to better target these communities hit by climate change-derived damages (Nepal Rastra Bank, 2008). Usually, the portfolio of existing projects is not expanded in remote areas. Furthermore, green microfinance has not been developed at its full potential in Nepal and many existing microfinance products are still completely not linked with adaptation. Microfinance Institutions should foster the climate resilience of their beneficiaries, as well as establishing new partnerships with non-traditional partners and diverse stakeholders in order to achieve climate resilience.

In addition, microfinance could be a reliable alternative to foster the sustainability of ice stupas' creation and maintenance, but the scarcity of literature and academic and field research that investigate this relationship does not allow to make stronger assumptions. It is essential to deepen the area of study, better analysing the possible correlation between microfinance institutions and climate vulnerability: the beneficiaries' exposure to new climate change-related hazards may lead to livelihood shocks, which in turn may result in increased financial management risks for microfinance institutions, such as increased delays in repayments, mass withdrawal of deposits and default rates (Fenton et al., 2015). In addition, further research regarding the impacts of ice stupas and a wider and updated collection of data is required. In fact, a scientific and consolidated knowledge regarding ice stupas does not yet exist. Many websites and media mention ice stupas as an effective local solution to counter climate change, and some articles examinate the topic more in depth; however, a general lack of analysis, reports and monitoring surveys after the

implementation exists. Especially, many articles and websites examinate the advantages of ice stupas. However, very few studies analyse limitations of ice stupas, concerning their technical implementation, but also the engagement of the local community during and after the construction. Eventually, the remote areas of Nepal have a lack of data on climate characteristics and changes due to the climate crisis; particularly, existing sources are based on local observations, which cannot be considered entirely reliable.

Limitations of this study can be also identified in the way local information was retrieved. In fact, data collected on site by Videh Foundation were mainly oral testimonies of villagers, as detailed reports and qualitative surveys have not been conducted. In addition, information contained in this thesis was not gathered by Videh Foundation through systematic qualitative interviews and quantitative surveys, but rather through online meetings. As a result, available information reveals the association's point of view and the Co-Founder's observations. In fact, this research does not provide a thorough examination of community perspectives; rather, it reflects the opinions of my Nepali contact, which cannot be supported by quantitative data. To overcome the data collection issues that have been identified, interviews and questionnaires on site should be conducted. Also, a further study on the topic should include i) a research phase conducted on site to gather primary data and ii) an engineering section on the ice stupa's technical design and implementation.

Conclusions

Climate change is hindering at the global level the possibility to have access to the full range of human rights. Nepal is one of the most vulnerable countries to climate change and climate-related extreme events such as droughts, forest fires and floodings are likely to increase during the next years, causing a detrimental impact on the lives of the communities living in the country. Climate change will have disproportionate consequences on more vulnerable groups of people putting their food security, agricultural production and the availability of water supplies at risk. The vulnerability to which Nepal is exposed led to the creation and implementation of multiple instruments, including adaptation strategies and Loss and Damages, in order to improve preparedness and minimize the impact of events related to climate change. Microfinance tools have rarely been used to directly tackle climate change as an intervention target. Nonetheless, green microfinance is increasingly emerging in the international financial landscape as an instrument that can help reducing the burden of climate change.

This thesis analysed the case of ice stupas in the Ladakh Valley of India and in the Mustang District of Nepal as a solution to cope with periods of droughts and water scarcity that are occurring as one of the consequences of climate change. The construction of artificial ice stupas allows long-term water storage that can be used during dry periods. The first implementation of this solution in Ladakh required a small investment, it has been financed through crowdfunding and resulted in high revenues and efficiency. Thanks to a joint collaboration of the team that created the Ice Stupa Project in Ladakh and Videh Foundation, the ice stupa solution was transposed to Nepal, allowing the village of Chhoser located in Mustang to store a great amount of water.

