IHCAP Indian Himalayas Climate Adaptation Programme

SCIENCE BRIEF:

MOUNTAIN AND LOWLAND LINKAGES: A CLIMATE CHANGE PERSPECTIVE IN THE HIMALAYAS

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About IHCAP

The Indian Himalayas Climate Adaptation Programme (IHCAP) is a project under the Global Programme Climate Change and Environment (GPCCE) of the Swiss Agency for Development and Cooperation (SDC), and is being implemented in partnership with the Department of Science and Technology (DST), Government of India. IHCAP is supporting the implementation of the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) as a knowledge and technical partner. The overall goal of IHCAP is to strengthen the resilience of vulnerable communities in the Himalayas and to enhance and connect the knowledge and capacities of research institutions, communities and decision-makers.

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Authors: Simon Allen, Divya Mohan, Markus Stoffel, Mustafa Ali Khan, Janine Kuriger, Nadine Salzmann, Shirish Sinha

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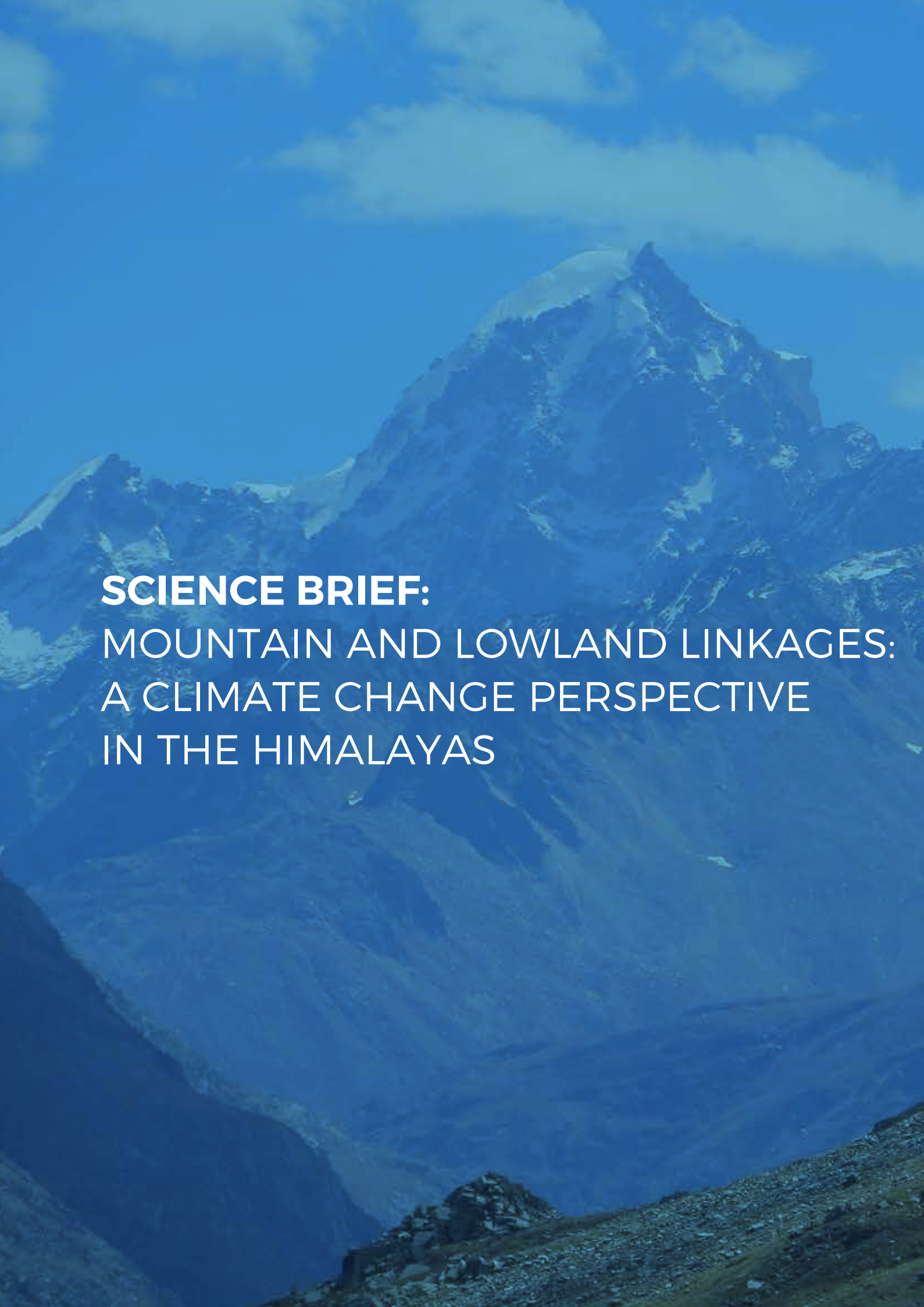

