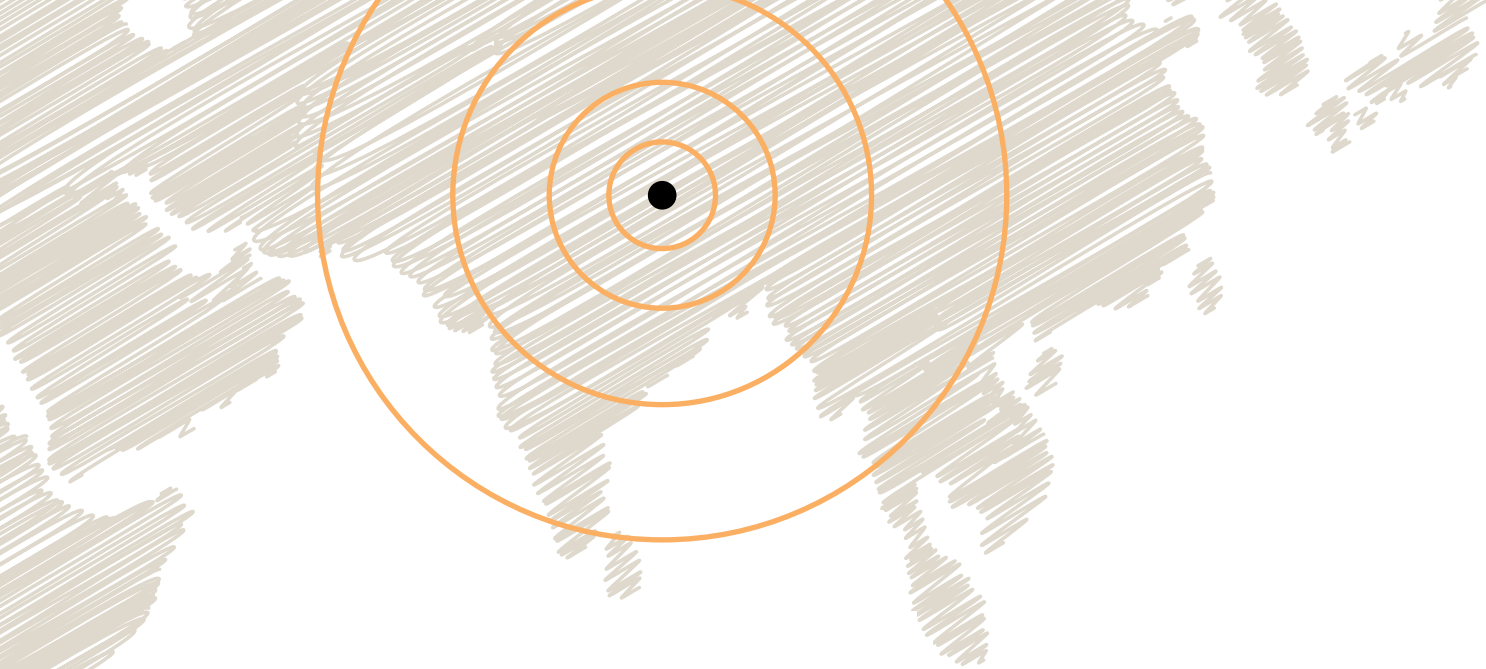

Smallholder farming systems in the Indian Himalayas

Key trends and innovations for resilience

Prakriti Mukerjee, Reetu Sogani, Nawraj Gurung, Ajay Rastogi and Krystyna Swiderska

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Partner organisation

Lok Chetna Manch (LCM) is an NGO based in Ranikhet, Almora District, northern India. It aims to improve and transform the livelihoods, conditions and opportunities of poor communities in the hill regions of the Central Indian Himalayas, through research and action.

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Traditional farmers in the Central and Eastern Indian Himalayas have observed significant climatic changes in recent years, reducing agricultural productivity. They have responded by innovating to increase resilience and yields, using traditional knowledge, biodiversity, and external knowledge. This report explores key trends in livelihoods, food security, crop diversity, and biocultural heritage across ten communities; the biocultural innovations developed in response to climatic and socioeconomic changes; and the social factors that have supported biocultural innovation.

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Acronyms and abbreviations

CH	Central Himalayas
EH	Eastern Himalayas
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MLLDB	Mayel Lyang Lepcha Development Board
PDS	Public Distribution System
PPV&FR	Protection of Plant Varieties & Farmers' Rights
SHG	self-help group
SIFOR	Smallholder Innovation for Resilience

Executive summary

The Smallholder Innovation for Resilience (SIFOR) project aims to strengthen traditional knowledge-based innovation systems for food security in the face of climate change, through participatory action-research in India, China, Kenya and Peru. The project focuses on biocultural heritage-based innovations: innovations that arise from the interaction between the components of biocultural heritage (traditional knowledge, biodiversity, landscapes, cultural and spiritual values, and customary laws), or between traditional and external knowledge.

The project is based in two sites in India: five traditional farming villages in the Central Himalayas (CH) and five Lepcha and Limbu villages in the Eastern Himalayas (EH). The CH population practise Hinduism and follow the caste system, but most people own and till their own land. Forests have always formed an integral part of their agricultural practices, with people depending on forest biomass for fuel, fodder and compost. In the EH, a sub-tropical forest and biodiversity hotspot, the Lepcha are instinctively hunter-gatherers whereas the Limbu were the chief cattle merchants. Agriculture continues to be the primary source of livelihood in both regions, with a shift towards market agriculture, although traditional mixed farming systems continue.

The communities in the CH and EH do not distinguish the biological and cultural realms: they consider nature sacred, and traditional knowledge of trees, crops, animals and home remedies play an important part in their livelihoods. Festivals and food form a seamless part of their traditions, and traditional knowledge, rituals and practices reflect their cultural values of reciprocity, solidarity, equilibrium and collectivity.

This report provides the findings of the SIFOR baseline study in India, which also served as a key research component. The study explored key trends in livelihoods and migration, food security, crop diversity and seed systems, climate change, and social capital, which provide the context for innovation. It explored biocultural innovations developed in response to climatic and socioeconomic changes, and the people, institutions, networking and community-level factors supporting their development. It entailed a qualitative baseline study in 2012–2013 and a quantitative survey in 2013–2014, involving 165 households in total.

Main findings

Livelihoods and migration: In both the study areas, household incomes increased between 2002 and 2012, and while expenses did too, net incomes overall have risen. In the EH villages, incomes rose due to an increase in cash crops (mainly landraces), as well as government employment schemes, while in the CH, income security largely comes from pensions, local jobs and money remitted by migrants. The contribution of agriculture to income has fallen: from 43% to 7% in the CH and from 83% to 63% in the EH. Farms are primarily rainfed, with an increasing share of land left fallow due to outmigration, which has reduced the availability of agricultural labour, and due to increased crop raiding by animals (particularly in the CH).

Food security and agricultural systems: Although the communities feel that food production and self-sufficiency is important, they recognise that it makes less economic sense in the face of declining yields and improved access to grain from the market and the government's Public Distribution System, as well as greater access to work (in CH). Most staple produce is consumed at home but a large share of the meat and milk raised in both communities is destined for the market. In the CH, changing weather patterns and destruction of crops by animals have demotivated farmers, increasing outmigration and reducing cooperation and the effort put into agriculture, leading to a significant decline in food self-sufficiency. In the EH villages, farmers have responded to changing conditions by selling more of what they grow, particularly vegetables, potatoes and spices. Despite this partial diversion into cash crops, staple food self-sufficiency has only declined slightly.

Crop diversity and seed systems: Households grew a rich diversity of crops: 20–33 different crops and 46 varieties in the CH villages, and 12–30 different crops and 42 varieties in the EH villages. However, crop diversity is declining. In EH, the number of landraces and area planted for the main crops has been stable, with the exception of maize landraces in Tandrabong, where the area planted declined from 90% to 50% between 1982 and 2012. Some crops have become locally extinct or are only cultivated in very small quantities due to changing tastes and the easier availability of other food, as well as animal attacks in the

CH and uneconomic yields in the EH. New varieties have also been introduced – some improved varieties or landraces from other areas, and some developed locally.

Farmers still self-save 80–90% of their seeds, although farmers in the CH no longer pre-select plants to harvest separately for seed. Women are largely responsible for sourcing landrace seeds in the EH, while the men largely source improved varieties; men are more likely to source both in the CH communities, although women play an important role in selecting and storing the seeds for subsistence crops in both regions.

Climatic change and adaptation: Scientists have observed rapid changes in the Himalayan climate, with rising temperatures, decreasing precipitation and changing rainfall patterns. Communities in the study areas have also noticed glaring changes in recent weather patterns, particularly more extreme and unpredictable weather, increased frost (CH), reduced rainfall (EH), and increased temperatures. This has resulted in the drying up of water sources and wetlands, declining forests, increased pests and diseases and reduced agricultural productivity. In the CH villages, they have responded by planting broadleaved trees and harvesting more water, while in the EH the response has been to change cultivation practices and switch to more drought-tolerant varieties.

Social capital: Despite considerable cultural change, most households still speak their traditional language, particularly in the CH communities. Other cultural practices are on the decline, however, with fewer people wearing traditional dress except during festivals and ceremonies. Traditional recipes are dying out or being modified, and traditional housing has disappeared (in the EH villages) or are less valued. Although sacred ceremonies, which strengthen social bonding and networking are on the decline, they are still important in the EH, and people have started to come together in new structures (Self Help Groups and crop protection committees) and still share resources at the community level.

Biocultural innovations: The communities have developed and adopted a wide range of biocultural innovations including technological, market and institutional innovations, based largely on traditional knowledge or a combination of traditional and external knowledge. These have enabled them to improve their food security, climate resilience and incomes, and maintain crop diversity. The most significant innovations in the CH have been more new and intensive mixed cropping close to houses; a new 25% higher yielding resilient radish variety; setting up crop protection committees to pay for guards against wildlife; and changing composting and cultivation techniques to reduce runoff and conserve water. In the EH, innovations have included developing new higher yielding cultivars of cardamom and black rice bean; changing the timing of planting and harvest in response to changing rainfall patterns; adopting new cash crops such as broomstick grass domesticated by farmers; and greater community cooperation in collective paddy seedling production, joint marketing, and adapting traditional labour sharing practices. The drivers and conditions that have supported innovation include pioneering elders, institutions like women's Self-Help Groups, and networks and collective activities, including kinship relations, pooling labour and traditional festivals, as well as interaction with external actors (scientists, for example).

Conclusions and recommendations

The communities in the two sites have developed a wealth of resilient practices and innovations to support adaptation to climate change. To strengthen these smallholder innovation systems, the study recommends the following further actions:

- Formally register new crop varieties developed by the communities under the Protection of Plant Varieties and Farmers' Rights Act, including a new variety of radish in the CH and a black rice bean cultivar in EH. The latter could also be registered as a Geographical Indication.
- Encourage communities to exchange seed collections with institutions such as research stations, while providing support to safeguard their rights over traditional varieties and knowledge.
- Support participatory processes to establish a biocultural heritage landscape in Lingsey-Lingseykha for *in situ* conservation of resilient landraces of major food crops (eg rice, beans, maize), and promote its formal recognition as a biodiversity heritage site under India's national biodiversity act.
- Develop new opportunities for community enterprises for biocultural products and services.
- Promote recognition of the value of traditional farming systems and biocultural innovations by the scientific community, and investment in participatory plant breeding for joint innovation to confront new challenges.

Introduction and methodology

Central Himalayas communities. Photograph by Ajay Rastogi.

1

1.1 The SIFOR baseline study in India

India is a partner country in the Smallholder Innovation for Resilience (SIFOR) project, which is coordinated by the International Institute for Environment and Development, and funded by the European Union and UK Aid. The project aims to strengthen traditional knowledge-based innovation systems for food security in the face of climate change, through participatory action-research in India, China, Kenya and Peru. Lok Chetna Manch, a civil society organisation based in the Central Himalayan region, is implementing the project in two sites in India: five villages in district Almora, Uttarakhand state in the Central Himalayas (CH), and five Lepcha and Limbu villages in district Kalimpong of West Bengal state in the Eastern Himalayas (EH). The villages in the EH were chosen to build on the action-research activities supported in three villages through a previous project,[1] which targeted areas rich in agrobiodiversity and traditional knowledge. The five villages in the CH were selected for their commitment to sustaining traditional farming systems.

Smallholder farmers in these marginal mountain environments have been adversely affected by changes in the climate in recent years and are trying to adapt and innovate to ensure their survival and enhance their incomes. This report presents the results of a comprehensive baseline study conducted as part of the SIFOR project in the 10 villages.[2] The study explored the situation and trends in livelihoods and migration, food security and farming systems, crop diversity, seed systems, social capital, and climatic changes — particularly between 2002 and 2012, but also going back 30 or 40 years for some indicators, based on farmers' recall. It also explored traditional knowledge-based or 'biocultural' innovations developed by smallholders in response to climatic and livelihood challenges, and the factors or conditions that support biocultural innovation systems, for dissemination amongst communities and to provide baseline data for monitoring and evaluation.

BOX 1. SIFOR STUDY SITES – CENTRAL AND EASTERN HIMALAYAS

The SIFOR site in the **Central Himalayas** is located in Almora district, in the state of Uttarakhand. This falls broadly in the subtropical belt of the Kumaon region. The five study villages are Galli, Basyura, Chinauna, Pichna and Gallakot in the Talla Sari valley of Govindpur, Kosi river catchment, with an average elevation of 1,400 metres. People in the region are exposed to modern communication channels and new chemicals and seed systems in agriculture. Some community members have experimented with them, but rates of adoption have been negligible. By and large, farmers seem to value time-tested methods and resources for cultivation, harvesting and processing. The main crops of the region are paddy (ie rice), wheat, finger millet, barnyard millet, proso millet, foxtail millet, barley, buckwheat, bitter buckwheat and amaranth. Pulses grown in the region include Himalayan black soybean, blackgram, pink lentil, rice bean and horsegram. People also grow a variety of vegetables and leafy greens in small gardens inside the homestead. However, the overall trend of declining agriculture in the hills is quite visible. Agrobiodiversity is being steadily lost, and access to traditional and local varieties is becoming a problem, due to loss of interest among farmers and general degradation in agricultural practices. People are generally aware of the impact of chemical inputs, especially on health and the environment.

The **Eastern Himalayas** (EH) study area covers the villages of Tandrabong, Lingseykha, Lingsey, Mudung and Pabringtar, which include Lepcha, Limbu and other ethnic groups. The Lepcha are considered to be indigenous inhabitants of the EH and are mostly settled in mid-altitude mountain areas. Similarly, the Limbu have a strong socio-cultural base in the EH and commonly settled in mid-altitude areas and low hills. Often these two communities are found in adjacent villages. The study selected three mainly Lepcha villages and two Limbu villages, following discussion with community leaders, rural development workers and government line departments. The villages are rich in traditional agriculture and biodiversity, and are highly dependent on agriculture and other natural resources. Besides grains, their food includes roots, tubers, fruits, vegetables and wild edibles. They are located in northern West Bengal, on the borders of Sikkim and Bhutan, at altitudes of 900 to 1,400 metres above sea level. They are located mostly in a sub-tropical region, which is the richest zone for the diversity of orchids, rhododendrons and many spectacular groups of flowering plants. In the mid 1980s, the Indian government declared a significant area along the Bhutan border and Lingsey-Lingseykha to be the Neora Valley National Park because of its rich flora and fauna.

[1] Swiderska K, Argumedo A, Song Y, et al (2009) Protecting community rights over traditional knowledge: Implications of customary laws and practices. Key findings and recommendations 2005–2009. IIED, London. http://pubs.iied.org/pdfs/14591IIED.pdf
[2] No control villages were selected since this would raise expectations among the residents, and it would be hard to justify why there were no project interventions in some of the villages where data was collected.

1.2 Methodology

The study used common indicators and questionnaires developed by research partners for the four SIFOR countries to allow comparison of the findings. It used a mixed methods research approach, involving both qualitative and quantitative surveys, to provide a more complete understanding. The first step was to seek free, prior and informed consent within the communities. Meetings were held in each village to share information about the project and explain the proposed approach in the local language. It was a challenge to explain the concept of 'innovation' because the humility of the people made it difficult for them to consider their adaptation strategies as innovations. However, as the project focused on traditional knowledge-based innovations, including the revitalisation of indigenous knowledge and practices as innovations, it was able to convince farmers that they have made a rich contribution.[3]

The second step was a qualitative baseline study. This was conducted from October 2012 to October 2013, at community and household levels, to broadly assess key trends and types of biocultural innovation developed by the communities, and inform the development of specific questions/indicators for the subsequent quantitative survey.[4] There were in-depth focus group discussions and interviews to explore trends in livelihoods, agriculture, forestry, crop diversity, climate, and social capital; identify biocultural innovations (technological, market and institutional); and explore four innovation factors: people, institutions, networking and community-level factors. The discussions also focused on identifying key groups and individuals involved in developing innovations to address climatic and socioeconomic challenges. In-depth interviews were then carried out with these innovators to further explore key innovations, the reasons behind them, and the factors or conditions that supported their development.

The third step was a quantitative household survey conducted between August 2013 and October 2014, using stratified random sampling.[5] Since it was a very comprehensive questionnaire, considerable time was needed to translate, field test and adapt it to the local context. Sixty-five households in the CH and 100 households in the EH (5% of the total population of the area) were randomly chosen for household interviews. Group discussions were undertaken with women, older people, teachers, and village heads in each community, to generate information at community level,[6] and later to share the findings. This report provides the results of both the qualitative and quantitative survey on trends and innovations, with details of key innovations identified and the innovation factors supporting them (Section 8).