However, the population was not involved in the construction process from the beginning, which led to a general mistrust of the locals towards ice stupas and a lack of sense of ownership. Therefore, this solution was not helpful in addressing the impacts of climate change by allowing fields to be irrigated with stored water; the community did not use the water provided by the ice stupa. This work argues that the ice stupa's construction may be supported through microfinance, particularly with a Cooperative model that would enable community engagement. The villagers of Chhoser expressed the need to plant potatoes; this research showed that an ice stupa would allow the community both to

receive potatoes from the harvest and to sell the remaining quantity, having a total income that could repay the costs of the ice stupa's construction. Microfinance would develop a sense of responsibility in the community over regular maintenance, attention and care of the asset; also, through this solution, villagers would be involved in the entire process of construction, as they invested part of their capital to finance the loan. Ice stupas represent a promising tool to tackle the effects of climate change in the Northern region of Nepal. Videh Foundation is currently looking for fundings to implement for the second time the ice stupa in Chhoser, after the learnings of their first implementation.

This thesis shows that a microfinance-based solution could be helpful to tackle climate change in the area and to create an income-generating activity from potato farming that could make the community economically independent. Starting from the limitations that were listed in the previous paragraph, I firmly believe that this research can be expanded through the improvement of qualitative and quantitative research methods and conducting on-site data collection. In the future, a possible implementation will be possible by listening the needs of the Chhoser Village. Eventually, further research could transpose the ice stupa solution to all areas characterised by the climatic features that has been described in the thesis, i.e. high altitude regions that suffer water shortages during winter and spring.

References

- 7 things we have learned about adapting to climate change by UNDP Climate - Exposure
- Academia Engiadina. (n.d.) *Ice Stupa im Engadin.* https://www.academia-engiadina.ch/zag/aktuelles/ice-stupa-im-engadin
- Adhikari, D., Prasai, R., Lamichhane, S., Gautam, D., Sharma, S., & Acharya, S. (2021). Climate Change Impacts and Adaptation Strategies in Trans-Himalaya Region of Nepal. Journal of Forest and Livelihood, 20(1).
- Agrawala, S., & Carraro, M. (2010). Assessing the role of microfinance in fostering adaptation to climate change.
- Allet, M., & Hudon, M. (2015). Green microfinance: Characteristics of microfinance institutions involved in environmental management. Journal of Business Ethics, 126(3).
- ANI News Official. (2019). *Unique "ice-stupa cafe" attracts tourists in Leh's village*. https://www.youtube.com/watch?v=Y-FoO4td_hY
- Asian Development Bank. (2021). Climate Risk Country Profile.
- Balasubramanian, S., Hoelzle, M., & Waser, R. (2022). Fountain scheduling strategies for improving water-use efficiency of artificial ice reservoirs (Ice stupas). *Cold Regions Science and Technology*, 103706.
- Balasubramanian, S., Hoelzle, M., Lehning, M., Wangchuk, S., Oerlemans, J., & Keller, F. (2020). A first attempt to model an Artificial Ice Reservoir (Ice Stupa) using a simple energy balance approach. In *EGU General Assembly Conference Abstracts*.
- Bapna, M., Brandon, C., Chan, C., Patwardhan, A., & Dickson, B. (2019). Adapt Now: A Global Call For Leadership On Climate Resilience. Rotterdam, The Netherlands: Global Commission on Adaptation.
- Bartlett, R., Bharati, L., Pant, D., Hosterman, H., & McCornick, P. G. (2010). Climate change impacts and adaptation in Nepal (Vol. 139). IWMI.
- Bhatta, L. D., Shrestha, A., Neupane, N., Jodha, N. S., & Wu, N. (2019). Shifting dynamics of nature, society and agriculture in the Hindu Kush Himalayas: Perspectives for future mountain development. Journal of Mountain Science, 16(5).