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INTRODUCTION

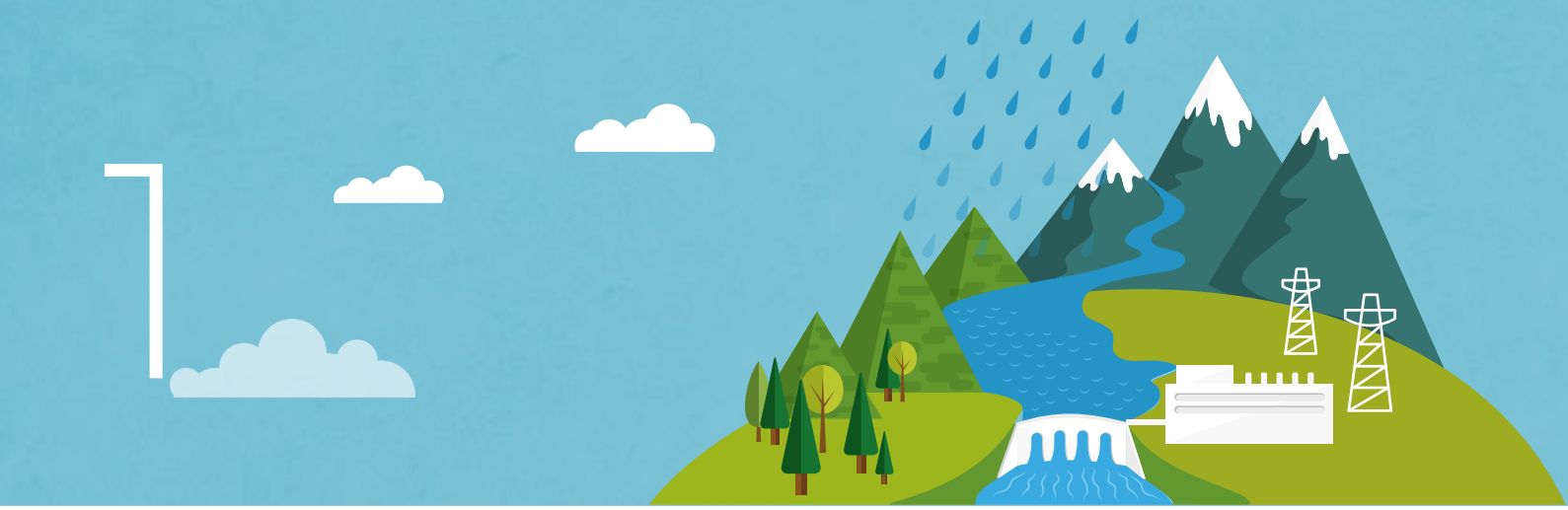
Mountain environments around the world are often considered to be amongst the most sensitive to the impacts of climate change. Rapidly changing snow and ice cover and changes in mountain ecosystems are indicative of the impact of humans on the climate system. Climatic changes, in turn, are directly impacting the mountain communities that depend on their surrounding natural environment for livelihoods and subsistence. But the impacts of the changes being observed in the mountains are not restricted to the uplands. The lowland areas too are being strongly affected.

Mountain ecosystems and lowland areas are closely linked as the upland areas form the reserves for crucial natural resources such as water and forests. These resources play an important role in providing ecosystem services for the communities living in the lowland areas. The geographical and social linkages between the uplands and the lowlands drive various processes. Owing to these linkages, issues such as extreme events arising in one region can have far-reaching consequences on the other. However, these two landscapes are often viewed in isolation. Administrative or political boundaries also become an inhibiting factor in recognizing the full dimension of issues which span across the uplands and lowlands.