1.3 Historical, governance, agricultural and climatic context

Central Himalayas

The majority of the population still practises Hinduism and follows the caste system. This deep-rooted caste system has its own prejudices and customs. However, compared to other parts of the country, there is an absence of sharp class divisions, and most people own and till their own land using family labour. Almost all of the agricultural labour except ploughing is carried out by the women of the family, making their workload extremely heavy.

Cultural traditions and institutions protected the forests, and forests formed an integral part of agricultural and animal husbandry practices. With the onset of the railways in the late 19th century, large-scale destruction of forests began, and the British government took over large tracts of land and notified them as reserved and district-protected forest, curtailing the use of forestland by villagers. After several rebellious movements in the early part of the 20th century, the government provided concessions for usufructs, such as fodder and fuelwood collection. At the same time, it allocated parts of forest land adjacent to villages under community arrangement referred to as *van panchayats* (forest committees). At the village level, *van panchayats*, which function under the Kumaon Van Panchayat rules, empower local committees to govern the subsistence as well as commercial usage of the area. The *van panchayat* is the only traditional institution in the region that still functions and has reasonable authority.

The people continue to primarily practise rainfed agriculture, despite persistent falls in production levels. According to the qualitative survey, changing weather patterns were an important factor in declining production, along with crop raiding by stray cattle and wild animals. People still depend on forest biomass for such needs as fuel, fodder and compost. Forests are degrading, mainly due to forest fires and erratic or

[3] The project defined innovations as "new ways of doing things" (ie practices) or new technologies, that emerge from the interaction between the components of biocultural heritage (ie traditional knowledge, biodiversity, landscapes, cultural and spiritual values, and customary laws) or between traditional knowledge and science.
[4] See Rastogi A, Sogani R, Gurung N (2014) Smallholder Innovation for Resilience (SIFOR) – Qualitative baseline study, Central & Eastern Himalayas, India. IIED, London. http://pubs.iied.org/G03829/
[5] The quantitative survey questionnaire can be found at http://pubs.iied.org/G04038/
[6] The community-level survey can be found at http://pubs.iied.org/G04037/

reduced rainfall, which leads to drier conditions prior to fires. Most people still have local breeds of animals (cows, buffaloes, goats) but the number of domesticated animals has gone down, as fodder is not easily available. Although formerly known as the land of milk and honey, the region suffers from considerable malnutrition. Despite increased infrastructure such as roads, schools and hospitals, outmigration to cities has steadily increased (see Section 2).

The scientific community has observed rapid climate changes in the Himalayas. Mean temperatures have increased more than the global and Indian mean, by an average of 1.5 degrees Celsius above pre-industrial levels. There have also been significant changes in rainfall. Unlike other Himalayan Indian states, Uttarakhand has seen a decreasing trend in precipitation, with an annual decrease of 2% in the past 100 years. Monsoon precipitation has fallen by 5% and winter precipitation by 2% but the pre-monsoon rains have increased by 4%, indicating a shift in rainfall patterns.[7]

Eastern Himalayas

The Lepcha (natively called *Rong*) are instinctively hunter-gatherers and possess rich knowledge about nature, whereas the Limbu (natively called *Tshong*) were the chief cattle merchants.[8] The names of the villages signify beliefs and practices of the region. *Tandrabong* means drumming in Lepcha as they play drums during rituals. The original name of Lingsey is believed to be Lyangsha meaning 'place of worship' (*Lyang* means land and *Sha* means worship). The place where they worship is called Damling Lake. The Lepchas of Lingsey and Lingseykha practise three different faiths: Shamanism, Buddhism and Christianity. They also follow common traditional rituals. The communities engage in trans-border activities, such as exchanging animals, food crops and seeds. Until recently, Drukpa communities from Bhutan used to cross the border for formal as well as monastic education. However, cross-border exchange has reduced considerably following an increase in border vigilance by Nepal and Bhutan.

Pabringtar is a Limbu stronghold that lays great emphasis on paddy cultivation. The name is said to be derived from the word *khupringtar,* meaning sacred place, and is also used to describe areas of paddy cultivation. Almost all the people, including the young, speak the native tongue and follow traditional ceremonies and cultural rituals. They also grow different types of beans, pulses and oil seeds. Pabringtar is the only village where dryland paddy is still grown. About 30 years ago they used to grow cardamom but the plantations were wiped out due to deforestation, population growth, the drying up of water sources, dry soil conditions and less rainfall. These drylands are covered with broomstick grass, which has become a major cash crop of the area. Some forest remains in the surrounding areas but, due to landslides, most of the area is unproductive wasteland. Mudung is an adjacent Limbu village with similar topography and agricultural practices.

Agriculture continues to be the primary source of occupation and livelihood. There has been a shift towards market agriculture, as pulses and vegetables are cash crops. Although traditional mixed farming systems continue, where several crops are grown in the same field simultaneously, the mix of crops has changed with a shift towards cash crops. This shift in livelihood has affected agrobiodiversity and nutritional security of households. This region has seen some political turmoil since 1986, including two armed revolutions to demand a separate state. As a solution to the problem, the government tried having two different administrative systems. It constituted the Darjeeling Gorkha Hill Council and the Gorkhaland Territorial Administration. In the process, democratic processes were paralysed and decentralised self-governance institutions like the Panchayati Raj system became defunct. No *panchayat* elections have been held since 2005. Formal institutions of local self-governance are non-existent today, whereas traditional institutions continue. The Lepcha and Limbu come under the Scheduled Tribe communities of India and have their own community organisations: the *Sezom* and *Yak-Thung-Sung Chumfo* respectively. These organisations have the objectives of conserving cultural heritage, rituals, tradition, language, and so on.

The average annual rainfall in Kalimpong is 2,250–2,500 millimetres, and the maximum temperature in summer reached 30 degrees Celsius, falling to 3–4°C in winter. According to the meteorological data between 2007 and 2012, Kalimpong has seen a change in monthly rainfall patterns. Rainfall during the peak season (June-July) has decreased and the overall rainfall period has shortened. The overall pattern of monthly temperatures also changed during this period. Seasonal fluctuations in temperature and weather conditions are not only disturbing farming systems, but are influencing the associated cultural ceremonies and festivals. The annual rainfall of Darjeeling district as a whole was 3,806 mm in 2007 and 3,415 mm in 2012, indicating a 10.2% decrease.[9]

[7] Joshi R & Kumar K (2014) Analysis of long term climate variability and changes in North-Western states of Indian Himalayan Region (IHR). In: *Climate Change and Himalaya: Natural Hazards and Mountain Resources.* P Gupta, J Sundaresan, R Boojh, KM Santosh (Eds). Scientific Publishers, New Delhi.
[8] The Bengal Government Secretariat (1894) The Gazetteer of Sikhim, p. 37.
[9] Government of West Bengal (2012) Statistical Handbook, West Bengal. Bureau of Applied Economics and Statistics, Kolkata, p. 58.

1.4 Key concepts and community perspectives

Biocultural heritage: The SIFOR project focuses on 'biocultural heritage' as interlinked traditional knowledge, biodiversity, landscapes, cultural and spiritual values, and customary laws. Although the concept was inspired by the holistic worldview of Quechua communities in the Andes (Peru), it is also evident in Lepcha and Limbu communities in India. The communities consider culture as an integral part of nature. Whether it is a religious ritual, family ceremony or community festival, all customs engage nature. The biological and cultural realms are not segregated. According to the communities in the CH and EH, they intrinsically relate to biodiversity conservation, and nature is considered sacred in their traditional cultures. Knowledge of trees, crops, animals and home-based health remedies still play a very important part in peoples' lives and survival.

In the CH, Hindu religious rituals involve the worship of trees, water sources and cows, and they have several rituals and customs to appease deities to protect their crops and animals. In the EH, Lepcha and Limbu communities have a deep relationship with their landscape features such as rocks, mountains and lakes, as well as with their ancestors. Traditionally, the Lepcha belief system is profoundly connected to the natural world. The Lepcha consider themselves beloved children of Mount Kanchendzonga. Ancestors are considered to be the protectors of the community. Lepcha, Limbu and other indigenous mountain communities have inherited practices rooted in faith and respect, expressed through many rituals.

Communities in both the study sites, associate the spiritual world with ancestors and elements of nature, merging the animate and the inanimate components of the landscape in a deep relationship. Festivals and food are seamlessly joined as part of local living traditions (ethos, customs and practices), and form the very essence of their rich biocultural heritage. Traditional knowledge, rituals and practices reflect the rich biocultural heritage and the cultural values of reciprocity, solidarity, equilibrium and collectivity.

Plant genetic resources: The Food and Agriculture Organization (FAO) Treaty on Plant Genetic Resources for Food and Agriculture defines these as: any genetic material of plant origin of actual or potential value for food and agriculture. The communities in the study have a wealth of traditional knowledge about plants and crops, and recognise the tremendous range of biological diversity both between species (different crops) and within species (cultivars and varieties). In the CH, women are the custodians of plant genetic resources. In the EH, *Bungthing* (Lepcha priests) and *Phedangbha* (Limbu priests) have maintained many of the endangered species of the plants in their homestead gardens for ritual requirements. There is a saying in Lepcha that "a monkey may die because of hunger but a Lepcha will not die because of hunger". It implies that Lepchas have so much knowledge about plants, animals and their ecosystem as a whole that they can always obtain food from nature.

Food security: The local languages and dialects have no word for food security. When discussed in detail, people basically interpret it as food that is sufficient enough to satisfy hunger, is nutritious and provides enough energy to undertake the physically demanding tasks of an agrarian way of life. They are known to plan for food security based on experiences of scarcity and abundance in the past. This is changing quickly with improved access to markets and the government's Public Distribution System (PDS). They feel that the food supplied under the PDS is only good enough to satisfy hunger. People are not sure of its nutritional value or safety, as it is mostly grown using chemicals and may be unhygienically stored and transported.

Conservation: This is a word that people did not use traditionally. It was customary to wisely use natural resources and do no harm. Local seed saving and maintaining the diversity in mixed cropping systems was widely practised and continues to some extent today. Traditionally, people in the Central Himalayan communities protected the forests under their respective *van panchayats*. As a result, these forests are characterised by broad-leaved species, such as oak, rhododendron and box myrtle. The broad-leaved forests are known to improve water infiltration and serve as primary source of several perennial springs in the region. As a result, some of these tree species and springs are considered sacred; many springs have an elaborate temple-like structure (*naula*). In the Eastern Himalayan communities, ancestors are regularly made offerings of crops and animals; many species and varieties are conserved specially to be used in rituals and sacrifices. Community perceptions of conservation are becoming more utilitarian in the case of regular food crops, and increasingly, communities only conserve those species or varieties with economic value.

Innovations: The SIFOR project uses the standard definition of innovation, a new way of doing things or new technology. It defines 'biocultural innovations' as innovations arising from interaction between the components of biocultural heritage, or between traditional knowledge and science. Farmers in the CH do not recognise the word innovation, even in Hindi. They relate it with 'adaptation'. According to them, they have come up with various adaptation mechanisms to cope with changes brought about by nature and other factors. Based on their experience and knowledge of their surroundings and challenges, they have developed coping mechanisms to address these issues. However, the study identified a range of biocultural innovations for adaptation in both the sites (see Section 9).

Livelihoods and migration

This section covers changes in income and expenditure over the period 2002–2012 and the importance of agriculture for households' income and food security. It also looks at the impact of migration on agricultural labour and the makeup of the agricultural labour force.

Mixed cropping, Eastern Himalyas. Photograph by Nawraj Gurung.

2

In both the Central and Eastern Himalayan regions, overall per capita incomes increased between 2002 and 2012, but expenditure also went up. The contribution of agriculture as a share of total income decreased. Non-farm income rose in the Eastern Himalayas (EH) due to wage labour under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and rising temporary employment in nearby areas and towns. In the Central Himalayas (CH), income security comes from pensions, jobs in local schools, and money remitted home by migrants working in hotels and factories in the adjacent plains. This may explain why in the CH, husbands and wives work together in their farm in 88% of households, whereas in the EH they continue working together in almost all households. In the CH, the trend has changed over the last two decades from temporary male outmigration to outmigration of families.

2.1 Household income and expenditure

Average household incomes have increased in the project villages. In the CH, they grew by 65% between 2002 and 2012 (Table 1). In the EH, incomes rose by 68% due to a shift from cereal food crops to cash crops such as cardamom, ginger and broomstick grass, as well as government schemes like the MGNREGA. However, per capita income in the project villages is much lower than the national average of US$1,570 (nominal) per year.

The contribution of agriculture to income has consistently decreased in both the project sites (Table 2). In the CH, income from agriculture declined from a high of 50% in 2002 to almost negligible in 2012 in Galli and Basyura. The rate of loss has been lowest in Pichna, where farming contributed 35% of household

Table 1: Household income, 2002–2012

	INCOME (RUPEES)*					
	CENTRAL HIMALAYAS			EASTERN HIMALAYAS		
	2002	2007	2012	2002	2007	2012
Average	67,075	84,523	110,797	41,862	49,761	70,481
Maximum	367,000	461,000	581,000	109,000	127,000	690,000
Minimum	3,700	7,800	9,800	7,000	7,900	8,700

* US$1 = 54.4 rupees in 2012.[10]

Table 2: Contribution of agriculture, non-farming activities and migration to income, 2002–2012

	% AGRICULTURE		
	2002	2007	2012
CH – average	42	31	7
EH – average	83	73	63

	% NON-FARMING ACTIVITIES		
	2002	2007	2012
CH – average	20	30	43
EH – average	12	13	15

	% MIGRATION		
	2002	2007	2012
CH – average	17	21	10
EH – average	7	7	8

[10] Reserve Bank of India (2013) Table 147. Handbook of Statistics on Indian Economy. www.rbi.org.in/scripts/PublicationsView.aspx?id=15268.

incomes in 2002 and 25% in 2012. The declining contribution of agriculture to income is primarily because of the increase in non-farm employment opportunities, such as construction work, around the villages. Government schemes like those under the MGNREGA have also increased employment opportunities and the minimum wage in the area. Many people have stopped practising agriculture because of the destruction caused by animals like wild boars and monkeys, since instances of crop-raiding are steadily on the rise.

In all the EH project villages, income from agriculture was more than 80% in 2002 (Table 2). This decreased by 15% in Tandrabong and 25% in Pabringtar between 2002 and 2012, but remained comparatively stable in Lingsey and Lingseykha, due to their more remote location (the other two villages are closer to towns with greater opportunities for non-farming livelihoods).

The percentage of non-farm income in the CH has grown over the years, reaching 43% in 2012 (Table 2). It is interesting to note that the share of income from migration to urban areas rose from 2002 to 2007 and then declined from 2007 to 2012. It is likely that local employment generated through MGNREGA accounted for this. However, the biggest contributors to income in the region are pensions, school jobs, and employment in factories and hotels in cities located in the lowland areas.

In the EH, villages adjacent to forests have the advantage of being able to earn additional income through cultivating cardamom in the forestland. Villages without potential for cash crops have a tendency to become more dependent on non-farm income. Livelihoods in all the villages have consistently improved, particularly in villages with potential for cash crops. There has been a significant increase in the market price of cardamom in the last few years, and production has been revitalised due to innovations in the cardamom farming system (Section 8).

In both the CH and EH, expenditure has also gone up (Table 3). However, net income grew in both sites, particularly in the EH where expenditure is lower. In the CH, food was identified as the most important item of

Table 3: Expenditure per household, 2002–2012

	AVERAGE EXPENDITURE (RUPEES)		
	2002	2007	2012
Central Himalayas	75,007	101,726	95,349
Eastern Himalayas	33,756	42,395	51,716

Table 4: Household spending: first, second and third most important items, Central Himalayas

% OF HOUSEHOLDS SURVEYED STATING FIRST, SECOND AND THIRD IMPORTANCE									
	2002			2007			2012		
Expenditure	First	Second	Third	First	Second	Third	First	Second	Third
Food	33	43	4	33	34	12	46	22	10
Interpersonal communication	0	0	0	0	0	0	0	0	0
Education	0	16	25	7	13	23	10	25	19
Health	11	20	45	8	30	30	5	32	39
Clothing	0	3	13	0	3	19	2	2	12
Agricultural inputs, eg seeds, pesticides, chemical fertiliser	0	0	0	0	0	0	0	0	2
Transport	0	0	4	0	0	2	0	3	3
Housing	11	13	5	11	11	12	18	8	14
Other (culture, ceremonies, gifts)	44	5	4	41	8	2	20	8	2

Table 5: Household spending: first, second and third most important items, Eastern Himalayas

% OF HOUSEHOLDS SURVEYED STATING FIRST, SECOND AND THIRD IMPORTANCE									
	2002			2007			2012		
Expenditure	First	Second	Third	First	Second	Third	First	Second	Third
Food	60	44	0	58	43	5	64	37	0
Interpersonal communication	0	14	2	0	4	2	0	0	0
Education	39	21	10	41	27	7	35	31	3
Health	1	1	10	0	6	12	0	11	14
Clothing	0	17	28	0	6	28	0	6	29
Agricultural inputs, eg seeds, pesticides, chemical fertiliser	0	4	44	1	15	42	0	15	50
Transport	0	0	2	0	0	2	0	0	1
Housing	0	0	2	0	0	2	0	0	1
Other (culture, ceremonies, gifts)	0	0	3	0	0	2	0	0	2

household expenditure (Table 4). Rising steadily, nearly half the households (46%) ranked purchasing food as the most important expense in 2012, compared to 33% in 2002. The second biggest item of expenditure is healthcare, which has steadily grown over the years. Another big area of household expenditure is for cultural and religious ceremonies for newborn babies, marriages, and so on (included in the "other"), followed by education and housing.