- Bista, R. (2019). Trend and forecasting analysis on climate variability: a case of Nepal.
- Brian, H. (2021). The Impact of a Tourism Boom in an Environmentally-Sensitive Region: A Case Study of Ladakh (Kashmir, India). Japanese Journal of Policy and Culture, 29, 21-41.
- Buckley, D., Groves, S., Bailey, J., Peters, J., & Bradshaw, F. (2012). Irrigation Best Practice Water Management for Potatoes a Guide for Growers.
- Central Bureau of Statistics. (2017). National Climate Change Impact Survey 2016: A Statistical Report.
- Charity Clubber, Videh Foundation, & Lomanthang Rural Municipality. (2022). Ice Stupa in Nepal. Chhoser Village, Lomanthang, Upper Mustang.
- Climate Champions (2022). COP27 Presidency launches Adaptation Agenda to build climate resilience for 4 billion by 2030. https://climatechampions.unfccc.int/cop27-presidency-announces-ambitous-climate-resilience-agenda
- Climate-Adapt. (2022). UN Climate Change Conference 2022 (UNFCCC COP 27). https://climate-adapt.eea.europa.eu/en/more-events/un-climate-change-conference-2022-unfccc-cop-27
- Clouse, C. (2016). Frozen landscapes: climate-adaptive design interventions in Ladakh and Zanskar. Landscape Research, 41(8), 821-837.
- Clouse, C. (2017). The Himalayan Ice Stupa: Ladakh's Climate-adaptive Water Cache. Journal of Architectural Education, 71(2), 247-251.
- Cunningham, I. (2015). *Ice Stupas: Water conservation in the land of the Buddha.* https://www.indiawaterportal.org/articles/ice-stupas-water-conservation-method-creates-artificial-vertical-ice-mountain
- Dahal, R. K., & Hasegawa, S. (2008). Representative rainfall thresholds for landslides in the Nepal Himalaya. Geomorphology, 100(3-4), 429-443.
- Dainik Bhaskar. (2020). देश का पहला आइस कैफे 14 हजार फीट ऊंचाई पर बनाया गया, मई तक सैलनियों के लिए खुला रहेगा. https://www.bhaskar.com/happylife/news/indias-first-ice-stupe-cafe-in-ladakh-open-till-may-for-tourist-see-ice-cafe-pictures-126800772.html

- Dame, J. (2018). Food security and translocal livelihoods in high mountains: Evidence from Ladakh, India. Mountain Research and Development, 38(4), 310-322.
- Della Faille, D. (2010). Review: Dead Aid: Why Aid Is Not Working and How There Is a Better Way for Africa.
- Dhakal, D., & Panthi, H. (2002). Paper for SAARC Finance Seminar on Micro Credit Operations. Bangladesh Bank.
- Dhimal, M., Bhandari, D., Dhimal, M. L., Kafle, N., Pyakurel, P., Mahotra, N., ... & Müller, R. (2021). Impact of climate change on health and well-being of people in Hindu Kush Himalayan region: a narrative review. Frontiers in Physiology, 12, 651189.
- Dilshad, T., Mallick, D., Udas, P. B., Goodrich, C. G., Prakash, A., Gorti, G., & Rahman, A. (2019). Growing social vulnerability in the river basins: Evidence from the Hindu Kush Himalaya (HKH) Region. Environmental Development, 31, 19-33.
- Dixit, A. (2011). Climate change in Nepal: Impacts and adaptive strategies. World resources Report. Institution for Social and environmental transformation-Nepal.
- Dowla, A. (2009). Climate change and microfinance. Grameen Foundation.
- Dudock, Y. (2022). Gli ultimi Loba in cima all'Himalaya. Internazionale, 1460.
- Dulal, H. B., Brodnig, G., Onoriose, C. G., & Thakur, H. K. (2010). Capitalizing on assets: Vulnerability and adaptation to climate change in Nepal (No. 54656, pp. 1-23). The World Bank.
- DW News. (2019, December 30). *How the ice stupas of Ladakh bring water to the Himalayan desert*. https://www.youtube.com/watch?v=aCacMeSOxAg
- ESG 360. (2022). COP27: nasce la Sharm-El-Sheikh Adaptation Agenda. (2022). ESG360. https://www.esg360.it/environmental/cop27-nasce-la-sharm-el-sheikh-adaptation-agenda/
- Fenton, A., Paavola, J., & Tallontire, A. (2015). Microfinance and climate change adaptation: an overview of the current literature. Enterprise Development & Microfinance, 26(3), 262-273.
- Forcella, D., Castellani, D., Huybrechs, F., & Allet, M. (2017). Green microfinance in Latin America and the Caribbean: An analysis of opportunities..
- General Assembly. (1948). Universal Declaration of Human Rights.