Climate impacts in the mountain regions can result in multi-sectoral impacts in the lowlands. Considering the wide-ranging ways in which societies in lowlands interact with and depend upon mountain environments, it is imperative that adaptation planning on how to respond to climate risks across the Indian Himalayan Region (IHR) is based on a complete understanding of the current and the future changes occurring in both lowland and upland regions. **This science brief is based on the findings from the Kullu study under the Indian Himalayas Climate Adaptation Programme (IHCAP), a project of the Swiss Agency for Development and Cooperation (SDC) and wider experience with processes occurring across IHR.** The purpose of this science brief is to make a case for special attention to the Himalayan Region for the well-being of South Asia, in general, and that of India, in particular.

THEMES HIGHLIGHTING MOUNTAIN-LOWLAND LINKAGES

This science brief highlights linkages between upstream (mountain) and downstream (lowland) areas with respect to specific themes in mountain ecosystems such as water, agriculture-horticulture, ecosystem services, hazards and disasters, tourism and transportation networks.



WATER

The vast quantity of water stored within and emerging out of upstream mountain catchments in the Hindu Kush Himalayas provides an important source for drinking, sanitation, irrigation and hydropower generation to over 1.35 billion people downstream (FAO, 2014).

The Himalayas are known as the water towers of Asia due to the water stored in the glaciated mountains in the form of snow and ice. The melting of this snow and ice contributes to the flow of water in the rivers downstream. Himalayan glaciers are estimated to provide around 8.6 x 10^6 m^3 of water annually, feeding Asia's seven major rivers (Government of India, 2010). In Kullu, Himachal Pradesh (HP), about 26 km^3 of ice volume is estimated to be stored in the glaciers in the mountain catchments. The meltwater and runoff from these catchments play an important buffering role in providing water downstream, especially in lean seasons (Figure 1). This is further validated from the findings of the IHCAP study in Kullu district where around 95 percent of the farmers interviewed indicated that monsoon rains are insufficient to meet the irrigation demand (IHCAP, 2016).

Most respondents perceived recent changes in rainfall patterns to be negatively affecting crop production in the lowlands, thus highlighting the vital role of runoff from glaciers in ensuring water availability downstream. Kullu, like many districts across IHR, has seen a rapid growth in large and small-scale hydropower projects over the past decade with significant investments and contribution to the state revenue. Further, these projects rely on snow and glacier-melt to sustain inflows during dry seasons or weak monsoon years. Although, there are still uncertainties regarding the extent of impacts of climate change on the glaciers and water reserves in IHR, the potential changes in rainfall, snow cover, monsoon timing and distribution will have implications on the quantity and quality of runoff from the mountain catchments to the lowlands.

Figure 1 *The glacial environment at the head of the Parvati valley, Kullu district, serves as a natural water reservoir helping to sustain industries and livelihoods in the downstream populated valleys.*

2

AGRICULTURE-HORTICULTURE

Agriculture and horticulture in IHR are vital for the production and supply of some of the major crops to the country.

Agriculture and horticulture are the mainstay of the economy in IHR and provide livelihoods to a majority of people in the region. For instance, the agriculture sector contributes nearly 30 percent to the gross state domestic product (GSDP) of HP (GoHP, 2012). Agriculture and horticulture supply not just the raw materials to industries in the mountain region, but also several crops to the lowlands. For example, the western IHR states of HP, Jammu and Kashmir and Uttarakhand account for the largest share of apple production (around 99 percent) in the country (GoI, 2015).

With climate change adversely impacting the production of important agriculture and horticulture crops in IHR, the supplies of these crops to the region and to the lowlands is likely to suffer. For example, increase in temperature and decrease in winter rainfall and snowfall has reduced the number of chilling hours, leading to a decline in apple production in the region. An assessment of productivity of apple in Kullu from 2003 to 2015 shows a decreasing trend except for the high production in the year of 2004-05 and 2012-13 (Figure 2). Farmers' perceptions obtained from IHCAP study in Kullu indicate a shift in the timings of flowering and fruiting of horticulture crops reflecting reduction in crop periods (IHCAP, 2016). The advancement of crop maturity and fruit setting is causing reduction in the yield of the crops. A shift of fruit belt to higher altitudes is also being observed[1].