In all the EH villages, the most significant expense was also food, identified as the most important by 60% of households in 2002 and 64% in 2012 (Table 5). Other important expenses are education, followed by clothing and purchase of agricultural inputs. It is interesting to note that investment in cash crops potentially increases incomes, but also increases expenditure on food.

2.2 Migration and agricultural labour

In the Central Himalayan villages, migrants from outside the area do not engage in agriculture — the whole labour force is from the village or local area. Women are the main farmers in the area. The percentage of women in farming out of total farming labour slightly increased from 62% to 64% between 2002 and 2012 (Table 6). There was not a single household where only men farmed. Non-farming couples are increasing in the whole CH area, although 88% of households surveyed still had both men and women involved in farming in 2012. The decadal census survey of 2011 revealed that some young men in the CH are moving with their families for a better life and education in urban areas.[11] This is mainly due to ecological changes and the non-commercial nature of agriculture in the region, which makes it increasingly difficult for households to sustain a livelihood through agriculture alone, while other local earning opportunities are scarce.

The SIFOR survey in the CH found that 100% of households in Chinauna and Pichna villages have women involved in farming, while in Galli and Basyura 50–60% of households do. In Gallakot, however, women are engaged in agriculture in only 5% of households. This is largely because Gallakot village is dominated by high-caste Brahmins who do not pursue

[11] Venkatesh S (2015) Why this abandoned village is a threat to Uttarakhand. Down To Earth. www.downtoearth.org.in/coverage/why-this-abandoned-village-is-a-threat-to-uttarakhand-52154

Table 6: Gender and age trends in farming, 2002–2012

% OF OVER-SIXTY-YEAR-OLDS IN FARMING LABOUR FORCE			
	2002	2007	2012
CH – average	24	18	11
EH – average	58	58	58

% OF WOMEN IN FARMING LABOUR FORCE			
	2002	2007	2012
CH – average	62	63	64
EH – average	43	53	60

% HOUSEHOLDS WITH BOTH MEN AND WOMEN IN FARMING									
	HUSBAND AND WIFE			MAINLY WIFE			MAINLY HUSBAND		
	2002	2007	2012	2002	2007	2012	2002	2007	2012
CH – average	98	94	88	14	12	12	0	0	0
EH – average	100	100	100	30	30	30	43	43	43

agriculture as a livelihood. The women grow a few vegetables around the house and most of their land is leased out.

The EH survey also found no migrant labour engaged in farming activities in the communities. In 100% of households both the husband and wife are engaged in farming activities. This suggests that there is less outmigration in the EH than in the CH, perhaps because cash crops in the EH mean that agriculture is a source of income, rather than just for subsistence. In 2002, 43% of the agricultural labour force were women, increasing to 60% in 2012. Those aged over 60 years made up 58% of farming labour and this trend did not change between 2002 and 2012 (Table 6).

2.3 Most important livelihood activities for income and food security

In the CH, 19% of the households surveyed identified food production and sale as the most important income-generating activity and 50% said it was the second most important activity (Table 7). The third most important activity for generating income was either agricultural labour or crop production, chosen by 26% of households. Dairy is not a very important source of income. Crop production was the most important priority for food security for 67% of households (Table 8). However, the biggest contributors to income security in CH are pensions, school jobs, and employment in the factories and hotels in the cities located in plains. They are all clubbed together in the 'other' category and in order of first importance to income security; they contribute as much as 40%.

In contrast, 82% of households in the EH considered crop production and sales to be the most important income-generating activity (Table 7). Livestock sales are also important for communities in the EH: 55% and 50% of households consider this to be the second most important activity for income generation and food security, respectively (Table 7 and 8). Around 45% of households consider employment in nearby areas to be important for food security and income generation.

Table 7: Most important activities for generating income (percentage of households surveyed)

	CENTRAL HIMALAYAS			EASTERN HIMALAYAS		
	First	Second	Third	First	Second	Third
Crop production and sales	19	50	26	82	7	3
Livestock production and sales	0	4	0	9	55	7
Milk production and sales	0	0	7	0	0	19
Labour in urban areas	10	6	4	0	3	0
Agricultural labouring	8	6	26	0	21	14
Employment in nearby areas	15	19	11	7	9	48
Small business	8	2	7	0	3	3
Petty trade, eg market stalls	0	0	0	0	1	2
Tourism	0	0	0	0	0	0
Household work	0	0	15	0	0	0
Renting out property (land, equipment, housing etc)	0	0	0	0	0	3
Other (pensions & jobs in schools, factories & hotels)	40	14	4	1	2	1

Table 8: Most important activities for ensuring food security (percentage of households surveyed)

	CENTRAL HIMALAYAS			EASTERN HIMALAYAS		
	First	Second	Third	First	Second	Third
Crop production and sales	67	21	5	68	9	3
Livestock production and sales	0	2	3	11	50	7
Milk production and sales	0	0	5	1	0	14
Labour in urban areas	4	2	3	0	2	0
Agricultural labouring	8	13	15	4	13	16
Employment in nearby areas	4	17	13	13	16	41
Small business	6	10	21	0	8	2
Petty trade, eg market stalls	0	0	0	1	0	2
Tourism	0	0	0	0	0	0
Household work	0	0	15	0	1	3
Renting out property (land, equipment, housing etc)	2	0	3	0	0	3
Other (pensions & jobs in schools, factories & hotels)	8	31	15	1	0	10

Food security and farming systems

This section looks at trends in food security over the last 30 years, along with yield and consumption of major food crops. It also covers trends in land ownership and livestock, to present an overview of the farming systems in the two sites and the major changes that have occurred.

Biopesticide preparation, Central Himalayas. Photograph by Ajay Rastogi.

3

3.1 Food self-sufficiency

For staple crops, food self-sufficiency declined significantly from 81% to 18% of households surveyed in Central Himalayas (CH), but decreased only marginally in Eastern Himalayas (EH), from 58% to 53% (Table 9). Self-sufficiency in vegetables decreased by 30% in the CH, while in the EH, it increased by 10%. In the CH, there is almost complete dependence on the market for cooking oils, except in the village of Pichna, where households could meet 20% of their household consumption in 2012, down from 40% in 2002. This decline is due to easier availability of cooking oil in the market and increasing difficulty in growing oilseeds, due to bird and animal attacks. In the EH, diversion into cash crops (including vegetables and pulses) has not greatly affected the overall self-sufficiency in staple foods. In contrast, in the CH, the overall degradation of agriculture has led to a substantial decline in food self-sufficiency.

Table 9: Food self-sufficiency in 2002, 2007 and 2012 (% of households surveyed)

STAPLE FOOD SELF-SUFFICIENCY/ SELF PRODUCED (%)			
	2002	2007	2012
CH – average	81	58	18
EH – average	58	53	53

VEGETABLE SELF-SUFFICIENCY (%)			
	2002	2007	2012
CH – average	59	32	18
EH – average	60	70	70

COOKING OIL SELF-SUFFICIENCY (%)			
	2002	2007	2012
CH – average	58	38	4
EH – average	0	0	0

In both the CH and EH, food self-sufficiency continues to be perceived as important. In the CH, 81% of households considered it very important and 19% considered it important (Table 10). They have not suffered from food deprivation and scarcity, thanks to non-farm sources of income, and therefore reported no coping strategies. Although production and productivity has declined, all major crops are local landraces, and there is negligible use of external inputs.

In all the EH villages, food self-production and sufficiency is very important, as attested by 100% of the respondents. However, they feel being self-sufficient in food production is not a viable approach in the present socioeconomic conditions. Food production in the mountains makes less economic sense, with decreased yields (due to climate change and other factors, see Table 11), increased cost of living, greater access to opportunities for better incomes, and cheaper food grain available from the market and the Public Distribution System (PDS).

Table 10: Importance of food self-sufficiency among respondents in the two sites

% HOUSEHOLDS SURVEYED		
	CH	EH
Very important	81	100
Important	19	0
Slightly important	0	0
Not important	0	0

In the CH villages, the productivity of wheat, rice and millet has declined considerably, while in the EH villages, the productivity of rice and maize has remained more or less constant, with minor falls in potato productivity (Table 11). In the CH, millets are still the most important source of crop and biomass yield, despite a greater decline in both crop and biomass yields than other cereals. Overall the productivity of wheat declined by 45%, rice by 37% and finger millet by 68% (Table 11).

In the CH, most agricultural production is consumed at home, except for some crops, such as barley, that are mainly grown for use in festivals and ceremonies. Some seasonal vegetables, such as radish and gourds, and spices, such as turmeric and coriander, are also sold when in excess (Table 12). In the EH villages, average maize production is 373 kilograms per hectare (kg/ha) (Table 11) and all the maize produced is consumed by households for feed, food and seed (Table 12). Vegetables are also grown in all the villages, with 53% of total produce sold in the market, on average. In Lingsey and Lingseykha spices are sold as a cash crop, as well as 30% of the rice beans, 20% of cassava and 10% of soybeans produced. The Limbu communities of Pabringtar and Mudung also produce a traditionally processed soybean product called *kenema* as a value-added product.

Table 11: Yields of important food crops, 2002–2012

CENTRAL HIMALAYAS			
		Crop yield (kg/ha)	Biomass yield (kg/ha)
Year	Crop	Average	Average
2002	Rice	2,738	3,061
	Wheat	2,635	2,473
	Millets	5,468	4,211
2007	Rice	2,123	2,417
	Wheat	1,907	1,801
	Millets	2,399	3,321
2012	Rice	1,714	1,837
	Wheat	1,462	1,640
	Millets	1,779	2,621

EASTERN HIMALAYAS*			
		Crop yield (kg/ha)	Biomass yield (kg/ha)
Year	Crop	Average	Average
2002	Rice	349	267
	Maize	395	325
	Potato	1,015	0
2007	Rice	467	259
	Maize	388	323
	Potato	1,093	0
2012	Rice	358	267
	Maize	373	323
	Potato	1,179	0

* Values are based on mixed cropping systems

Table 12: Self-consumption and market crops

CENTRAL HIMALAYAS — % PRODUCE FOR CONSUMPTION AND MARKET (AVERAGE)		
Crop	Self consumption	Market*
Rice	71	2
Wheat	76	3
Finger millet	70	5
Barley	20	51
Black Soybean	59	10
Lentil	68	1
Coriander	77	0
Mustard	79	0.3
Gourd	60	4
Vegetables	71	4

EASTERN HIMALAYAS — % PRODUCE FOR CONSUMPTION AND MARKET (AVERAGE)		
Crop	Self consumption	Market*
Maize	56	0
Potato	66	21
Vegetables	59	53
Pulses	84	19
Soybean	93	6
Cassava	89	9
Millets	97	2
Rice	95	1
Wheat	91	2
Spices	17	77

* where the rows add up to less than 100%, the rest of the produce is used as seed or given to friends and relatives

3.2 Trends in food security and farming systems

People in the CH have noted several changes in food security and livelihoods between 2002 and 2012. Among the households surveyed, 93% reported a decrease in the availability of food grains, and 90% a decrease in personally cultivated seeds (Table 13). Traditionally, farmers would preselect some plants from each crop and harvest seeds from these plants separately. Of late, due to the uncertain survival of crops and constantly declining quantities of seeds, this practice of seed-selection has considerably reduced. Most farmers now save a small part of their regular crop to be used as seeds. This explains why we see as many as 96% of households using self-saved seeds (see Section 5.1), even while almost 90% say that there has been a decline in personally cultivated seeds.

Destruction of crops by animals, reduced interest in practising agriculture, and untimely rainfall are among the main reasons behind these changes. Farmers in the CH have been demotivated by the very high incidence of crop raiding by animals, increased outmigration and reduced collaboration in farming, and the labour-intense nature of traditional practices of crop maintenance. Their primary coping and adaptation strategies are setting up crop protection committees which appoint guards to protect standing crops from animal attack (see Section 8), protecting forests, accessing government schemes, and purchasing food grains. If crops were more certain to survive, people might not only revive the tradition of prior selection of seeds but also start growing good seeds in excess to barter for crops that do not produce good seed in their own farm.

Livelihoods and food security in the EH have shifted from being almost entirely self-sufficient to diversifying into cash crops, such as cardamom, broomstick grass and ginger (Table 14). In Lingsey, 21% respondents mentioned market inflation and rising household expenditures as driving change, by fuelling the need for cash crops. Peoples' food preferences have also been affected, due to easy access to cheaper alternative food sources, through improved connectivity to the market and the widespread government PDS. All these factors have contributed to shifting food dependence from self-production to the market.

Many changes have occurred in farming practices in the CH over recent years. Previously, land would be ploughed about three to four times, but now it is ploughed only once or twice before sowing. Given the uncertainties of getting a harvest, this half-hearted cultivation continues, as there is hope that something is better than nothing and it is not considered socially appropriate to leave the fields barren.

Farmers used to collect manure from the cowshed after considerable decomposition, for 15 to 20 days. Now, 94% of households surveyed report that they collect it much earlier, and the premature use of this manure leads to the growth of white-grub pests (Table 15). Cow dung used to be mixed with oak and nettle leaves to improve the manure, but manure is now mostly made with pine needles, as broadleaved trees are harder to find. This increases the acidity of the soil, making it less fertile and substantially affecting the growth of beneficial microorganisms. The frequency of weeding and irrigation has also declined, affecting the growth of crops. According to the local farmers, they are trying to overcome this problem by improving awareness,

Table 13: Changes in livelihoods and food security: key reasons and coping strategies, Central Himalayas

KEY ISSUES	% HOUSEHOLDS NOTED	KEY REASON	COPING STRATEGY
Decrease in personally cultivated seeds	90	Decrease in interest	Crop protection committee was set up
Decrease in food grains	94	Untimely rain	Government schemes were run
Destruction by animals	73	Deforestation	Appointing guards
Increased dependency on the market	46	Decrease in interest	Crop protection committee was set up
Dependency on rain	10	Untimely rain	Buying from the market
Migration	4	Families are becoming smaller	None

Table 14: Changes in livelihoods and food security: key reasons and coping strategies, Eastern Himalayas

KEY CHANGES	% HOUSEHOLDS NOTED	KEY REASON	COPING STRATEGY
Change in income sources	100	Decline in soil fertility, Unpredictable rainfall Prolonged dry periods Pests and diseases Change in food preferences	Adoption of alternative income sources Dependence on alternative food sources
Reduced agricultural productivity	100	Decline in soil fertility Unpredictable rainfall Prolonged dry periods Pest and diseases	Use of fertilisers Adoption of alternative income sources Dependence on alternative food sources
Change in food sources	100	Change in food preferences	Dependence on alternative food sources

Table 15: Changes in farming systems and coping strategies, Central Himalayas

EARLIER SITUATION	KEY CHANGE	% HOUSEHOLDS NOTED	COPING STRATEGY
Age-old practice was to let the cow dung decompose in the shed for a couple of weeks	Now the cow dung is removed every alternate day	94	Inducting and enlightening younger generations about agriculture
Age-old practice was that manure would be mixed with nettle and oak leaves as well	Leaves are not added	90	Inducting and enlightening younger generations about agriculture
Earlier the farm would be ploughed and de-weeded three to four times	This is not done properly anymore	73	Inducting and enlightening younger generations about agriculture
Earlier people were more enthusiastic about agriculture	Interest in agriculture is decreasing	60	None
Weeding and irrigating happened regularly	Interest in agriculture is decreasing	21	None
Earlier there was no white grub	White grub pest is increasing	31	Vermi-composting

motivation and training in better agricultural practices. At the same time, improving the security of the harvest is considered crucial for the revival of the best traditional practices.

According to farmers in the EH, the major changes in crops and farming practices are the partial loss of traditional varieties, reduction in overall crop diversity, and the introduction of synthetic fertilisers (Table 16). The villages of Pabringtar and Mudung have adopted modern farming practices, but in a limited way.

Table 16: Changes in crop diversity and farming practices: key reasons and coping strategies, Eastern Himalayas

KEY CHANGES	% HOUSEHOLDS NOTED	KEY REASON	COPING STRATEGY
Reduced crop diversity	100	Prolonged dry periods	Adoption of new crops
Loss of traditional varieties	100	Reduced rainfall Prolonged dry periods	Irrigation
Adoption of modern farming practices, synthetic fertilisers	30	Reduced soil fertility Reduced rainfall Resistance of pest, diseases and weeds Prolonged dry periods	Adoption of new crops and modern varieties

3.3 Household land ownership and use

In both regions, farmers own most of the land they cultivate (see Box 2 for details for the EH). A significant percentage of land is rented from others in the community — almost 20% in the CH, which signifies that the land of some outmigrant families is still under cultivation. The primary driver for outmigrants to lease their land is to prevent it from being left barren, which is considered culturally and socially inappropriate. However, the amount of land rented to others is very small among the surveyed households. Neither region recorded significant changes in household land ownership between 2002 and 2012, primarily because, although the number of family members is growing, land is still held jointly and is not physically divided.