- General Assembly. (1966). International Covenant on Economic, Social and Cultural Rights.
- General Assembly. (1986). Declaration on the Right to Development.
- Griffin, P. (2014). Ice Stupas: Conserving Water The 3 Idiots Way. Forbes India. https://www.forbesindia.com/article/checkin/ice-stupas-conserving-water-the-3-idiots-way/39265/1
- Hammill, A., Matthew, R., & McCarter, E. (2008). Microfinance and climate change adaptation.
- Himalayan Institute of Alternatives – Ladakh. (n.d.). https://www.hial.edu.in/ https://www.unhcr.org/news/stories/2021/11/618a301d5/climate-change-emergency-everywhere.html rivedi
- Human Rights Council. (2019). Climate Change and Poverty. Report of the Special Rapporteur on extreme poverty and human rights. A/HRC/41/39.
- Ice Stupa Project. (n.d.) *Amazing eco-nomics of Ice Stupas.* http://icestupa.org/news/amazing-eco-nomics-of-ice-stupas
- ICIMOD. (2020). *The pulse of the planet*. https://www.icimod.org/who-we-are/the-pulse-of-the-planet/
- Karki, C. (2021, November 29). *Mustang Nepal Weather and Temperature. Nepal Eco Adventure.* https://nepalecoadventure.com/mustang-nepal-weather-and-temperature
- Khattri, M. B., & Pandey, R. (2021). Agricultural adaptation to climate change in the trans-Himalaya: a study of Loba Community of Lo-manthang, Upper Mustang, Nepal. International Journal of Anthropology and Ethnology, 5(1), 1-33.
- Köhn, D. (2012). Greening the Financial Sector: How to Mainstream Environmental Finance in Developing Countries (p. 249). Springer Nature.
- Kumar, S. (2019). A Self-Governance Approach to Solving the Water Crisis in Ladakh, India: The Ice Stupa Project (Master's thesis, University of Twente).
- Lanzavecchia, A., Palumbo, M., & Thapa, B. S. (2021). Climate Change and Microfinance: A Wake-up Call for Policy Makers. Università degli studi di Padova, dSEA.
- M, Khadka. (2017). Glacio - Hydrological Modelling of Dudh Koshi River Basin, Nepal. Master of Science thesis, Central European University, Budapest.

- Mahadew, R. (2021). A Human-Rights-Based Approach to Climate Change. Revue juridique de l'Océan Indien, (31), 155-168.
- Maheshwary, S., Raspall, F., & Verma, S. (2019, October). Optimized structure for Ice Stupa-architecture that supports nature to resist climate change. In Proceedings of IASS Annual Symposia (Vol. 2019, No. 8, pp. 1-8). International Association for Shell and Spatial Structures (IASS).
- Molden, D. J., Vaidya, R. A., Shrestha, A. B., Rasul, G., & Shrestha, M. S. (2014). Water infrastructure for the Hindu Kush Himalayas. International Journal of Water Resources Development, 30(1), 60-77.
- Mosleh, A. (n.d.). Microinsurance in Nepal - The Professional Consortium. The Professional Consortium. https://profconso.com/microinsurance-in-nepal/
- Moyo, D. (2009). Dead aid: Why aid is not working and how there is a better way for Africa. Macmillan.
- Moyo, D. (2009). *Is Aid Killing Africa? Dambisa Moyo talks about Dead Aid on ABC.* https://www.youtube.com/watch?v=HIPvlQOCfAQ&t=525s
- Nepal Economic Forum. (n.d.) *European Microfinance Platform.* https://nepaleconomicforum.org/neftake/green-finance-is-it-the-way-forward-for-nepal/
- Nepal Rastra Bank (2008). Micro-financing towards empowerment of disadvantaged groups in Nepal: Innovations and practices. Sahakarya Project Centre for International Studies and Cooperation (CECI).
- Nepal Rastra Bank. (2013). Some Glimpses of Microfinance Activities in Nepal. Microfinance promotion and Supervision Department.
- NIBL Ace Capital Limited. (n.d.). *Models of Microfinance Institutions in Nepal* https://niblcapital.com/insights/models-microfinance-institutions-nepal/
- Núñez, R. (2022, January 10). *Proyecto Nilus: un laboratorio del agua en los Andes Chilenos*. EL ÁGORA DIARIO. https://www.elagoradiario.com/agua/proyecto-nilus-agua-andes-chilenos/
- Nüsser, M., Dame, J., Kraus, B., Baghel, R., & Schmidt, S. (2019). Socio-hydrology of "artificial glaciers" in Ladakh, India: assessing adaptive strategies in a changing cryosphere. Regional Environmental Change, 19(5), 1327-1337.
- Oerlemans, J., Balasubramanian, S., Clavuot, C., & Keller, F. (2021). Brief communication: Growth and decay of an ice stupa in alpine conditions–a simple