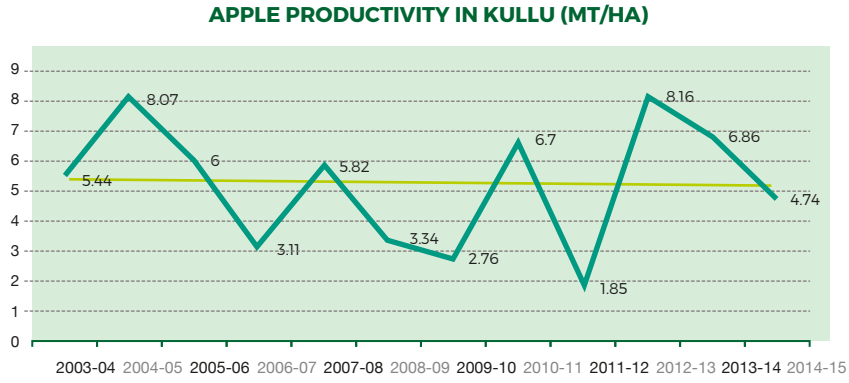


Figure 2 *Apple productivity in Kullu (MT/ha)*
Source: Department of Horticulture, GoHP

[1]*Another example of impacts of climate change on agriculture is the decline observed in production of cash crops such as cardamom in Sikkim since 2004. The North Eastern region of IHR is the major producer of large cardamom and Sikkim alone contributes nearly 88% of the total cardamom production of the country. In addition to infrastructure development, one of the factors contributing to this declining trend in production of cardomom is changes observed in the climate in the form of temperature increase and erratic rainfall. (Sharma et al., 2016)*

3 ECOSYSTEM SERVICES

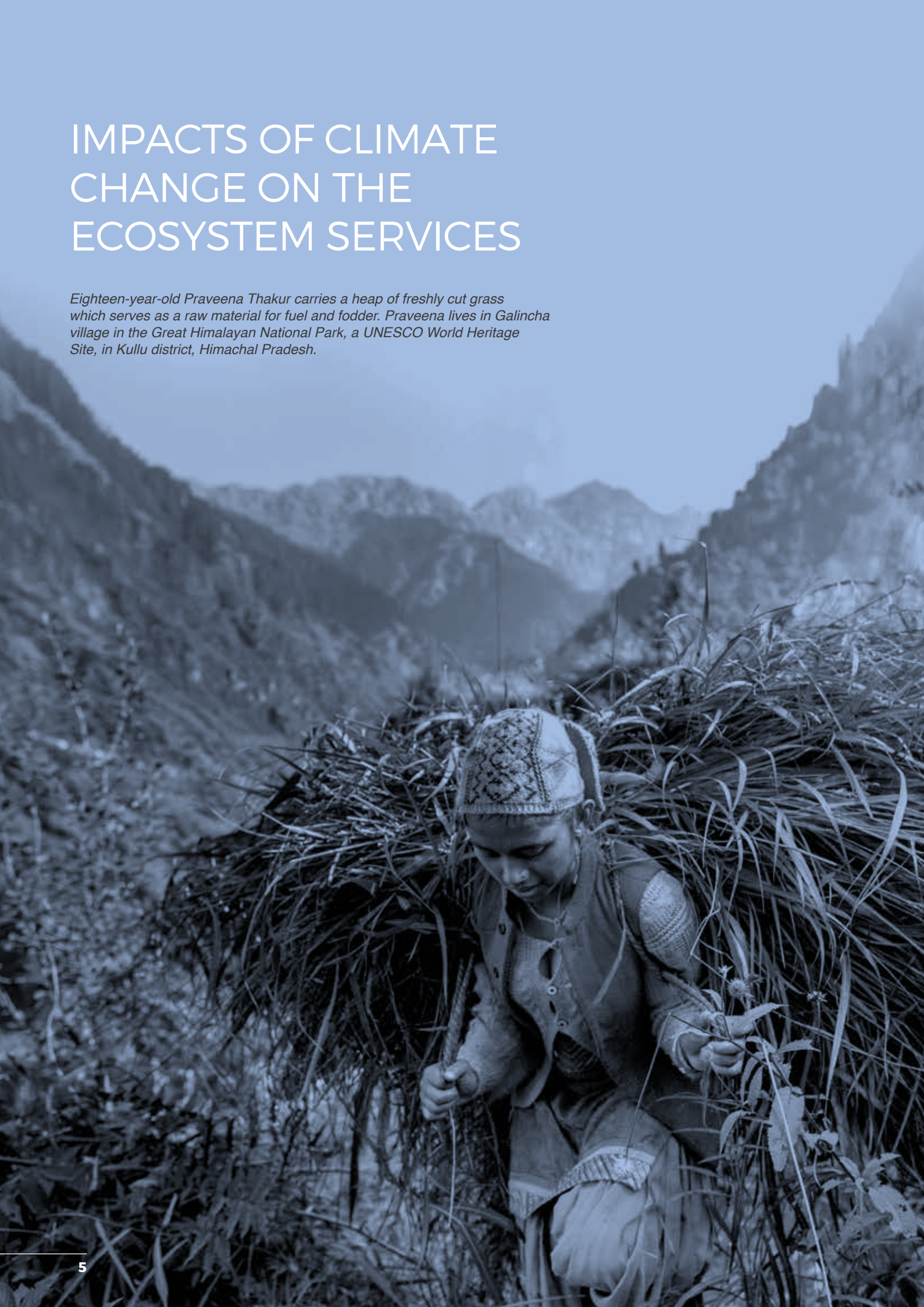
The Himalayan region is one of the most recognized biodiversity hotspots in the world, with diverse forests providing ecosystem services to both upland and lowland communities.