In the EH, households held an average of 0.67 ha of rainfed land in 2012, which is almost two and a half times the CH average (Table 17). The maximum rainfed landholding was also almost double in the EH (2.73 ha). The average holding size of irrigated and uncultivated land is only slightly bigger in the EH. Interestingly, rainfed lands make up the same percentage of total land — 82% — in both regions. There is a substantial difference in the proportion of irrigated land, which is seven times higher in the EH (14% as opposed to 2% in CH). This is primarily due to the higher overall rainfall in the region, distributed over a much longer period, combined with indigenous methods of irrigation. The CH has a much greater share of abandoned agricultural land than the EH — 16%, compared with 4%. One of the primary reasons for this is that people have stopped cultivating faraway fields, due to increased crop-raiding by animals, and fewer household members are engaged in farming.

In the CH, uncultivated land is also rainfed, making the share of rainfed land almost 98% (Table 17). All the villages have access to a floodplain. Their geographical position, with easy access to water, alluvial soil and large flat fields, offers better conditions for agriculture and access to forests. The diversity of land use and land types (forest, agricultural, floodplains and rainfed highlands) has enabled farmers to use traditional rotation and mixed cropping systems. Land is used in rotation and also left uncultivated periodically under traditional agricultural practices.

BOX 2. LAND OWNERSHIP AMONGST VILLAGES IN THE EASTERN HIMALAYAS

In the EH, households own 100% of their landholdings in Pabringtar, 94% in Tandrabong, and 97% in Lingsey-Lingseykha, with the rest rented from others. In Mudung, only around 70% of the land held is owned, 20% is rented from others, and around 12% is rented to others. In Lingsey-Lingseykha and Mudung, the average household has 0.4 ha of rainfed land, compared with 0.8 ha in Tandrabong and 1.0 ha Pabringtar. The average irrigated area is 0.1 ha in Mudung and Lingsey-Lingseykha, and 0.5 ha in Pabringtar. Only households in Pabringtar report any uncultivated land, which is due to deforestation and the drying up of water streams in the highland area of the village.

Table 17: Land holdings and use trends, 2002–2012 (hectares)

		CENTRAL HIMALAYAS			EASTERN HIMALAYAS		
		Rainfed	Irrigated	Fallow	Rainfed	Irrigated	Fallow
2002	% land of HHs surveyed	85	2	12	82	14	4
	Average size	0.27	0.16	0.10	0.72	0.17	0.13
	Maximum	1.30	0.30	0.32	2.74	0.95	0.31
	Minimum	0.04	0.02	0.02	0.11	0.05	0.10
2007	% land of HHs surveyed	82	2	16	84	11	4
	Average size	0.27	0.16	0.12	0.82	0.16	0.13
	Maximum	1.30	0.30	0.40	12.02	0.64	0.31
	Minimum	0.04	0.02	0.02	0.11	0.05	0.09
2012	% land of HHs surveyed	82	2	16	82	14	4
	Average	0.25	0.16	0.10	0.67	0.19	0.13
	Maximum	1.30	0.30	0.40	2.73	1.03	0.31
	Minimum	0.04	0.02	0.02	0.11	0.05	0.10

All the Central Himalayan project villages have community *van panchayat* forests, while in the EH there are private forest groves owned by households. In both regions, these forests help diversify landuse and promote mixed farming. Both regions are seeing increasing numbers of trees on private land; mostly for fodder in the CH and for fuel in the EH.

3.4 Livestock production

The trend in the CH is towards rearing more goats – the proportion of goats out of total livestock grew from 7% in 2002 to 14% in 2012. Most of this is for the market – only 5% of goats raised are for self-consumption. Milk production in the CH has marginally declined and the share of buffalo milk consumed by households has declined. One reason for this is improved opportunities to sell milk, especially with the State Cooperative Dairy Federation Network, which was strengthened when Uttarakhand achieved statehood in 2000.

In the EH, only 6–7% of pork and goat meat produced is consumed at home, and the proportion of livestock (pig, chicken, cow and goat) sold in the market has grown since 2002, with related income more than doubling. Pigs and poultry are required in many rituals in the Limbu and Lepcha communities. With pork being a popular meat, pig farming is common in these project villages. Interventions by the dairy industry, initiated by the Himalayan Cooperative Milk Producers' Union, have improved availability of and access to fodder. Livestock rearing remains small-scale in both regions and the proportion of livestock consumed has generally decreased since 2002. Beef is not consumed in the CH and much of India.

Crop diversity

Both study sites are still rich in crop diversity, although crop diversity is declining. This section looks at the current situation and trends in crops and varieties grown, the reasons for crop diversity loss, and the varieties introduced in the 20 to 30 year period prior to 2012.

Lepcha and Limbu communities, Eastern Himalayas. Photograph by Nawraj Gurung.

4

4.1 Crops and varieties grown

In the Central Himalayas (CH), all the households surveyed grew at least 20 different crops and 23 different varieties – the average was 27 crops and 33 varieties (Table 18). Each household usually grows no more than two or three varieties of the same crop, and there is usually one popular variety that is grown by all. Most households grow their own vegetables in kitchen gardens but still need to heavily supplement this with produce from the market. They all grow traditional varieties of vegetables, except for a few households which have obtained seeds of improved vegetable varieties like cauliflower from agricultural extension services. Three landraces of finger miller are grown.

In the Eastern Himalayas (EH), households grow 10 different crop species on average and 20 different varieties. The maximum number of different crop species planted by households is 30 in Lingsey-Lingseykha, 15 in Tandrabong, 8 in Pabringtar and 12 in Mudung. The most diverse crops are beans, pulses and lentils, with over 30 varieties grown in the EH in total: 20 local and 10 introduced. Three maize landraces and two finger millet landraces are grown. Two rice landraces are regularly grown and dryland paddy is still grown in one village.

In the CH, almost 100% of households grow finger millet, followed by rice (90%), barley (79%) and wheat (71%) (Table 19). Only 2% of households grow foxtail millet. Rice takes up the largest area at 0.08 hectares (ha) per household, followed by wheat and finger millet at 0.07 ha each. Among the pulses, most households grow rice beans (72%) and Himalayan black soybean (72%), followed by pink lentil (67%). Pumpkin, gourds and spinach are grown in kitchen gardens occupying very little space.

In the EH, even though food habits have changed significantly during the last 30 years and many exotic crops have been introduced, maize still remains the major cereal crop of the region and is considered the "king of the cereals", followed by rice. Maize is the main food crop grown in all households surveyed, and only landrace maize is grown (hybrid maize has been tried only occasionally by farmers when supplied by Government extension agencies). Two maize landraces are grown consistently: *paheli* (yellow) and *seti* (white) and a third, *thapleykuchey* (smashed head), is popular in Tandrabong village. *Paheli* maize is considered good in terms of taste, as a substitute for rice, tolerant of many pests and diseases, and easy to store. However, it also had lower yield, and takes time to mature and cook. The Limbu of Mudung village also consider *seti* to taste good. It has a small grain size and produces more fodder for cattle than *paheli*. Another maize variety, *birmakai* (cliff maize), a semi-wild type, has become extinct in the region.

Even though the farming community does not have any serious dissatisfaction with the local maize landraces, they sometimes try new varieties introduced by the agriculture department. The strengths of the introduced varieties are very high yield, no lodging problem and quick maturation; the weaknesses are that the seed cannot be retained, they are prone to pest and diseases when stored, and very poor taste. The new varieties have therefore not been adopted.

The second most important food crop is millet in Lingsey-Lingseykha, and paddy in Pabringtar, grown by 100% of farming households. There are two landraces of millet, which account for 100% of the area under millet, and around six varieties of paddy. Two landrace varieties are popularly grown, accounting for 70% of the area under the paddy. The millet landraces are *dolley* and *nangrey*, but the latter has become rare. Both are hardy but *dolley* has better yield. Although millet cultivation has drastically declined, some households grow it for consumption or for ritual needs. Millet is considered to be labour-intensive and its yield has also declined.

All the villages except Tandrabong grow more than two varieties of rice paddy. Different names are given to the same variety in different villages and locations, and many landraces, improved and introduced varieties are cultivated in this region. As the communities live close to the border with Nepal and Bhutan and share kinship relations (mainly with Nepal), seeds were frequently

Table 18: Number of crops and varieties grown by households

	CENTRAL HIMALAYAS		EASTERN HIMALAYAS	
	Crops	Varieties	Crops	Varieties
Average	27	33	12	24
Maximum	33	46	36	50
Minimum	20	23	5	5

Table 19: Yield and area under production per household of important crops, Central Himalayas

CROP	% HOUSEHOLDS	AVERAGE YIELD (KG/HA)	AVERAGE AREA (HA)
Paddy (ie rice)	90	1,415	0.08
Wheat	71	1,521	0.07
Soybean	3	5,500	0.02
Potato	5	1,611	0.03
Horse gram	19	748	0.03
Finger millet	100	1,699	0.07
Mustard greens	41	4,376	0.01
Turmeric	48	1,758	0.01
Barley	79	1,083	0.02
Foxtail millet	2	625	0.02
Black soybean	72	1,049	0.16
Black gram	2	41,667	0.03
Pink lentil	67	812	0.00
Rice bean	72	1,379	0.02
Chillies	5	922	0.01
Mustard	72	931	0.01
Sesame	10	1,283	0.02
Spinach	19	2,752	0.01
Pumpkin*	17	–	–
Bottle gourd*	34	–	–
Ridge gourd*	14	–	–
Garlic	12	3,214	0.02
Potato	7	2,213	0.02

* Grown in kitchen gardens as climbers, so the area covered is not specified and yield cannot be calculated.

exchanged across the border. This exchange has reduced considerably but continues.

Addey and *parakhey* are common local paddy landraces. *Addey* rice is high yielding and does not have lodging and grain dropping problems. It produces less fodder than *bringphul* and its light grain weight makes it difficult to husk. *Bringphul* is tasty with a good yield but is also difficult to husk. Similarly, *tupoo-maruwa* was introduced as an improved variety; it can adapt well to changing climate, produces good fodder, and has an average yield but is difficult to husk. *Mashiney* is a landrace grown in Pabringtar along with other landraces. It is popular for its taste, flavour and storage qualities, but its cultivation is declining due to poor yields.

The third most important food crops in all the villages are beans, pulses and soybean. In Lingsey-Lingseykha, beans and pulses have more significance, since they grow approximately 30 varieties of these, of which around 20 are landraces and the rest are introduced. Black rice bean is a very important pulse in Lingsey-Lingseykha. Because of its taste and highly localised production base in and around this village, it is in high demand in the market, and its yield is very high due to its large size. People prefer it because it is tasty, nutritious, filling, easy to cook and palatable with many cereals. The seed quality in these villages is good, with no diseases reported so far. Elders reported that this black rice bean was developed in the last 10 to 15 years in these villages, through selection from yellow and

red rice beans. It fits well in crop rotation with maize. *Potherey* is another landrace of rice beans of the region. It is tasty and good for soil fertility.

For the three main crops, the total number of landraces remained constant between 1982 and 2012, and the area planted remained fairly constant, with the exception of maize landraces in Tandrabong, where the area planted declined from 90% to 50% (Table 20).

Even though potatoes are grown in all the villages, the quantities grown are small and only for household consumption, except in Tandrabong where it is an important cash crop. Of the households surveyed, 59% grew potatoes in less than a quarter of the cultivated area and 41% grew it in small areas in the home garden. Earlier, Darjeeling Red Round potato was a popular regional landrace but during the late 1960s and early 1970s, it was diagnosed with wart diseases. To compensate, another improved variety called *Kufrijyoti* was introduced. It is high yielding and tastes good but is susceptible to frost.

For Lingsey-Lingseykha and Tandrabong, cardamom is the most important cash crop and for Pabringtar it is broomstick grass. The share of land under cardamom landraces has been decreasing consistently by 25–30% every five years. An improved landrace variety of large cardamom called *varlangay* was introduced during the 1990s in all the villages (see below). Cardamom was previously grown in forested conditions on slopes, and has been brought to cultivation in fields with the introduction of this variety. There is only one landrace of broomstick grass which is used in 100% of its cultivation area. Ginger is another important cash crop and all households grow only one landrace.

Squash is a common, easily available and widely grown vegetable. It is popular because almost all of the parts of the plant — roots, fruits and shoots — are eaten. During the last ten years, a new variety known as *hajarey* has replaced the local landrace because it fruits early and therefore fetches a better price in the market, and it is high yielding. In 2012 the landrace was grown on only 2% of the total crop area for squashes. However, *hajarey* does not taste as good as the local variety, is susceptible to diseases, and has a short lifespan. Local vegetables are commonly grown in all the project villages. They are hardy, tasty and there is a good demand for them in the market. However, their yield is poor and some local vegetables do not have good storage qualities.

In general, all the Eastern Himalayan study villages retain their own seeds, especially for food crop grains, beans, pulses and local vegetables. The main reason for retaining their own seeds and preserving landrace varieties is "old family custom" — cited by more than 50% of households — and to avoid the loss of certain crop types (44% of households surveyed) (Figure 1). Other major reasons are conserving diversity, maintaining alternative food resources, and increasing income and personal food security.

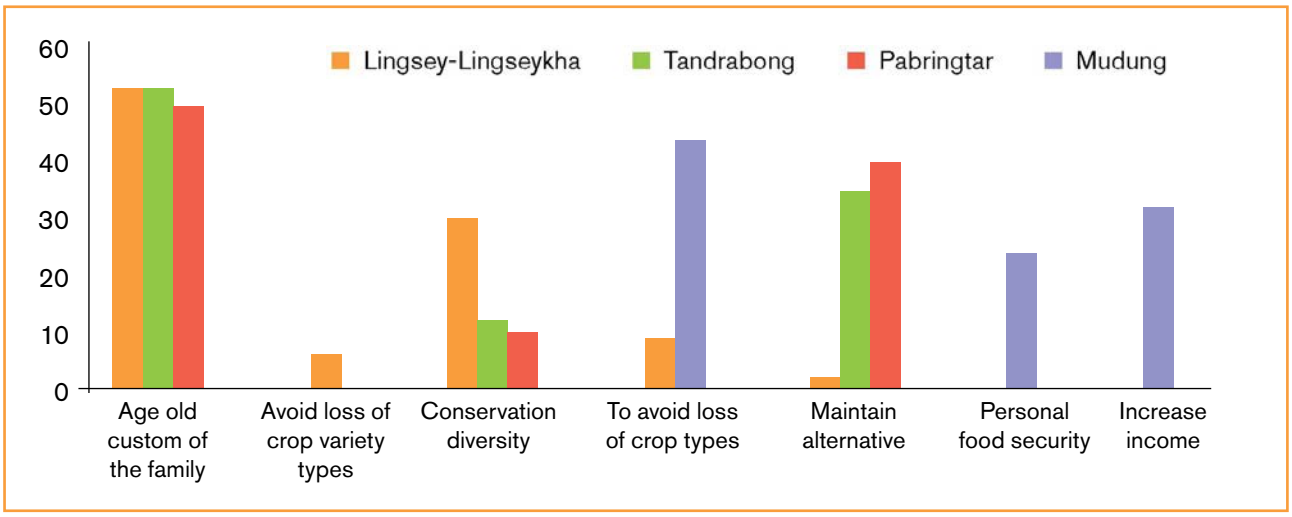
4.2 Crops and varieties lost

In terms of loss of diversity, a number of crops are either locally extinct or barely cultivated: flax seed, Chinese

Table 20: Trends in diversity of major food crops in the Eastern Himalayas, 1982–2012

			1982			1997			2012		
	Crop	Variety	No. of varieties	% of total area	% of households	No. of varieties	% of total area	% of households	No. of varieties	% of total area	% of households
Lingsey-Lingseykha	Maize	Landraces	2	70	100	2	70	100	2	70	100
	Beans	Landraces	20	50	100	20	50	100	20	48	100
		Introduced/ improved	–	–	–	–	–	–	10	2	70
Pabringtar	Maize	Landraces	2	60	100	2	50	100	2	50	100
	Rice	Landraces	2	70	90	2	70	90	2	70	90
		Introduced / improved	8	30	–	6	30	–	6	30	–
Tandrabong	Maize	Landraces	3	90	100	3	70	100	3	50	100
	Millet	Landraces	2	15	40	2	15	40	2	5	10

Figure 1: Reasons for preserving own seeds and landrace varieties



basil (*bhangeera*), groundnut and proso millet in the CH; and buckwheat, wheat, millets and sorghum (*junelo*) in the EH (Table 21). Common factors in both regions are changing food habits (particularly in the EH), and increased availability of food grains throughout the year, through state rations and from markets. Climate change-related water scarcity is also a common reason, particularly in the EH.

In the CH, at least 11 varieties of paddy were lost between 1982 and 2012, and four varieties of wheat (Table 22). The major reason for the loss of varieties in CH is predation by animals, cited by 45% of respondents (Table 25), followed by lack of interest (28%), and destruction by birds (17%). Other reasons include fields getting swept away in floods (3%). Climate change is not considered a very important reason for the loss (1%). This may be because other causes like destruction by animals are more widespread and obvious. Most of the varieties appear to have been lost since 1992. The greatest number of people reported losing a crop in 2000 (Table 23), while for varieties, it was 2005 (Table 24).