model driven by energy-flux observations over a glacier surface. The Cryosphere, 15(6), 3007-3012.

- OHCHR, U. (2015, November). Understanding human rights and climate change. In Submission of the Office of the High Commissioner for Human Rights to the 21st Conference of the parties to the United Nations Framework Convention on Climate Change (Vol. 26).
- Parvaiz, A. (2018). *Ice stupas spark conflict between farmers in Ladakh*. The Third Pole. https://www.thethirdpole.net/en/climate/ice-stupa-ladakh/
- Poenaru, V. (2019). 12 The HIAL Project in India. *Real Estate in South Asia*, 191.
- Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E. & Birkmann, J. (2022). Climate change 2022: Impacts, adaptation and vulnerability. IPCC Sixth Assessment Report.
- Practical Action. (2021). Assessing and addressing climate-induced loss and damage in Bangladesh.
- Pradeep, B., & Prabin, M. S. (2020, July). LOSS AND DAMAGE in Nepal. Prakriti Resources Centre.
- Reuters. (2021, October 28). Conservationists in Chile aim to freeze water in man-made glaciers. https://www.reuters.com/world/americas/conservationists-chile-aim-freeze-water-man-made-glaciers-2021-10-28/
- Rijal, H. B. (2021). Thermal adaptation of buildings and people for energy saving in extreme cold climate of Nepal. Energy and Buildings, 230, 110551.
- Rolex Awards for Enterprise. (2016, November 16). *Sonam Wangchuk, Rolex Awards Laureate, 2016*. YouTube. https://www.youtube.com/watch?v=FdVijr10DZ0
- Selina Wamucii. (2022). Nepal Potatoes Prices. https://www.selinawamucii.com/insights/prices/nepal/potatoes/
- Shaheen, F. A. (2016). The art of glacier grafting: innovative water harvesting techniques in Ladakh. *IWMI-Tata Water Policy Research Highlight*.
- Sharma, A. (2019). Giving water its place: Artificial glaciers and the politics of place in a high-altitude Himalayan village. Water Alternatives-An Interdisciplinary Journal On Water Politics And Development, 12(3), 993-1016.
- Shaw, B. (2018). *Fragile Equilibrium: Environmental change and Cultural Resilience in the Himalayas* (Doctoral dissertation, Carleton University).