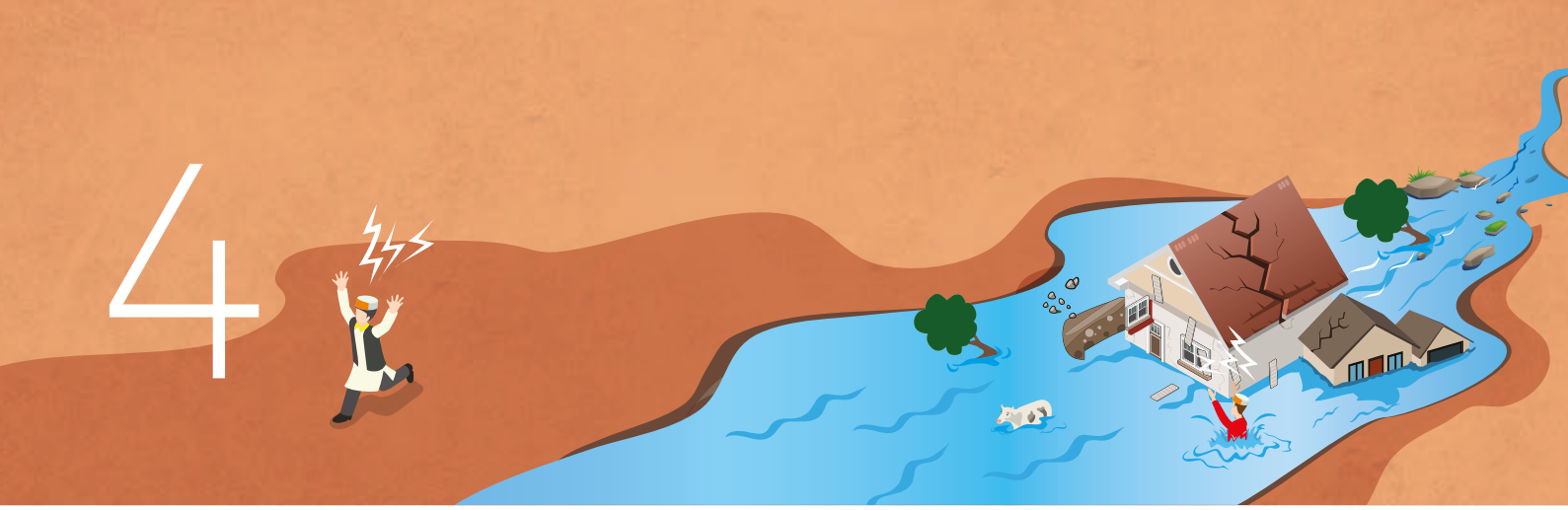
While local inhabitants directly depend on this biodiversity for sustenance, lowland inhabitants too place great value on goods and services coming from mountain regions. This is particularly true for medicinal plants, some of which are unique to specific elevation zones in high mountain environments. In Parvati valley, Kullu district, a biodiversity survey identified about 500 economically significant plant species, of which, close to 250 are being used for medicinal purposes (Samant et al., 2016).