In the EH, buckwheat and wheat varieties were almost completely lost and *junelo* (sorghum) largely lost around 1980–1985, while the loss of finger millet varieties took place between 1980 and 1990. Similarly, *kaguni*, a kind of wild millet, and *titey* (bitter), a buckwheat landrace, were lost from all the villages between 1980 and 1985. The main reasons for the loss of these winter food crops in different villages were: uneconomic yield due

Table 21: Crops lost, 1982–2012

CENTRAL HIMALAYAS	
Crop	% households surveyed
Flax (Alsi)	66
Chinese basil (bhangeera)	36
Groundnut (moongfali)	34
Proso millet (cheen)	6
Sorghum (junelo)	6
Jakhiya	2
Foxtail millet (kauni)	2
Pea	2
Soybean	2
Rice bean (rains)	2
Ginger	2

EASTERN HIMALAYAS	
Crop	% households surveyed
Buckwheat	100
Sorghum (junelo)	18
Millets	43
Wheat	76
Rice	25

Table 22: Households reporting varieties lost in the region, 1982–2012

CENTRAL HIMALAYAS		
Crop	Variety	% households surveyed
Paddy	Bakuli	6
	Bhangraat	2
	Borani	13
	Basmati	6
	Gajai	4
	Govindi	4
	Khimuwa	15
	Laal	13
	Saal	15
	Thaapchin	26
	Doodh	2
Wheat	Doodh	2
	Jhusau	4
	Sat	2
	Raat	23
Barley	Bhau	6

EASTERN HIMALAYAS	
Variety	% households surveyed
Paddy (sanoaddey)	16
Buckwheat (titey)	100
Buckwheat (methey)	16
Nangrey	71
Pangdur	5
Nakima	63
Kaguni	50

to longer dry periods and inadequate moisture (cited by 45% of households); availability of grains through the Public Distribution System (40%); demand for potato cash crop (35%); and changes in food habits (28%) (Table 25). However, some households, especially those who perform traditional rituals like *Bungthing* (Lepcha priests) and *Phedangbha* (Limbu priests), still grow finger millet and buckwheat in small areas for rituals. In Tandrabong, no rice has been planted since 1967–68 when a massive landslide destroyed the water sources and irrigation channels along with the paddy fields. A landrace variety of rice, *sanoaddey*, was lost around the 1990s because of declining yields and access to an alternative variety (Table 22). Another important wild edible vegetable with medicinal properties called *nakima* (*Tupistranutans*) has been lost from the forest but has been grown in private gardens since 2001.

Table 23: Loss of crops by year, Central Himalayas

YEAR	NUMBER OF HOUSEHOLDS REPORTING THE LOSS OF A CROP
1970	7
1973	1
1976	2
1980	3
1983	2
1985	2
1988	2
1990	10
1992	2
1995	4
1998	3
1999	3
2000	14
2001	6
2002	2
2003	7
2004	2
2005	10
2006	2
2007	4
2008	4
2009	7
2010	3
2011	1

Table 24: Loss of varieties by year, Central Himalayas

YEAR	NUMBER OF HOUSEHOLDS REPORTING LOSS OF A VARIETY
1975	2
1980	2
1982	3
1985	2
1990	2
1993	2
1995	5
1997	2
1998	6
2000	7
2001	2
2002	2
2003	7
2004	5
2005	12
2006	1
2007	9
2008	2
2009	2
2010	2
2011	1

Table 25: Reasons for loss of crops

CENTRAL HIMALAYAS	
Reasons for loss	% Households surveyed
Destroyed by animals	45
Destroyed by birds	17
Causes stomach problems	2
Climate change	1
Didn't grow	2
Fields got swept in the floods	3
Lack of interest	28
Not enough hands	2
Seeds	1

EASTERN HIMALAYAS	
Reasons for loss	% Households surveyed
Long dry period	45
Change in food habits	28
Uneconomical	17
Tedious post-harvest operations	3
Reduced soil moisture	4
Decline in production	13
Demand for potato (cash crop)	35
Availability of grains through market and PDS	40

4.3 Crops and varieties introduced

The introduction of potato as the main winter cash crop in the EH has been a key driver of crop diversity loss. However, several other crops and varieties have been introduced in the two regions, particularly the EH, many of which are both landraces and cash crops. In the CH, farmers have brought two finger millet landraces from the neighbouring region of Garhwal Himalayas for their higher productivity, and two varieties of dryland paddy (*laal* and *thaapchin*) and a wheat landrace from other farmers in the region. The main advantage of this wheat variety is that it has long awns, which help to reduce damage by birds. In the EH, some landraces that were originally grown on a limited scale have become widespread.

In the CH, only three pulses have been introduced in the last decade, two landraces of pigeon pea and kidney bean, and a modern soybean variety introduced by government extension services. The most widely adopted is the improved soybean, grown by 68% of households. However, this did not threaten the cultivation of two native varieties, as traditional dishes are only made with native varieties. The introduced soybean is larger, has a higher yield and better market value, and is used in local cattle feed mix. People have not introduced many crops or varieties in the area.

Out of the six introduced varieties of finger millet, traditional *Garhwali* finger millet is very popular among households (80%) because of its high productivity and early ripening, which reduces the impact of erratic rainfall. However, it doesn't taste very good and is not considered to be as nutritious as the *gol* variety, which is the second most popular by a huge margin. As rainfed farms are the norm and are consistently increasing, the traditional *laaldhaan* paddy variety is becoming more popular, as it grows well in rainfed conditions despite the erratic rainfall.

Potatoes were commercially introduced to the Eastern Himalayan villages in 1985. In Tandrabong, they were first introduced by Mr Raiman Rai, who obtained seeds of Darjeeling Red Round variety of potato from Agricultural Extension agencies. Lepcha farmers learned the technology from him and started commercial production of potato. Similarly, farmers in Lingsey-Lingseykha and Mudung obtained potato seeds by exchanging them for maize from Sherpas living in high altitudes, and from their relatives. Kufrijyoti, an improved variety of potato, was introduced in 1987, with the seed being obtained from the market and from relatives. Other crops, such as improved varieties of beans (pulses and soybean), were introduced during the 1990s and used as cash crops as well as food. Many other new vegetables were also introduced between 2002 and 2008.

For a long time, ginger was only planted in people's gardens for its significance in rituals and medicines, and to a limited extent as a spice for household use. Only in 1985 in Lingsey, and 1990 in Tandrabong and Pabringtar, was a landrace introduced as a cash crop. Most of the farmers in the villages obtained their ginger seeds from farmers known for their good seeds in the same or neighbouring villages. Ginger became a commercially viable cash crop due to high market demand for it in the plains, but for the last two decades it has been seriously affected by diseases.

For the last two decades the cardamom crop has been heavily affected by disease and unfortunately the scientific community did little to address this problem. In the quest to solve the problem, the farming community identified and improved the *varlangay* landrace, which has wider ecological adaptability, high yield due to bigger pods, and good demand in the market. As a result, cardamom has gradually shifted from an under-canopy forest crop to farmlands. However, in this new habitat its lifespan is reduced to only 8–10 years, down from 15–20 years.

In the past ten years, two improved varieties of rice were introduced — *parakhey*, introduced in 2004–2005, and *tupoo-maruwa*, introduced in 2008–2009 — with seeds obtained through exchange with farmers of other communities. These varieties adapt well to the changing climate (they are tolerant to drought and other factors) and the changing ecology, and taste good. However, their yield is average and biomass is nominal. The government agriculture department also occasionally introduces high-yielding varieties of paddy. Their strengths include high yields and no lodging, but they have weaknesses, such as poor taste and producing less biomass.

Seed systems and seed security

This section presents the primary methods farmers use to source seeds of landraces, and hybrid and improved varieties (self-saving, community and external). It also looks at the roles played by both women and men in the sourcing, selection and storage of different types of seed, and strategies for maintaining seed security.

Limbu priest offering prayers, Eastern Himlayas. Photograph by Ajay Rastogi.

5

Farmers in both regions still access 80–90% of their seeds from seeds saved from the last crop, and most source only their potato cash crop seeds externally. They source some seeds and seedlings locally from neighbours who have improved traditional varieties, such as onions in the Central Himalayas (CH), and beans and mustard in the Eastern Himalayas (EH). In both regions, farmers have sustained the practice of improving traditional seeds through selection. They only depend on seeds supplied by agricultural extension agencies for hybrid varieties or some improved varieties of vegetables and cereals, but people only grow them when they are available for free. Farming communities have no systemic need to purchase seeds, and are by and large self-sufficient, except for potatoes. However, in earlier times, even seed potatoes were supplied by farmers from higher altitudes in both the regions.

5.1 Seed sources and seed security

In the CH, more than 96% of households surveyed rely on their own saved seeds for access to landraces, and just 1% depend on local markets for seeds and seedlings of crops such as potato and onion (Table 26). There is negligible demand for seeds of modern varieties from agricultural departments. Other sources, such as non-governmental organisations, gifts and remittances, or food-aid grain, are not of any importance. Traditional seeds are highly popular in the area, while hybrid and improved varieties are not because people believe they are not well adapted to their ecosystem and they have to be purchased every season. Improved seeds are accessed primarily through local markets (20% of households) and through local extension services (17%). Households also save and prepare improved seeds at home (20%), unlike hybrid varieties which are not accessed at all in the area.

In the EH, 97% of households surveyed obtain their landrace seed from self-saved seeds (Table 26). For traditional cereal food crops, 97% of seeds are self-saved, compared with only 25% for commercial vegetables. Seeds for these vegetables and potatoes come from external sources. Community improved seeds are mostly local vegetables, for which villagers continuously follow traditional selection practices; 43% of respondents use these seeds, and all the respondents said that they save the seeds of landraces themselves.

In Lingsey-Lingseykha, the community has improved existing rice beans to develop a black rice bean with a higher yield. Similarly, 10% of respondents said that

Table 26: Procurement methods for seeds

	CENTRAL HIMALAYAS, % HOUSEHOLDS			EASTERN HIMALAYAS, % HOUSEHOLDS		
	Landraces	Hybrid	Improved	Landraces	Hybrid	Improved
Retained/self-saved	96	0	20	97	25	3
Self improved	0	0	0	0	0	2
Community improved	0	0	5	2	25	86
Purchased	0	0	7	1	0	0
Exchanged with other farmers in the same community	0	0	5	0	0	0
Exchanged with farmers from other communities	0	0	0	0	0	8
Local market	1	0	20	0	0	0
Local extension station	0	0	17	0	0	0
Government input programme	0	0	15	0	0	0
Other	2	0	12	0	0	0

they improved the mustard and paddy crop through seed selection. New or improved varieties are mostly purchased (56%), with a small share sourced through gifts or exchanges (8%). Surprisingly, no households have found it difficult to access seed. Improved varieties are not freely shared between neighbours and relatives. It appears that people do not like to exchange these varieties with neighbours and friends without testing them, as relationships can be affected if crops fail.

Lingsey-Lingseykha and Tandrabong are in the cardamom-growing belt and they are in the process of rejuvenating their plantations with the improved variety, *varlangay*, which has wide adaptability to soil types and climate. They procure planting materials from the market.

Potato seeds cannot be retained in the EH project villages because storing them until the next season needs a cooler climate. Farmers purchase most of the seed from the higher reaches of Sikkim through personal contacts, and the seed is quite accessible to them. Most of the paddy growers retain paddy seeds from their produce. In Lingsey-Lingseykha, 67% of households acquire improved paddy varieties as gifts or remittances, while 33% farmers purchase them. In Pabringtar, 57% of households bought their introduced and improved varieties of paddy and consider them difficult to access. Twenty-nine per cent source them from private firms and 14% through exchange.

Local seed security is considered critical in both regions, although there is a general decline in the tradition of seed exchange. Seed security is very important to 89% of households in CH and 100% in EH (Table 27).

Table 27: Importance of seed security (percentage of households surveyed)

	CENTRAL HIMALAYAS	EASTERN HIMALAYAS
Very important	89	100
Important	11	0
Slightly important	0	0
Not important	0	0

5.2 Gender and seed systems

Women are responsible for sourcing landrace seed in 75% of households in the EH, compared to 23% in the CH (Table 28). In the CH, men play a greater role in sourcing seeds of both landraces and improved varieties, probably due to the restricted mobility of women. However, women play a critical role in the saving, storing, processing and sowing of seeds. Women in the CH take most of the decisions on the criteria for seed selection (91% of households), selecting (89%) and storing (93%) those seeds that are primarily for home consumption (Table 29). On the other hand, they make a much smaller contribution to decision making over the seeds of market crops than men, who take the lead in setting criteria for seed selection (85% of households), selecting seeds (83%) and storage (80%). Women thus play a more critical role in the seed selection and storage of subsistence crops, while men play a more critical role for market crops.

In the EH, more than 80% of households responded that women are engaged in seed sourcing of landraces

Table 28: Role played by men and women in seed sourcing (percentage of households surveyed)

	CENTRAL HIMALAYAS		EASTERN HIMALAYAS		
Type of seed	Men	Women	Men	Women	Both
Landraces	77	23	15	75	10
Hybrid	0	0	35	29	10
Improved varieties	96	5	55	45	0

Table 29: Role played by men, women and elders in seed selection (percentage of households surveyed)

WHO IN THE FAMILY IS RESPONSIBLE FOR CRITERIA FOR SEED SELECTION FOR THE NEXT CROP SEASON?							
	Household			Market			
	Men	Women	Older people	Men	Women	Older people	Men & women
CH	9	91		85	15		
EH	23	61	16	28	51	16	5

WHO IN THE FAMILY IS RESPONSIBLE FOR SELECTING SEEDS FOR THE NEXT SEASON?				
	Household		Market	
	Men	Women	Men	Women
CH	11	89	83	17
EH	39	61	39	61

WHO IN THE FAMILY IS RESPONSIBLE FOR STORING SEEDS FOR THE NEXT SEASON?					
	Household		Market		
	Men	Women	Men	Women	Both
CH	7	93	80	20	0
EH	0	100	18	66	16

in most project villages, and women also play a significant role in sourcing hybrid seed and improved varieties (Table 28), depending on their access to the market. For example, in Lingsey-Lingseykha, 42% of households responded that men were engaged in hybrid seed sourcing, while in Tandrabong and Mudung, 100% responded that women sourced hybrid seeds because they have easy access to market.

5.3 Access to seed in case of crop failure

When farmers were asked how they obtain seed after crop failure, more than 70% of respondents in the CH said neighbours and relatives were the most important source, while in the EH almost the same proportion said they bought from the market (Table 30). This is because the chances of traditional cash crops like ginger and cardamom failing is much higher than other traditional crops, and planting material for these crops has to be purchased. Ginger and cardamom are local landraces but have been suffering from serious diseases over the last few decades.

In the CH, neighbours seem to be the most popular source of seeds in the case of crop failure, used by 56% of households. Relatives were also popular: the first choice for 18% of households and the second for 49%. Households also source seeds from government departments, neighbouring villages and markets, although these seem to be less popular.

The project villages in the EH have not experienced total crop failure except for cash crops like ginger and cardamom. When crops do fail, some of the important resorts are purchasing seed from market sources, borrowing from neighbours and trying alternative crops. This is because once there is disease in cash crops like ginger and cardamom, people have to get new disease-free planting materials from outside. They also need money, as planting materials are expensive compared with other traditional food crops.

Table 30: Accessing new seeds in case of crop failure

	CENTRAL HIMALAYAS, % HOUSEHOLDS SURVEYED				
	First importance	Second importance	Third importance	Fourth importance	Fifth importance
Neighbours	56	14	2	0	0
Relatives	18	49	19	3	0
Neighbouring villages	11	12	26	16	0
Market	4	16	17	32	90
Horticulture / agriculture division	11	9	36	48	10

	EASTERN HIMALAYAS, % HOUSEHOLDS SURVEYED				
	First importance	Second importance	Third importance	Fourth importance	Fifth importance
Market	76	0	0	0	0
Loan from neighbour	23	44	0	0	0
Try another crop	0	0	37	0	0

Climate change and adaptation

This section presents the changes in climate and weather patterns observed by the farming community, and their responses to them. It explores the major changes that have taken place since 1982, and the main coping and adaptation strategies. It also examines the degree of the changes, and their associated impact and phenomena, including changes in staple crops and adaptation strategies.

New radish variety developed by Dayanand Joshi, Central Himalayas. Photograph by Reetu Sogani.

6

People in both study regions have noticed glaring changes in weather patterns in recent years — in particular, more extreme and unpredictable weather and an overall decrease in water availability. The cumulative changes in weather conditions, like reduced rainfall and longer summer seasons, are reflected in observations such as rivers and lakes drying up, and the disappearance of wetlands. Communities also reported increased incidence of floods due to higher volumes of rain in short periods. These changes have affected the yield of the main staple crops and reduced agricultural productivity, causing declines in livelihood and food security, and have also led to declining crop biodiversity in regions. However, the two regions have tried different coping strategies. In the Central Himalayas (CH), there is more focus on water conservation and planting broadleaved trees, while in the Eastern Himalayas (EH) it is on adapting the timing of planting crops and cultural operations. Farmers have adopted new crops and devoted more areas to perennial crops such as broomstick grass and cardamom, and adjusted agricultural practices such as planting times, cropping patterns and growing fodder trees.

6.1 Major climatic changes and coping strategies since 1982

Most respondents in the CH reported changes in the climate and related phenomena between 1982 and 2012. Increased frost in winter was reported by 88% of households surveyed, increased summer temperatures by 67%, increased fog in winter by 65% and erratic rainfall by 54% (Table 31). Increased temperatures are thought to be due to deforestation and increased forest fires. People have also noticed decreased water availability (52%) which they believe is due to a decline in forest cover and broadleaved species. Interestingly, they attribute increased incidents of extreme events such as droughts and cloudbursts to increasing ill-treatment of animals and growing injustices in society, as people believe natural disasters to be divine retribution. As coping strategies, they have planted broadleaved species of trees, created water harvesting structures to harvest runoff, and covered their fruit and vegetable plants in winter to protect them from frost.