- Shrestha, B. R. (2019). An assessment of disaster loss and damage in Nepal. The Geographic Base, 6, 42-51.
- Shrestha, M. R., Rokaya, M. B., & Ghimire, S. K. (2005). Vegetation Pattern of Trans-Himalayan Zone in the North-West Nepal. Nepal Journal of Plant Sciences, 1, 129-135.
- Simfruit. (n.d.). *Nilus: el proyecto chileno que crea glaciares artificiales para combatir el cambio climático*. https://www.simfruit.cl/nilus-el-proyecto-chileno-que-crea-glaciares-artificiales-para-combatir-el-cambio-climatico/
- Singh, S. P., Bassignana-Khadka, I., Singh Karky, B., & Sharma, E. (2011). Climate change in the Hindu Kush-Himalayas: the state of current knowledge. International Centre for Integrated Mountain Development (ICIMOD).
- Spagnolo, M. (2021). Ice stupas: the artificial mini glaciers bringing water to some of the driest, coldest places on Earth.
- Statista. (2022). Distribution of gross domestic product (GDP) across economic sectors Nepal 2021 from https://www.statista.com/statistics/425750/nepal-gdp-distribution-across-economic-sectors/
- Statista. (2022). Share of rural population Nepal 2012-2021. from https://www.statista.com/statistics/761008/nepal-share-of-rural-population/
- Strochlic, N. (2021). *The "Ice Stupas" That Could Water the Himalaya.* National Geographic
  Magazine. https://www.nationalgeographic.com/magazine/article/explore-desert-glaciers
- Sustainable Banking and Finance Network, International Finance Corporation. (2021). Accelerating Sustainable Finance Together. Global Progress Report of the Sustainable Banking and Finance Network. Evidence of Policy Innovations and Market Actions across 43 Emerging Markets.
- Sustainable Banking and Finance Network. (n.d.). https://www.sbfnetwork.org/
- Swain, R. B., & Floro, M. (2010). Reducing vulnerability through microfinance: Evidence from indian self help group program (No. 2010: 23). Working Paper.
- The Banking with the Poor Network & SEEP Network. (2009). Microfinance Industry Report - Nepal.
- Thouman, S. (2019). Water in 21st century: The northeast (India) profile. *IAHRW International Journal of Social Sciences Review*, *7*(3), 475-478.

- Times of India. (2020). *The innovative Ice Stupas of Ladakh, solving water crisis in the Himalayas. Times of India Travel*. https://timesofindia.indiatimes.com/travel/destinations/the-innovative-ice-stupas-of-ladakh-solving-water-crisis-in-the-himalayas/articleshow/78315648.cms
- Uddin, M. N., Kassim, S., Hamdan, H., Saad, N. B. M., & Embi, N. A. C. (2021). Green Microfinance Promoting Sustainable Development Goals (SDGs) in Bangladesh. Journal of Islamic Finance, 10, 011-018.
- UNDP. (n.d.) *7 things we have learned about adapting to climate change*. https://undp-climate.exposure.co/7-lessons-on-adaptation
- UNFCC. (n.d.). *What do adaptation to climate change and climate resilience mean?*. https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean
- UNHCR. (2021). *Climate change is an emergency for everyone, everywhere*.
- UNHCR. (2022). Climate change, displacement and human rights
- United Nations (2015). Paris agreement.
- United Nations Climate Technology Centre & Network. (n.d.). *Ice stupas*. https://www.ctc-n.org/products/ice-stupas
- Vaidya, R. A. (2015). Governance and management of local water storage in the Hindu Kush Himalayas. International Journal of Water Resources Development, 31(2), 253-268.
- Videh Foundation (2021). https://www.videhfoundation.org
- Wagle, N., Dhakal, M. P., & Shrestha, A. B. (2021). Adaptation Strategies to Address Challenges of Traditional Agricultural Water Management in the Upper Indus Basin. *Mountain Research and Development*, *41*(3), R24-R31.
- Wangchuk, R. N. (2019, May 13). *An Ice Cafe in Ladakh That Serves Maggi & Masala Tea? 3 Village Lads Have Built It!* The Better India. https://www.thebetterindia.com/182117/ladakh-maggi-tea-ice-cafe-stupa-innovation/
- Weaver, S., Bakhmetyeva, T., & Rinn, D. W. (2022). Climate Witness: Oral Environmental History and Community-Based Research—A Case Study from Trans-Himalayan India. *The Oral History Review*, *49*(1), 56-76.

- Wester, P., Mishra, A., Mukherji, A., & Shrestha, A. B. (2019). The Hindu Kush Himalaya assessment: mountains, climate change, sustainability and people. Springer Nature.
- Wijiesiri, M., & Grimard, F. (2019). Microfinance programs and women's empowerment 1: New evidence from the rural middle hills of Nepal. In Business and Development Studies (pp. 401-423). Routledge.
- Winkler, A. (2022, February 2). Chile is making its own glaciers. Freethink. https://www.freethink.com/environment/artificial-glaciers
- World Bank Climate Change Knowledge Portal. (n.d.). https://climateknowledgeportal.worldbank.org/country/nepal