However, climate change is causing noticeable effects on the life cycles and distributions of medicinal plants. For example, evidence has shown that an altitudinal shift is occurring in their habitation range. Likewise, animals may be migrating from lowland to upland zones as temperatures increase. Hence, climate change is causing an additional stress to the Himalayan ecosystems that are already struggling due to other anthropogenic pressures such as over-exploitation, land degradation and habitat destruction. The impacts of climate change on forests in IHR and on the ecosystem services they provide are also affecting communities in both upland and lowland areas. For critically endangered or vulnerable plant species, and the societies or communities that depend on them, it is of paramount importance to better understand how these sensitive ecosystems will respond to further climate change.

IMPACTS OF CLIMATE CHANGE ON THE ECOSYSTEM SERVICES

Eighteen-year-old Praveena Thakur carries a heap of freshly cut grass which serves as a raw material for fuel and fodder. Praveena lives in Galincha village in the Great Himalayan National Park, a UNESCO World Heritage Site, in Kullu district, Himachal Pradesh.





4 HAZARDS AND DISASTERS

The impacts in downstream areas from flood and landslide disasters that originate from mountain catchments can be significant and far-reaching.

Disasters originating in mountain regions can often lead to a chain-reaction of events, where processes such as glacial lake outburst flood (GLOF) transform or initiate secondary events, progressively increasing the downstream reach and consequences (Figure 3). For example, the Kedarnath disaster of 2013 in the state of Uttarakhand, India highlights the devastation that can happen in downstream areas when floods (GLOF) originate from former glaciated landscapes together with an extreme event of cloudburst and excessive precipitation[2].

In IHR, there is a pronounced threat from landslide dammed lakes, which can burst a few weeks, months, or even years after the initial landslide, causing devastating flash floods extending hundreds of kilometers downstream. For example, in 2000, a landslide dammed lake in Tibet breached which caused destruction about 100 km downstream in Kinnaur, HP. Over 150 people lost their lives and the incident resulted in substantial damage to the infrastructure and a loss of revenue to the tune of US$ 222 million (Gupta and Sah, 2008). In another incident, landslide dammed Paree Chu Lake in Tibet breached in 2005. This led to a sudden rise of water level of the Sutlej River by 12 to 15 meters resulting in downstream impacts in Kinnaur district of HP. However, effective monitoring and response strategies by the state authorities prevented loss of life, although financial losses up to US$ 177 million were still reported from Kinnaur district. Studies conducted in Kullu have identified that some areas, such as the Upper Beas catchment or the Parvati Valley face a significant threat from multiple hazards such as monsoon-triggered flooding, glacial lake outbursts, landslides and earthquakes (IHCAP, 2016). This increases the potential for far-reaching, cascading disasters to occur in downstream.

With climate change influencing both the frequency and magnitude of landslides in mountain regions (through retreat of glaciers, thawing of frozen slopes, increased heavy rainfall, etc.), and glacial lakes increasing in number and expanding in size as the ice melts, the risk of related far-reaching lake outburst events is expected to increase substantially.

[2]*Other examples of such events originating upstream and causing excessive damage downstream have been observed in the Hindu-Kush Himalayan Region. For instance, the ice-rock avalanche at the head of the Seti River in Nepal in 2012, transformed into a far-reaching debris flow and flood event causing significant loss of life along its 35 km downstream path (Petley and Stark, 2012)*

Figure 3 *A natural disaster initiating upstream can travel down as debris flow and flood event, destroying remote mountain villages and raising the water level in downstream areas.*