Table 31: Change in climate and natural disasters: key reasons and coping strategies, Central Himalayas

KEY ISSUES	% HOUSEHOLDS NOTED	KEY REASON	COPING STRATEGY
Unpredictable rainfall	54	Decrease in broadleaved trees	Plant broadleaved trees
Reduced rainfall	21	Deforestation	Plant broadleaved trees
Decrease in sources of water	52	Deforestation	Check dams
Increase in natural disasters	27	Increase of injustice/torture	
Increase in drought	19	Ill treatment of animals	None
Increase in fog	65	Deforestation	None
Increase in frost	88	Deforestation	Cover fruit and vegetable plants and trees in winter
Harsher winters	33	Deforestation	None
Cloudbursts (increased frequency)	6	Ill treatment of animals	None
Temperature increase	67	Forest fires	Plant broadleaved trees

The main climatic changes experienced in the EH are unpredictable rainfall and prolonged dry periods in winter and summer, reported by 100% of households, reduced annual rainfall (96%), increased temperatures (95%) and increased pests and diseases (94%) (Table 32). High-intensity rainfall over shorter periods, coupled with deforestation and rampant rural road construction, has increased incidences of flooding and landslides (92%). The most important reason that local people identified for these climatic changes is deforestation. They also blamed the high levels of humidity during July and August for increased diseases and pests in plants and animals.

To cope with the impact of climatic changes, they have adopted the following strategies: adjusting the planting and harvesting time of paddy, millet, and maize; intercropping of food grains and vegetables in the newly adopted large cardamom habitat in fields; adoption and domestication of drought-tolerant crops like broomstick grass and paddy varieties like *addey*; taking up the afforestation of private wastelands; and planting of fodder trees and fast-growing trees in fields, sacred places and water sources (Table 32). To overcome the problem of pests and diseases, agricultural operations such as roughing (removal of infested plants) are generally undertaken. In Pabringtar, a few farmers with access to neighbouring tea gardens use some chemical pesticides as well, but this is more the exception than the norm.

6.2 Degree of changes in climate since 2002 and associated phenomena

In both regions, 79% of households observed much change in extreme weather conditions between 2002 and 2012 (Table 33). In the CH, the majority of households surveyed observed 'much' change in climate since 2002, particularly in the occurrence of droughts, insects/pests and diseases, summer and sunshine, and rainfall and floods (Table 33). More than a third of households noticed much change in wind strength at certain times of the year, which was not the case earlier.

In the EH, all or most households observed a 'little' change in insects/pests, drought, disease, flooding and summer, and about a third observed 'much' change in flooding, rainfall, drought and summer (Table 33). Associated changes include a sharp increase in river flow during the peak rainy season, although, as Table 34 shows below, 25% of households also reported the drying up of rivers and lakes.

Table 32: Changes in climate and natural disasters: key reasons and coping strategies, Eastern Himalayas

KEY CHANGES	HOUSEHOLDS NOTED (%)	KEY REASON	COPING STRATEGY
Unpredictable rainfall	100	Deforestation	Adjust planting time, intercropping and plant fast-growing crop varieties
Reduced rainfall	96	Deforestation	Adoption of drought-tolerant crop and varieties
Prolonged dry period	100	Deforestation	Adoption of drought-tolerant crop and varieties
Increased incidences of pests and diseases	100	Increase in humidity	Adoption of cultivation practices such as roughing
Increase incidences of flood/landslide	92	Deforestation	Adoption of drought-tolerant crop and varieties
Temperature increase	95	Deforestation	Intercropping, afforestation and reforestation

Table 33: Degree of changes in weather/climate reported, 2002–2012 (percentage of households surveyed)

	CENTRAL HIMALAYAS					EASTERN HIMALAYAS			
	Normal (no change)	Very little	Little	Much	Very much	Very little	Little	Much	Very much
Rainfall	2	0	16	71	11	25	41	34	0
Summer	5	0	5	80	11	0	66	28	21
Wind strength	50	5	9	36	0	0	50	0	0
Sunshine	7	0	7	80	7	0	0	0	0
River water flow	6	9	45	13	4	0	42	29	0
Prolonged drought	0	0	8	90	3	0	69	31	0
Flood	5	2	26	49	19	0	59	41	0
Insects and pests	2	0	5	80	14	0	100	0	0
Disease	2	0	7	81	9	0	66	0	0
Extreme weather conditions	5	0	2	79	14	9	11	79	0

Table 34: Climate change phenomena observed, 2002–2012 (percentage of households surveyed)

CLIMATE CHANGE PHENOMENON	CENTRAL HIMALAYAS	EASTERN HIMALAYAS
Disappearance of native species	8	7
Drying of rivers and lakes	22	25
Reduction in area of forests	18	0
Disappearance of wetlands	17	18
Change in length of seasons (eg winter season is longer)	17	5
Crop growth period is longer or shorter	6	7
Changes in seeding patterns of trees	2	20

In the CH, households have observed several climate change-related phenomena: 22% associated the drying up of lakes and rivers with the changing climate (Table 34). Many farmers have observed a reduction in the area of forests (18%), the disappearance of wetlands (17%) and changes to the length of seasons (17%). Two per cent of households also reported changes in seeding patterns associated with climate change.

In the EH, there are now prolonged dry periods, due to longer summers and a shorter rainy season. Households have reported small increases in the incidence of pests and diseases, and of high winds in February and March (Table 33). They also observed major impacts of such changes, such as the disappearance of wetlands, changes in seeding patterns of trees, disappearance of native species, and changes in the length of seasons and crop growth period (Table 34).

Table 35 shows that 100% of households surveyed in the EH observed changes in the rainy season between 1982 and 2012, compared to 46% in the CH. This suggests that changes in rainfall are more pronounced in EH than CH when viewed over a longer timeframe (ie 30 years, rather than 10 years as in Table 33). All the project villages of the EH reported that the monsoon season starts in late May/early June, and ends around October/November. Farmers maintained that 30 to 40 years ago, the monsoons used to arrive in April and end in November/December. This indicates that the overall period of the rainy season has reduced from 7–8 months to 6–7 months.

Table 35: Changes in rainy season and its duration, 1982–2012

	CENTRAL HIMALAYAS	EASTERN HIMALAYAS
% of households that have observed a change in rainy season and duration	46	100

All households surveyed in the CH experienced floods and cloudbursts between 2002 and 2012 (Table 36). A cloudburst and flood in September 2010 caused large-scale damage in the region. All villages in the EH experienced periods of drought for 4–6 months between 2002 and 2012 (Table 36), and there have also been incidences when there was no rain for as long as seven months, which was not the case earlier. There were regular incidences of landslides, cloudburst and drought in the region from 2002 to 2012. A major landslide in 1968 caused widespread damage to land and property, and is etched in the community's collective memory.

6.3 Changes in staple crops and adaptation strategies

In the CH, as many as 33% of households surveyed claimed a significant reduction in Garhwali finger millet yields, and 25% reported much reduced quality (Table 37). However, they have not observed any change in plant height, planting conditions, planting time and harvesting time. Some households have adopted strategies such as afforestation (5%), cultivating fruit trees and broad leaved forest species close to their houses (2%) and even worshipping deities to appease them (2%), but most (84%) have not yet adopted any adaptation strategies.

In the EH project villages, staple food crops have experienced various changes since 2002 (Table 37). Changes to planting times were reported in all villages to different degrees. In Mudung, the changes in planting conditions and time were significant. This may be because it lies in the eco-tone region between the lower and the higher altitudes. Normally, they grow high-altitude crops as well as low-altitude ones with average yield. With even a marginal change in climate, their growing conditions and time are significantly affected. However, overall, little change was reported in yield, resistance to pests and diseases, and location of staple crops.

Small farmers in the EH have been practising various strategies to confront the challenges posed by climate change. An average of 26% of households surveyed have changed their cropping patterns, 24% have adjusted the planting time of crops, and around 20% have opted to plant cash crops like broomstick grass and fodder trees for cattle farming. Around 12% have changed their crops, and 22% use insecticides on vegetables to cope with increased diseases and pests. More farmers in the EH have adapted to these changes as their shift towards a cash economy has meant they are more actively engaged with agriculture than farmers in the CH.

Table 36: Extreme events, 2002–2012 (percentage of households surveyed)

	CENTRAL HIMALAYAS		EASTERN HIMALAYAS	
	Yes	No	Yes	No
Drought	80	20	100	0
Floods	100	0	3	22
Cloudburst	100	0	0	0
Other	0	0	0	0

Table 37: Key changes in staple food crops, 2002–2012

	CENTRAL HIMALAYAS (GARHWALI FINGER MILLET)					EASTERN HIMALAYAS (RICE)				
	Normal	Very little	Little	Much	Very much	Normal	Very little	Little	Much	Very much
Yield	42	0	26	33	0	0	0	100	0	0
Quality	68	0	7	25	0	-	-	-	-	-
Characteristics	100	0	0	0	0	-	-	-	-	-
Resistance	80	0	2	18	0	0	100	0	0	0
Plant height	100	0	0	0	0	71	0	29	0	0
Planting location	100	0	0	0	0	0	17	72	0	0
Planting condition	100	0	0	0	0	0	0	81	19	0
Planting time	100	0	0	0	0	25	1	60	13	0
Harvesting time	100	0	0	0	0	0	0	100	0	0

Social capital and biocultural heritage

This section looks at trends in social capital and biocultural heritage between 1982 and 2012, given their role in social cohesion, resilience and the development of biocultural innovations. It explores trends in traditional housing, food preferences, languages, clothing and farming practices. It also touches on social networks within and between communities.

7

Both the Central Himalayan and Eastern Himalayan study regions have experienced considerable cultural change. However, native language continues to be spoken by 100% of households surveyed in the Central Himalayas (CH) despite the fact that Hindi is the formal language of education. In the Eastern Himalayas (EH), the Lepcha and Limbu languages continue to be spoken, but there has been some loss of native languages, as Nepali is the common language linking various ethnic communities. Loss of traditional housing is much greater in the EH, since tin roofing has almost completely replaced traditional thatched roofing. In the CH, stone-tiled roofs are still quite common, but are gradually being replaced by cement slabs. However, traditional beliefs, festivals, and collective activities are stronger in the EH region than in the CH. The biggest change in both regions seems to be in food culture and diversity. Traditional food is still cooked in the CH but to a lesser extent and with some change in ingredients, while in the EH, traditional cuisine is largely limited to festivals and ceremonies. In both regions, many traditional recipes were lost in the 30 years prior to 2012.

7.1 Central Himalayas

People are aware that their ancestors settled in the region 600–800 years ago from different parts of India. They brought their different caste identities from their lands of origin. Some villages are identified by the castes of the primary occupants. Gallakot is primarily a Brahmin village, while Basyura is inhabited mostly by Thakurs. Even though these caste identities remain as stringent as before, the areas where the people originated from have disappeared from collective memory. Formal history states that the Brahmins of the region came from Northern Karnataka and Maharashtra, and the Thakurs from Rajasthan.[12]

All the households interviewed speak the native language, Kumaoni. The script is Devnagri (the same as Hindi). Kumaoni is mostly used orally and has never been used in formal education. Many older women in the region do not speak any other language apart from Kumaoni; as extended families — where many generations of the family live together — survive, the native language continues to survive too.

Most people in the area do not wear traditional clothes (Table 38). This includes men and women of all ages, castes and class. Women can still be seen in Indian dresses like sarees, which is not a local dress. The local dress used to be the *ghagra* or full skirt and *pichoda*, a kind of large wrap around. It is not as common to see men attired in Indian clothes like *dhoti kurta*; they mainly wear trousers and shirts.

Table 38: Use of traditional clothing, Central Himalayas

WHO WEARS TRADITIONAL CLOTHING	% HOUSEHOLDS
Nobody	84
Head of the household	7
Others	9

A high percentage of households (72%) still retain traditional housing. However, modern cement (*pucca*) houses are symbols of affluence and therefore an important aspiration for people in the village.

People still cook a large number of traditional dishes in different seasons, although they no longer use many of the traditional spices such as *bhangeera*, *jambu* and *gandrayani*. However, the younger generation have no particular affinity to local food, preferring other food available in the market such as instant noodles and dumplings. These are dishes from outside the region that are advertised on TV and in newspapers.

The dominant perception is that people used to be more hardworking and interested in farming. They would spend a lot of time in the fields nurturing the soil, to improve the quality and increase the quantity of produce. They would level the land, break the soil lumps with a *deeler* (a kind of wooden hammer), weed out the roots of earlier finger millet crops and burn them to add fertility to the soil. Many of the age-old farming practices have faded out, as they require a lot more labour. Some are still practised but with less intensity.

Traditionally, different castes have had different roles and occupations. Although this is changing, some professions still follow caste-based distinctions. When asked to specify who they interact with in the community in daily life, people identified their relationships with certain individuals from other castes. For example, they mentioned priests who belong to the Brahmin community, and *haliya* (the person who ploughs the fields of others) who belong to Scheduled Castes. This shows that some relationships between various social groups are still quite old-fashioned and based on caste, as these professions continue to be strictly hereditary and hierarchical.

In the CH, around 800 years ago a strong wave sanskritisation started. That led to a gradual shift from nature worship to the establishment of temples of

[12] Atkinson E (1882) The Himalayan Districts of the North Western Province of India. Government Press, Allahabad.

gods and goddesses. Priests also follow this dominant tradition. There are *jagris* (mediums) who invoke spirits of ancestors but this is mainly restricted to seeking guidance in settling family disputes through seances and animal sacrifice ceremonies. This practice is weakened in the sense that it is only resorted to when other options fail, and the younger generation is not so keen on this mechanism. *Seances* are also in decline, as this is no longer a viable vocation.

People reported that the communitarian spirit of earlier times has deteriorated (Table 39). People would get together to smoke *hukkah,* and hold meetings in the village (*chaupals*), and there were many other community practices that have reduced drastically or become extinct. There used to be informal networks through which seed and other exchanges would take place, and people used to sit together and discuss farming, but these networks and interactions have been discontinued. However the establishment of crop protection committees to prevent crop raiding by animals has helped to bring the community together and increase community cohesion. According to the people, giving children a good upbringing will instil in them values such as respect for elders, awareness of social evils like alcoholism, and helping each other in times of need.

7.2 Eastern Himalayas

The rich biocultural traditions of the Lepcha and Limbu community are visible in the five project villages. People believe that Lepchas settled in the Lingsey and Lingseykha area during the 17th century, and in Tandrabong in the 19th century. The Limbu believe that they settled in Pabringtar in 1800 and in Mudung in the mid-1850s. Lepchas make up 10% of the inhabitants of Tandrabong and 36% in Lingsey-Lingseykha. Lepchas are the majority ethnic group in the area and most of them own their own farm land. Limbus comprise 20% of the inhabitants of Pabringtar. Although Nepali is the dominant language for conversation and formal work, 100% of Lepchas in the households surveyed in Lingsey-Lingseykha, and 90% of the Limbus of Pabringtar continue to speak their native language. Around 50% of Limbus and Lepchas in Pabringtar and Lingsey-Lingseykha can write in their native language.

Table 39: Changes in social capital, networking, institutions and organisation, Central Himalayas

KEY ISSUES	% HOUSEHOLDS NOTED	KEY CHANGE	COPING STRATEGY
Earlier there was more brotherhood	96	There used to be higher mutual reliance	Crop protection committee brought people together
There was more respect for elders; people did not smoke in front of them	2	People have started smoking more	Giving children a good upbringing
Purdah[13] was practised	2	Respect and Purdah has ended	Giving children a good upbringing
People stood by each other in times of happiness and need	63	Food and drinks are not good anymore	Giving children a good upbringing
People used to take care of everyone completely	21	None	None
Chaupals have ended	79	People don't interact much anymore	Crop protection committee brought people together
People used to smoke *hukkah* together	63	People don't interact much anymore	Crop protection committee brought people together
People used to sit together and discuss agriculture	65	People don't interact much anymore	Crop protection committee brought people together
Migration to cities	52	Families are becoming smaller	None

[13] A customary practice of seclusion of women from public spaces (and sometimes men within the household) through exclusion or garments covering their face and body.

There are efforts to revive the native Lepcha language in primary schools but similar efforts to revive the native Limbu language have not begun.

Table 40: Status of native language, Eastern Himalayas

STATUS OF NATIVE LANGUAGE	% OF HOUSEHOLDS SURVEYED
Speak native language	80
Write native language	43
Spoke native language 30 years ago	93

Lepcha men and youth only wear traditional clothing for festivals and ceremonies, while women continue to wear traditional dress daily. Since the establishment of the Indigenous Lepcha Tribal Association in the 1990s, and later the Mayel Lyang Lepcha Development Board (MLLDB), which was formally recognised in 2013, there has been considerable emphasis on reviving the Lepcha language and dress, and many more men now wear the Lepcha hat. The Limbus, both men and women, have now almost completely stopped wearing traditional clothing, except on special occasions.

Although traditional beliefs and festivals are stronger in the EH than the CH, there has been a much bigger decline in traditional housing. Only one well-maintained typical Lepcha *dokomulli* house remains in Lingsey village and while there has been some discussion in the community about constructing some traditional houses to boost tourism, no action has yet been taken.

Maize used to be the main staple crop, however rice has replaced it, largely because it is easily and cheaply available in the market and the Public Distribution System. Barley and buckwheat have also lost their due importance in the normal diet of the communities. Many recipes have been lost and traditional food is largely restricted to festivals and ceremonies. In the last 30 years, one major change in traditional agricultural practice is that some farmers in remote locations who used to practise slash and burn have stopped doing so. Sticks and broadcasting were also commonly used to sow maize and dryland paddy, and this practice continues to some extent. Bullocks are still commonly used for ploughing, although the availability of bullocks has become increasingly limited over the years.