5

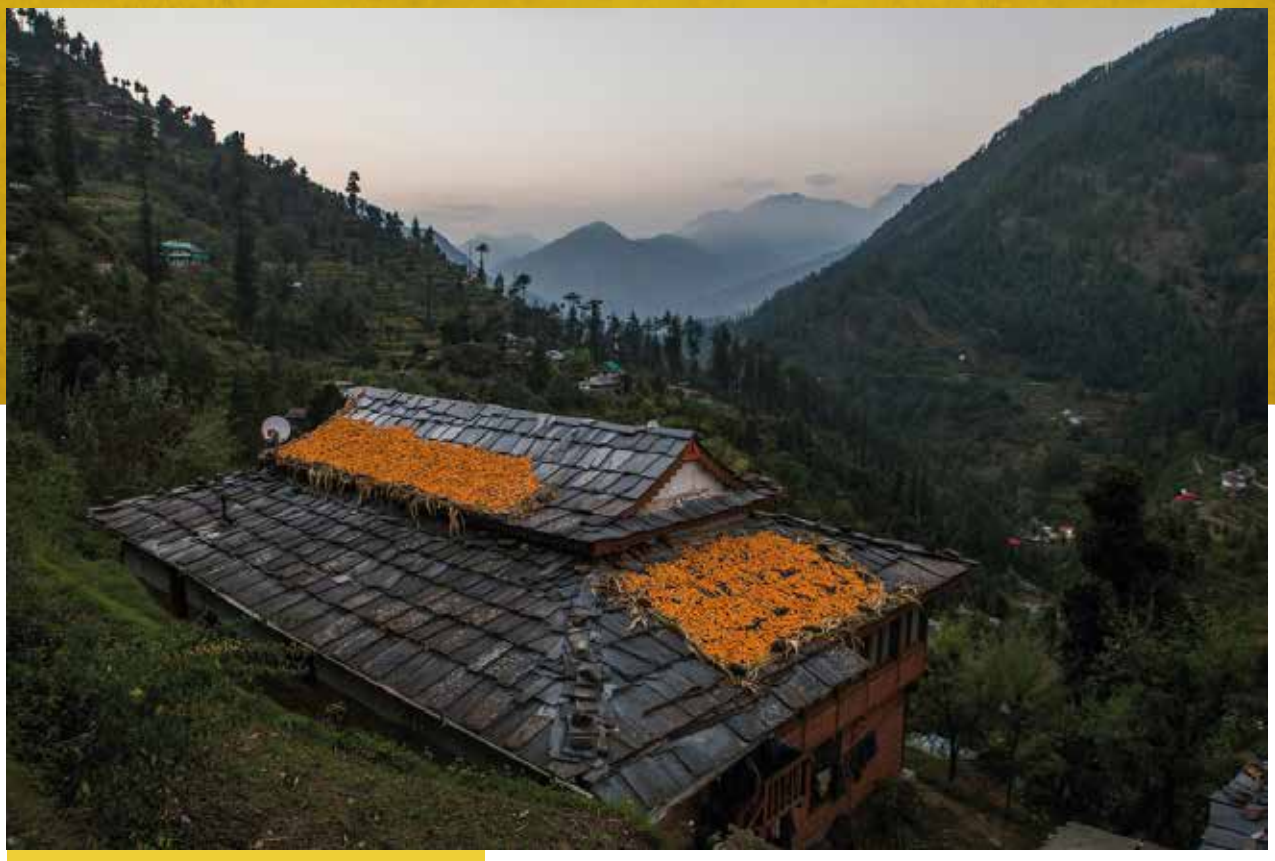
TOURISM

The natural scenic beauty and cultural and religious significance of the Himalayan region attracts large numbers of tourists, contributing positively to the economic development of the region.

Tourism in mountain regions generates economic growth, infrastructure development and employment opportunities for the mountain communities. However, a rapid influx of people and associated growth in tourism infrastructure also brings challenges, and puts further pressure on the already sensitive natural landscapes. Major tourist destinations in the Himalayas, such as Manali, may concentrate large numbers of people at the same time in hazard-prone regions, thereby increasing risk. In view of the rapidly changing environmental conditions, a key challenge for local authorities is to maintain a safe and sustainable tourism industry that is resilient to the threat of climate change. Transportation or trekking routes into many popular destinations in IHR are threatened by wide-ranging natural hazards, such as floods and landslides. The aftermath of a disaster on tourism industry and the state economy can be far-reaching. For example, following the 2013 flooding in Uttarakhand, which has been linked to extreme rainfall, snowmelt, and breach of a glacier lake, there was an 85 percent reduction in tourism business, with an estimated loss of US$ 1,850 million to the state's tourism sector (Trivedi, 2014; Press Trust of India, 2013). The livelihoods of a large number of people, both in mountains and lowlands, which were completely dependent on tourism, were also adversely affected.

In HP, the growing importance of tourism to the state economy has been recognized by the government. Against this background, it is important that infrastructure and economic development programmers take into account climate-related threat to the tourism sector.