In Lingsey-Lingseykha, which has a largely Lepcha population, in 100% of households surveyed, both men and women participate in collective community activities and there has been no change between 1992 and 2012. In Tandrabong, both men and women take part, but participation has reduced from 90% of households to 80%. In Pabringtar, which is mainly Limbu, it is mostly men who participate in collective activities, and this has not changed. Households normally contact village elders and headmen for prayers and ceremonies, and to share knowledge. Village elders normally conduct ceremonies, and often the *Bungthing* (Lepcha priests) and the *Phedangbha* (Limbu priests) are considered village elders.

In recent decades, the government has started to promote most programmes through Self Help Groups (SHGs). Therefore, one major change that has occurred with regard to social capital is that the community has started to come together to form these SHGs (Table 41). The traditional system of sharing resources in cash, kind and service (referred to as *Saraw*) continues at the community level; the SHG system has helped improve access to government resources that are largely linked to livelihoods.

The communities attribute the loss of local markets and reduced demand for local produce to changes in food preferences and lifestyles. This has not only affected the economy but has also influenced meetings and networking possibilities. The sacred ceremonies and socio-cultural rituals relevant to agricultural practices, natural resource management, food and seasonal weather conditions are on the decline. These ceremonies strengthen social bonding and networking and are governed by local community organisations. These village-level community organisations have now been brought together under overarching community organisations called *Sezom* (for the Lepcha organisations) and *Yak-Thung-Sung Chumfo* (for the Limbu organisations) as a coping strategy. These community organisations are registered under India's society registration acts.

The state government itself is a major stakeholder in these organisations, and routes money for the culture and development of these communities through them. The boards organise several cultural and development activities, such as the promotion of SHGs for inducting micro-finance, and livelihood activities related to agriculture and livestock. These organisations also conduct activities like organising cultural festivals, publishing magazines, and conserving and promoting language and traditional rituals.

Table 41: Changes in social capital, networking, institutions and organisations, Eastern Himalayas

KEY ISSUES AND CHANGES	% HOUSEHOLDS NOTED	KEY REASON	COPING STRATEGY
Lack of access to and links with government schemes	100	Traditional institutions not recognised by the government	Adoption of micro-finance institutions and registering SHGs
Loss of local markets, reduction in demand for local produce, and emergence of new markets	85	Competition with commercial products; changing lifestyle preferences; quantity of produce required for marketing and transport	Partnering with other communities, enhancing awareness of biocultural heritage, registering SHGs and improving access to newer markets
Abandoning traditional culture	100	Modernisation	Reviving traditional organisations, holding regional cultural festivals

Biocultural innovations and innovation factors

This section presents the main biocultural innovations developed in the two sites to enhance food security and adapt to climate change, the extent to which they have been adopted, and the key drivers of innovation, based on the household surveys. It also explores key technological, market and institutional innovations, and the social factors supporting their development and spread, based on the qualitative survey findings.

8

Innovations in the Central Himalayas (CH) include: cultivating crops near homes, new ways of composting, a new variety of radish, and reintroducing lost crops. In the Eastern Himalayas (EH), they include early uprooting of maize for paddy planting, developing an improved variety of black rice bean, and reintroducing traditional mustard. In the CH, it is evident that individuals or 'pioneering farmers' have been the main innovators. These progressive farmers have had considerable exposure to modern agricultural research institutions, through farmer visits conducted by government extension programmes. In the EH, much of the innovation has taken place through community networking, and the innovations that have been more widely adopted have mostly been the ones derived from traditional knowledge. Farmers are more closely knit, devoid of caste-based divisions, and more communitarian. This has also resulted in much wider adoption of the innovations in EH. Market incentives for innovation are much more pronounced in the EH because they have surpluses to sell and are aware of the income-generating potential of cash crops. In the CH, farming is mostly limited to subsistence-based agriculture and a declining return from agriculture may explain low adoption levels.

8.1 Biocultural innovations in the Central Himalayas: survey findings

Almost all the households interviewed had developed innovations related to cultivation techniques and farming closer to the house (Table 42). The second most widely adopted innovations are crop protection committees to address the problem of crop raiding by wildlife. One of the farmers developed a new higher-yielding radish named *dayakesari,* by crossing a hybrid with a local variety of radish and experimenting for six years. He has also mixed two different kinds of soils to increase soil productivity. Another innovation developed by a farmer is the growing of crops like flax seeds in mixed cropping systems, since flax seeds are not attacked by birds and flax thus also protects crops like spinach when it is grown around them.

Table 42: Innovations and households practising them, Central Himalayas

INNOVATION TYPE	% OF HOUSEHOLDS
Cultivation techniques for farming near houses	100
Farming near houses	100
Crop protection committee	27
Changing the soil	3
Creating field bunds	3
Compost pit	3
Sowing in a line	3
Switching from fruit trees to vegetables	3
Drip irrigation	2
Growing flaxseeds at the borders	2
Composting technique	2
Created a new seed/variety	2

Of the 12 innovations identified in Table 42, nine result in saving resources like water, seeds, land, labour and manure while, more than half (55%) increase productivity (Table 43). While some of the innovations have led to positive changes in customs and traditions, a few have reduced the frequency of customs and traditions that strengthened community spirit and cooperation, particularly those related to farming near the house.

Table 43: Key characteristics of innovations, Central Himalayas

KEY CHARACTERISTICS OF INNOVATIONS	% OF INNOVATIONS
Increases productivity	55
Increases variety	45
Crop protection	36
Saves water	36
Saves area/land	27
Saves manure	27

The qualitative survey explored four social factors that contribute to the development and spread of innovations: people/individuals, networking, institutions and community level factors (see also Sections 8.3 and 8.4). Most of the innovations have been developed by individuals. Innovations in composting, sowing methods (in a line), drip irrigation and so on, have evolved using information from scientific institutions. Farmers/innovators have combined their local and traditional knowledge with knowledge from these institutions to develop innovations that suit their local requirements and conditions (Table 44). However, all four factors have been important driving factors for innovation. Innovations of cultivation techniques and farming near the house have been influenced by a wide range of community and family members.

Table 44: Contribution of traditional and external knowledge, Central Himalayas

SOURCE OF KNOWLEDGE	% OF INNOVATIONS
Mainly traditional knowledge	64
Both traditional and external knowledge	36
Mainly external knowledge	0

The survey found that at least 66% of households surveyed do not spend time thinking up new ideas. So most people do not allocate time specifically to think up new ideas but mostly learn from others through discussions and observation, and innovate new practices by doing. However, 25% spend one to two days a month thinking of new ideas, while 2% spend three to five days a month. New innovations are 'very important according to 72% of households, while the rest consider them to be 'important' (Table 45).

Table 45: Importance of innovations for the wellbeing of the household, Central Himalayas

IMPORTANCE	% OF HOUSEHOLDS SURVEYED
Very important	72
Important	23
Somewhat important	0
Not important	0

The survey identified maximising agricultural production as the main area where innovations are needed (83% of households), followed by economic growth (38%) and confronting climate change (4%) (Table 46).

Table 46: Areas where innovations are most needed for the wellbeing of the household, Central Himalayas

AREAS	% OF HOUSEHOLDS SURVEYED
Maximisation of agricultural production	83
Economic growth	38
Confronting climate change	4
Marketing/product sales	0
Models of community participation	0
Integration with national and international economies	0
Reduced cost of living	0

8.2 Biocultural innovations in the Eastern Himalayas: survey findings

Innovations related to the market and livelihoods are the most prominent in many households in the EH. These include joining community organisations to assist with farming (such as membership of a Self Help Group, SHG), use of formal markets to sell cash crops instead of traders visiting the villages, and enhancing crop domestication (Table 47). Crop domestication — through change in the habitat and variety of large cardamom — and crop rotation had been adopted by 72–75% of households. Landslides and the destruction of water sources has led to the domestication of wild plants like broomstick grass, and this has become a major cash crop for smallholder farmers. More than 70% of the households reported engaging with community organisations for indigenous rights, market access and farming activities. This is because of an increasing sense of belonging and solidarity towards community organisations among the indigenous communities.

Half of the innovations identified have been developed using both traditional knowledge/biocultural heritage,

Table 47: Innovations and households practising them, Eastern Himalayas

SOCIAL CAPITAL (INSTITUTIONAL)	% OF HOUSEHOLDS
Organisation to assert indigenous rights	72
Community organisation for market access	82
Community organisation to assist with farming	72
Community-based seed production	22
Community-based crop improvement	16
Repatriation of traditional crops	39

CROP AND BIODIVERSITY (TECHNOLOGICAL)	% OF HOUSEHOLDS
Improved/more resilient crops	25
Reintroduction of traditional crops	23
Crop domestication	72
Cropping practice	75
Protection of crops in preservation areas	5

LIVELIHOOD AND FOOD SECURITY (MARKET)	% OF HOUSEHOLDS
Other	25
Use of financial accounting principles	25
Use of marketing strategies to sell products	72
Sale of crops/products nationally	25
Micro-finance or banking service	75

and external knowledge, mostly livelihood and market innovations (Table 48). One quarter were developed mainly using traditional knowledge/biocultural heritage, and the other quarter mainly using external knowledge. The traditional knowledge-based innovations were mostly around maintaining traditional crops and varieties, while those based on external knowledge related to the use of financial principles by social institutions. For example, the traditional social institution of Lepcha women's groups called *Depthong* have taken the form of SHGs, and benefit from the government's micro-finance schemes.

Table 48: Contribution of traditional and external knowledge, Eastern Himalayas

SOURCE OF KNOWLEDGE	% OF INNOVATIONS
Mainly traditional knowledge	25
Both traditional and external knowledge	50
Mainly external knowledge	25

Going by the responses, it is evident that innovations are motivated by a number of factors and address a range of needs, including the need for market linkages, enhanced access to credit institutions, and the conservation of rich biocultural heritage (Table

Table 49: Key characteristics of innovations, Eastern Himalayas*

SOCIAL CAPITAL	% OF HOUSEHOLDS
Recognises customary law/practices/rights	6
Improves awareness of customary laws/practices	47
Reduces resource conflict	22
Improves seed source	17
Enhances access to better market	19
Increases in the household income	21
Enhances food security	17

CROP AND BIODIVERSITY	% OF HOUSEHOLDS
Reduces instances of pests and diseases	7
Improves soil conditions	20
Increases food self-sufficiency	29
Increases crop diversity	24
Enhances the conservation of traditional cultivars	84
Results in improved and reliable seed source	40
Increases food production	18
Soil specific (does well in specific soil types)	20
Uses locally available materials	20

LIVELIHOOD AND FOOD SECURITY	% OF HOUSEHOLDS
Enables farmers to get better price for their products	60
Offers access to better market	32
Offers access to credit institution	59

* These add up to more than 100% as each household could answer more than once.

49). This is reflected in characteristics such as better access to markets (32% of households) and better price (60%) coupled with improving crop diversity (24%) and conserving traditional cultivars (84%). Improved awareness of customary laws/practices/rights is another key characteristic identified by 47% of households, suggesting strong motivation for the recognition and maintenance of cultural identity.

All of the households surveyed identified maximising agricultural production as the most important area for innovation for community wellbeing, followed by increasing market sales (91%) (Table 50). At the same time, 88% of the community considered innovations to offset rising costs of living to be critically important. Healthcare expenses are one of the major components of rising cost of living, and 27% consider innovations in this sector important. As discussed in Section 6, almost 100% of households surveyed have experienced climate change and its adverse effects, and it is no surprise that 66% think innovations for resilience and adaptation to climate changes are critical for future wellbeing.

Table 50: Areas where innovations are most important for the wellbeing of society, Eastern Himalayas

AREAS	% OF HOUSEHOLDS
Maximisation of agricultural production	100
Economic growth	40
Confronting climate change	66
Marketing/product sales	91
Models of community participation	35
Integration with national and international economies	0
Reduced cost of living	88
Proper healthcare	27

8.3 Key reasons for biocultural innovation

In the CH, ecological risks and changes, and shortage of labour are the main reasons that lead people to innovate, both identified by 36% of households surveyed (Table 51). Crops being increasingly decimated by wildlife, insufficient precipitation at different times of the year — and sometimes too much rainfall when it is not needed for crop cultivation — have all affected production severely. Migration and livelihood diversification have reduced the availability of labour to carry out agricultural tasks.

The next most important reasons for innovation are economic and market needs, collaboration with scientists, and experimentation (all identified by 27% of households). Economic pressures have made people reintroduce some crops that had disappeared but currently have huge market demand. Some farmers have learnt new and better techniques of cultivation, to increase production and improve soil quality and land productivity, through their interactions with scientists. They have then adapted them to local conditions by experimenting. One of the farmer innovators developed a new variety of radish to address food and nutrition requirements. Other driving factors identified are socio-cultural needs (18%) and major climatic failures or events (9%).

In the EH, ecological risks and changes are the most important factor leading the innovation, according to 92% of respondents (Table 52). Crop failure due to extreme weather was the second most important factor, identified by 43% of respondents, followed by social and cultural needs (27%). Accidental innovations — driven by mountain farmers' integrated and mixed farming system, frequent changes in the weather, and

Table 51: Drivers of innovation, Central Himalayas

DRIVERS	% OF HOUSEHOLDS
Ecological risks/changes	36
Major climatic event that led to crop failure/scarcity	9
Economic and market needs	27
Social and culture needs	18
Labour shortage/saving	36
Repatriation/collaboration with scientists (= supporting factor)	27
Discovered by accident	0
Experiment and exploration	27
Other	36

Table 52: Drivers of innovation, Eastern Himalayas

DRIVERS	% OF HOUSEHOLDS*
Ecological risks/changes	92
Major climatic event that led to crop failure/scarcity	43
Economic and market needs	19
Social and culture needs	27
Labour shortage/saving	16
Repatriation/collaboration with scientists (supporting factor)	17
Discovered by accident	25
Experiment and exploration	0
Other	0

*The figures add up to more than 100% as each household could give more than one answer.

their inquisitive nature to try out new things — were seen as a driver by 25% of respondents. Changing economic and market needs are leading factors for innovation for 20% of households, as patterns of dependency for food security and overall livelihoods have shifted from the local economy/produce to the cash economy. Only 16% of respondents considered collaboration with scientists as the main factor leading to innovation, due to poor access to research stations and scientific information, and a lack of collaborative research programmes with farmers. Scarcity of agricultural labour was a key innovation factor for 15% due to outmigration to towns and cities, and the younger generation losing interest in agriculture because of better opportunities in non-farm activities.

8.4 Exploring key innovations and innovation factors in the Central Himalayas

This section explores in more detail the traditional knowledge-based or biocultural innovations identified in the CH study area through the qualitative baseline study.[14] The innovations are largely technological, related to farming systems, crops and practices, but also include a successful institutional innovation that the community came up with (a crop protection committee). Where possible, it also identifies the factors that supported the development of these particular innovations: people, institutions, networking, and community-level factors.

Technological innovations

One of the primary challenges in recent times that has led farmers to find innovative solutions is increased crop raiding by wild animals. The main reasons for this are the general degradation of forests, and loss of food and habitat due to forest fires. Wild animals, such as wild boar and monkeys, feed on, uproot and damage crops. A key reason for the excessive population of wild boars in the degraded forests is an invasive weed called lantana, which provides excellent protection of litters from predators. Another factor is reduced winter rainfall, which has contributed to drier forests. Increased crop raiding has resulted in more intensive cropping closer to houses, in order to guard the crops and provide irrigation during long dry spells in winter.

More intensive mixed cropping close to the house, and growing turmeric in far away fields to reduce crop damage: Earlier, farmers would grow just one or two vegetables in one patch of land but now they grow vegetables, spices, oil seeds, and even one or two grains all on one patch of land. For example, they are growing *ogal* (buckwheat), pumpkin, radish, French beans and *gadheri* (family of colocasia) together. This strategy makes food available at different times of the

[14] More details can be found in: Rastogi A, Sogani R, Gurung N (2014) Smallholder Innovation for Resilience (SIFOR) - Qualitative baseline study, Central & Eastern Himalayas, India. IIED, London. http://pubs.iied.org/G03829/

year to address food security and livelihood needs. Growing several crops together also saves on labour, compost and water used for irrigation. The roots of different crops use different zones and some (such as beans) fix nitrogen. In order to reduce wildlife raiding, mixed cropping is now done close to the house, while turmeric and ginger are now planted in large fields further away, as they are not decimated by animals like boars and monkeys, and fetch a good price in the market. These innovations can be attributed to 'people' factors (ie individual innovators) and market factors.

Various modifications in cropping patterns to increase productivity:

- *Cultivating garlic in the margins*: Shiv Ram of Chinauna village grows garlic in the margins of land around other crops, as garlic is able to consume compost and water that remains unused by the main crops. Moreover, the leaves of the garlic plant are sturdy and the bulbs are underground, allowing easy passage through the fields without it being disturbed. In fact, according to him, garlic leaves become stronger with a little disturbance. He came up with this method on his own and experimented for a year or so to observe the results.
- *Cultivation of* haldi *(turmeric) in the margins:* Shiv Ram grows turmeric along the path of the fields frequented by cows and other domesticated animals, as the underground parts of turmeric are not damaged by trampling, and this enhances income.
- *Cultivation of* lai *(mustard) on supporting terrace walls:* Farmers have started growing crops, especially *lai,* on the supporting walls between two terrace fields, mainly as a leafy vegetable. This crop is high in iron and does not require much looking after, composting or irrigation. Moreover, growing on the wall reduces the germination period, due to higher temperatures on the south-facing walls.
- *Cultivation of potato and coriander together*: Since coriander is disliked by animals, it doesn't get damaged and it covers the potatoes and keeps them hidden from animals.
- *Cultivation of wheat and mustard separately*: Generally wheat and mustard are mixed winter crops. Ramesh Singh of Chinauna has started growing mustard and wheat separately for the last four years and this has increased the productivity of both crops.