CLIMATE CHANGE AFFECTING LIVELIHOODS OF PEOPLE



Banjar block in Kullu district, Himachal Pradesh.

6

TRANSPORTATION NETWORKS

The Himalayas form a natural barrier through which nationally significant and strategically important transportation networks are maintained.

High mountain passes have for many centuries served as important transportation routes. They provide an economic lifeline that facilitates tourism and the movement of goods and agri/horticulture products, linking different regions. In addition, these routes are strategically important for national security since a large fraction of India's international borders with neighboring countries are located in the Himalayas. However, many soldiers have also lost their lives due to avalanches in the high mountainous terrain. For example, in February 2016, 10 soldiers were buried in an avalanche in Siachen (The Indian Express, 2016).

Climate change will alter not only avalanche conditions, but also flood and landslide activities that threaten such vital transportation networks passing through mountainous areas. For example, the landslide lake outburst floods that happened in Kinnaur district of HP in 2000 and 2005 led to major indirect losses to the local economy after export of apples to the market was disrupted (Gupta and Sah, 2008). In HP, another key transportation corridor is the Rohtang pass and tunnel, linking Kullu with Lahual and Spiti districts in the north (Figure 4). Studies have shown that this corridor is threatened by a range of climate-related hazards, including debris flows, flash floods and snow avalanches (IHCAP, 2016). This highlights the need to consider climate change scenarios in development plans to ensure the long-term sustainability of vital transportation networks in IHR.

Figure 4

RECOMMENDATIONS:

The research carried out under IHCAP in Kullu valley, helped in generating an understanding of the linkages between the mountain environment and lowlands. **It highlights the need for having a holistic approach at landscape level considering both uplands and lowlands in understanding climate risks and vulnerabilities for adaptation planning and implementation.** Some specific recommendations are as follows:

- **Monitoring of the high mountain environment for climate adaptation:** Systematic monitoring of the high mountain environment (including the cryosphere) in the Himalayas is essential to ensure that adaptation decisions for different altitudinal regions are evidence-based and well supported by latest scientific understanding. Such monitoring will help in tracking climate risks originating in the upland but having the potential to cause impacts or damage in lowlands as well. For example, monitoring of hydro-meteorological conditions in upland areas can help in early detection of relatively slowly evolving as well as rapid onset flood threats for downstream areas. Availability of such data can facilitate designing and implementation of appropriate adaptation response.

- **Formulation of specific policies and adaptation finance mechanisms for the Himalayas:** Specific policies customized for the Himalayas are required as the policies designed for the plains might not be suitable for mountain ecosystems. Priority allocation of funds and formulation of policies for the Himalayas is required in the context of climate change adaptation because focussing on the high mountain environment will lead to risk reduction for lowland areas as well.

- **Green Bonus for Himalayan states:** More support needs to be provided for conserving forest cover in the Himalayan states. Provision of green bonus will incentivize management of natural resources and environmental conservation in lieu of developmental activities. Conserving forest cover will not only benefit mountain communities but also lowland areas by ensuring provision of key ecosystem services such as water and various food commodities.

- **Awareness programmes on the significance of mountains:** Mass awareness and education programmes are needed in the lowlands to make the communities as well as decision-makers aware of the significance of mountains, their linkages with lowlands and the need for conservation and sustainable management.

Evidence-based planning and implementation of adaptation measures is a pre-requisite for building resilience of mountain communities and ecosystems in the Indian Himalayan Region (IHR). Recognizing the pervasive and complex challenge that the communities face in the IHR, the Swiss Agency for Development and Cooperation (SDC) together with the Department of Science and Technology (DST), Government of India, initiated the Indian Himalayas Climate Adaptation Programme (IHCAP). Under IHCAP, a pilot study was done for Kullu district, Himachal Pradesh in coordination with the Department of Environment, Science and Technology (DEST), Government of Himachal Pradesh, to provide an integrated assessment of climate vulnerability, hazards and risk for climate adaptation planning. This series of Science Briefs on specific topics represents the key messages drawn from the outcomes of the Indo-Swiss scientific studies for Kullu in simplified language to inform decision making.

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Indian Himalayas Climate Adaptation Programme (IHCAP)

Embassy of Switzerland
Swiss Cooperation Office India, Nyaya Marg, Chanakyapuri, New Delhi – 110021, India
Phone: +91-11-49959570 E-mail: info@ihcap.in