Increased cultivation of finger millet (a traditional crop): Women in Gallakot have increased the cultivation of finger millet, which is very rich in calcium, is less labour intensive than rice and wheat, and requires less water. Informal networking among the women has motivated them to gradually increase its cultivation, due to its high resilience to climate change, high nutritional value and great demand in the market.

Revival of almost extinct crop to reduce pest damage and enhance nutrition: *Alsi* (flax seed) is grown as a border crop to increase production of other crops (such as spinach) as it does not get eaten by birds, and prevents birds from eating seeds that have been recently sown. *Alsi* was almost locally extinct, but now its popularity and market demand is growing.

Developing a new variety of radish: Dayanand Joshi has developed a new variety of radish by crossing a hybrid with traditional variety. He carried out this experiment for six years. This new variety, called *Dayakesari*, is higher yielding and can be used as both a vegetable and salad, unlike the original varieties. The green leaves can be used as a vegetable during the summer season when not many greens are available. Efforts are being made by SIFOR to register this variety under the Protection of Plant Varieties & Farmers' Rights Act (PPV&FR Act, 2001).

New composting techniques to improve soil fertility and moisture: These innovations have improved the quantity and quality of the produce, while enabling farmers to use scarce water resources very efficiently:

- Using pine branches to contain the compost in an enclosure and covering it with a layer of dry leaves helps retain the runoff its with nutrients and moisture for microbial activity. The compost is located at a slightly higher level, so that any runoff eventually reaches the lower fields and doesn't get drained away.
- Mixing cow dung and cow urine in a pit and covering with a layer of grass and a bed of dry leaves. This compost adds fertility to the soil and helps retain moisture.
- Sloping the land upwards towards the terrace wall reduces water runoff and crops become sturdy. People have observed Shiv Ram doing it and adopted it in their fields.

Bio-pesticide preparation: Dayanand Joshi mixes bitter-tasting leaves of walnut (*Juglans regial*), *bakain* (*Melia azedarach*) and *neem* (*Azadirachta indica*) in water and uses this mixture after a couple of weeks by sprinkling on the plants as a bio-pesticide which has proved very effective especially in vegetable cultivation.

Switching from fruit trees to vegetable production in response to lower temperatures: Seeing the declining trend in fruit production due to increased temperatures and frost, Dayanand Joshi of Gallakot replaced fruit trees with vegetable cultivation, as vegetables have a good market value and are used for household consumption. This has led to a number of innovations:

- *Modification of the soil to suit vegetable cultivation*: To switch from fruit to vegetable, Dayanand Joshi spent three years bringing tons of soil from a river bank

2.5 kilometres away with no road, to change the top soil into a clayey loam, locally called *do mat mitti*.

- *Improved onion seedlings*: The onions don't lead to formation of seeds and the bulb is much bigger. These onion seedlings are popular in the entire area and booked ahead of the season by other farmers. He sows the seeds almost one month later than usual. It takes a bit longer to harvest the bulbs but the crop is better.
- *Improved cauliflower cultivation*: The quality of his cauliflower is also very good and is quite popular in the local market. Its yield is also better than that of other farmers. Rather than ploughing the fields, he uses a spade to dig much deeper and mixes the soil well at least one and a half feet deep.
- The quality and yield of his *gadheri* is also much better than that of other farmers. According to Dayanand Joshi, this is due to frequent weeding, which also loosens up the soil, and ensuring proper drainage of water.

Keen observation, introduction of scientific ideas, experimentation and continuous adaptation of farming practices has led to his success. Many of the scientific ideas are his own (as claimed by him), but he has learnt some techniques from research institutions.

Planting fodder trees on farms in response to forest degradation: Previously, people were highly dependent on forests for biomass, but they have gradually shifted their dependence to fodder trees planted near hamlets on agricultural land, as the forests have become degraded, are far away and are mostly pine monoculture plantations, which are not suitable for fodder. This has greatly reduced their workload and partially reduced their dependence on forests. Informal networking among women has helped them gradually start cultivation of fodder trees, using their traditional knowledge and experience to choose local species and varieties that are environmentally friendly, and to increase the quality of fodder as well as its availability.

Institutional innovations

Establishing crop protection committees to confront wildlife crop damage: The village of Chinauna came up with a novel idea to safeguard their crops. They formed a body called *Fasal Suraksha Samiti* (Crop Protection Committee). The committee decided to collect a contribution from each household and hire a person from the village to keep watch against monkeys and stray cattle during the day. For the first time in five years, there was a good winter crop of wheat in the village, and there was greater availability of fodder grasses. As a result, neighbouring villages have started to form similar institutions. The first committee formed in Chinauna received an award and recognition from the State Biodiversity Board.

8.5 Exploring key innovations and innovation factors in the Eastern Himalayas

The qualitative baseline study identified a number of traditional knowledge-based or biocultural innovations in the EH study area, mainly technological innovations in farming systems, crops and practices, but also a few institutional and market innovations. Where possible, it also identified the factors that supported the development of these innovations: people, institutions, networking and community-level factors.[15]

Technological innovations

New cardamom cropping system and locally adapted variety developed in response to pests and disease: Cardamom cultivation is declining in its original forest habitat, due to outbreaks of pests and diseases attributed to rising temperatures and erratic rainfall patterns, and the depletion of biomass available for mulching, due to competing requirements for ginger cultivation. To overcome these problems, farmers collectively identified and developed a new cardamom cultivar, shifted cardamom growing from forest shade to open farmlands, and adopted a crop rotation system that requires them to uproot the cardamom bushes every eight to ten years. The new resilient cultivar, known as *varlangay* was brought from a village close to Bhutan called Thoday. Gradually, through selection, farmers developed a locally adapted cultivar called *lhaphrakey*, which requires less soil moisture and shade. These innovations enabled farmers to revive cardamom cultivation, and at the same time, production increased as the maturation period reduced by one to two years, and yields improved as irrigation and manure for inter-crops, such as maize and vegetables, were also useful for the cardamom.

Networking was the dominant factor that enabled the innovations in this case. This enabled the farmers to access the new cardamom variety from Thoday village. Farmers from north-east Kalimpong and south-west Bhutan attend the same weekly market in Bindu (in India). In addition, there are family relationships across the border and it is likely that the *bharlang* variety was

[15] More details on the innovations identified can be found in: Rastogi A, Sogani R, Gurung N (2014) Smallholder Innovation for Resilience (SIFOR) - Qualitative baseline study, Central & Eastern Himalayas, India. IIED, London. http://pubs.iied.org/G03829/

brought to Kalimpong around the 1990s, when the problem of pest and disease infestation became acute. Some farmers then started experimenting with its cultivation in kitchen gardens and on farms.

Early uprooting of maize in response to erratic rainfall: Farmers normally plant paddy after the maize harvest in July and August. Because of unpredictable and erratic rainfall, when the rains arrived before the maize was mature, the farmers of Lingseykha harvested it early to clear the land for paddy cultivation. They uprooted the maize plants along with the cobs, and left them at the side of the terrace until the paddy planting operation was complete. They realised that early uprooting of maize plants along with the cobs, and keeping their roots under wet soil, does not affect the maturing process. This innovation was discovered by accident. Considering the kind of work, the fact that rain often comes at night, and the decision-making process of the male-headed households, men had a significant role in this innovation.

New cultivar of black rice beans to enhance yield: Rice beans have seeds of many colours, and over time, farmers have carefully selected the black ones because they are heavier (higher yielding) and tastier. The special black bean cultivar also fetches a better price than other rice beans and is a local staple food. It is a location-specific crop and does not suit other villages of the region with different altitudes and climatic conditions.

Replacing an old variety of squash with a higher-yielding one from Nepal: *Iskush* (Chayote squash) has been an important vegetable crop in the region but production has been declining, presumably due to changes in climate. A farmer from Tandrabong brought a new variety of squash from a village in Nepal through his daughter, who was married there. Some farmers collected seeds from his field while working as agricultural labourers. Now this crop has become one of the major cash crops in this village and many adjacent villages. Key factors which led to this innovation are the institution of marriage and networking.

Adoption of potato cultivation after a landslide: After a massive landslide in the region in 1968 destroyed paddy lands and most of the water sources, a farmer visited the government potato seed farm in Darjeeling, where he obtained seed potatoes and learnt a new cultivation technology, which enhanced his production tenfold. After this trial, he shared the knowledge with other villagers. Today, potatoes from Tandrabong village are recognised as having special quality in the Kalimpong market and they are grown as a cash crop. Farmers have also synchronised potato cultivation in the annual crop rotation. Farmers improvised the techniques to take up potato and maize farming in a way that complements both the crops. The dominant factors which led to the innovation are networking (with the government seed farm) and people — ie the innovative farmer — as well as the institution or custom of sharing knowledge and seeds.

Domestication of broomstick grass to reclaim land destroyed by a landslide: A few farmers from Tandrabong and Parbingtar collected broomstick plants from the forest and started planting them in the landslide area where they could no longer cultivate food crops. Simultaneously, many government agencies popularised broomstick plantations on wasteland and in landslide areas. Over time, broomstick grass has gained tremendous popularity, as it has good market demand, good soil conservation characteristics, is a good source of fodder in the lean season, and is used for fencing material as well as fuel. It is now the most important cash crop of the region, after cardamom and ginger. The dominant factors that led to broomstick domestication are 'people' factors, as it was the work of pioneering farmers, while the Department of Forests played an important role in its spread.

Reintroduction of traditional mustard cultivation: Local mustard cultivars (yellow and red) were traditionally grown by Limbus and Lepchas of Mudung and Lingsey villages, for oil and oilcake for cattle feed. This declined in the 1970s, as potato cultivation became profitable because good seed was available in exchange for maize seed from Sherpas, who lived at higher altitude. Farmers are now switching back to traditional mustard cultivation because of rising potato dew damage, and a lack of access to good seed because of the takeover of the potato cultivation area by a government protected area. Mustard is also a good remedy against rising soil pathogens and fits well into crop rotations alongside maize and rice. Most households have their own traditional oil extraction equipment. Beekeeping is expanding due to mustard cultivation, providing an additional source of nutrition and income, and the presence of a higher density of pollinators enhances the yield. Elders have played major role in conserving traditional mustard seeds — they continued to cultivate small quantities just to prevent extinction and continue family traditions. Other farmers in the village obtained seed from them and now most households have reintroduced mustard.

Sustaining traditional millet varieties by changing planting times. In the whole mountain region, millet is considered a difficult crop to grow and is declining fast. In the project villages, it is still grown and conserved for rituals, making a traditional alcoholic brew and for food. Millet is grown in two different seasons — Tolley Lepcha of Lingseykha, has experimented with sowing at different times to adapt to reduced rainfall and reduce weeding, and so facilitate continued cultivation. The dominant factors which led to the innovation for sustaining millet agrobiodiversity are cultural and spiritual values (ie institutions).

Market innovations

Vegetable collection to connect farmers to the main Kalimpong market: Farmers in mountain areas find it difficult to market agricultural produce, especially perishable crops such as vegetables. They have small landholdings, practise mixed farming, produce small quantities, and also face rough topography and poor road connections. It is not feasible for individual households to transport small quantities of vegetables to the market. However, some innovative enterprising youths of Tandrabong and Parbingtar have taken the initiative to combine farmers' produce to create marketable quantities. This has encouraged small farmers, especially women, to produce vegetables and enhance their income. The major factors behind this innovation are the trust that the community have and the cooperation they have extended to these youths, along with the skill of the youth in coordinating this collective activity.

Institutional innovations

Formal or modern institutions or mechanisms play a limited role in the sharing of knowledge and information between people, and the creation of rules and norms for natural resource management in the EH. Instead, there are customary rituals and social activities where knowledge, information and planting materials are exchanged and community norms for resource management are set. Some of these cultural institutions have adapted in response to climatic and socioeconomic changes.

Collective paddy seedling production in response to reduced rainfall: In the last 10 to 15 years there has often been less rainfall during winter and a delayed monsoon, which has resulted in the drying up of many perennial water streams and resources. Consequently, many farmers find it difficult to raise a paddy nursery during the required time of May to June. To overcome these challenges, the farmers of Lingsey village together came up with the idea of establishing a common community nursery in the field where water is available. In addition, some farmers raise a nursery by applying mulch to overcome the scarcity of water. The dominant factors leading to this innovation to overcome the impact of erratic rainfall are coordination and mutual trust at village level, which are community-level innovation factors.

Adapting traditional agricultural workforce practices to address labour shortages and climatic challenges: There is a traditional practice in which representatives of many households collectively work in an individual's field, and rotate labour turn by turn. This enables the community to regulate the use of natural resources like water, and share the workforce available in the community. The practice is called *huri* or *parma*. Originally, instead of accounting the work in terms of time, it was more about completion of the task. This practice is losing its significance due to the scarcity of agricultural labour, lack of accounting of the number of work days provided by individuals, and inadequate financial returns, so the norms of participation in *parma* or *huri* have been adapted. The number of workdays put in by each individual is counted and individuals can also sell their workdays or even sell or swap the turn of *parma* with others. This innovation also has indirect relevance to climate change as it means farmers can avail themselves of labour for urgent time-bound agricultural work needs created by climatic challenges, in exchange for non-farm services off season for those who do not require seasonal labour support.

As farmers visit each others' fields in groups for farming, they automatically share knowledge, information and planting materials very effectively. In fact, the word used for *parma* is *khelnu*, which means 'play' (*parmakhelnu*) — ie having fun while working in a group. This system of collective work has been extended to other activities like construction. The dominant factors influencing these innovations are networking and community-level factors.

Conclusion and recommendations

9

9.1 Conclusion

The surveys in the two regions highlight some of the key trends in Himalayan agriculture. The Central and Eastern Himalayan regions are home to traditional agricultural practices that have proven their resilience over time in these communities. With many parts of India in the grips of an agrarian crisis, with rapidly decreasing productivity and soil health, and increasing instances of drought, the two sites offer a wealth of crop diversity and resilience practices and innovations to support adaptation to climate change. These sites are especially important from the perspective of biocultural heritage agriculture (see Section 1.4), as the communities in both sites live in biodiversity-rich areas and practise agricultural methods that have evolved over centuries. Culture and agriculture in the two sites are interlinked and closely adapted to their landscapes.

In both regions, agriculture is the primary activity for the communities. In the CH, however, it has been steadily declining as a source of income but continues to be the most important source of food security (Section 2.3). More men were engaged in farming in the EH households than in the CH, probably because men in the CH are more involved in non-farming activities and migration. Income from pensions, jobs in local schools, and money remitted home by migrants working in urban areas, has been on the increase in the CH. The share of food from own sources has declined, and food security has shifted to procurement from the market or the supply of subsidised grains through the national Public Distribution System (PDS). In the EH, however, there has been a shift to cash crops using traditional methods (with some biocultural innovations like adaptation of crop rotation, on-farm cultivation of cardamom, and domestication of broomstick grass), which has led to agriculture becoming the most important source of income. This may also be because there are fewer options for non-farm income in the EH. This is also reflected in food self-sufficiency, where the CH has shown a more drastic fall than the EH (Section 3.1). In fact, in the EH, vegetable self-sufficiency has increased, with more vegetables being grown as cash crops, as these are grown in wastelands (broomstick grass), seasonally (ginger) or mixed with food crops (cardamom). Both areas have seen a rise in non-farm income, with a rise in welfare schemes like the Mahatma Gandhi National Rural Employment Guarantee Act increasing livelihood opportunities, leading to a fall in the share of income from outmigration between 2002 and 2012 (Section 2.1).

The majority of the cultivated land in both areas is rainfed (82%) (Section 3.2). In the CH, a greater share of land is fallow land than in the EH, where irrigated land is the second largest category of land use by area. Only 2% of land in the CH is irrigated, compared to 14% in the EH. At the national level, irrigated land makes up 46% of the net sown area.[16] Greater irrigation levels reflect the greater livelihood opportunities that agriculture provides in the EH, which receives higher rainfall over a longer period of time, making irrigation (done using indigenous methods) a more viable prospect compared to the CH. People in CH have also abandoned remote fields due to increased instances of attack by animals, and decreases in farm labour due to migration to urban areas. The average landholding is with 0.25 hectares (ha) in the CH and 0.67 ha in the EH, both much lower than the national average of 1.32 ha. Both areas have access to forests allowing for diversity of land-use and farmers practise mixed farming, that is, growing several crops in the same field simultaneously.

The rich crop diversity of both areas is reflected in the crops and varieties grown (Section 4), although several crops have declined and are now cultivated at almost negligible scale. These include flax seed, Chinese basil (*bhangeera*), groundnut and proso millet in the CH, and buckwheat, wheat and sorghum (*junelo*) in the EH. Rice and wheat remain popular in the CH, as are maize and rice in the EH. Crop raiding by wildlife including birds was cited as a factor for declining crop diversity by almost 46% of households in CH. In the EH, people cited prolonged dry spells as a factor for loss of crop diversity, as well as a preference for growing cash crops. Common factors in both the regions are changing food habits and the increased availability of food grains throughout the year, through the PDS as well as from markets. This is reflected in food habits, where a large number of traditional recipes have been lost over the last 30 years (Section 7.2).

In both regions, 80–90% of all seeds used are landrace seeds sourced locally, mostly saved from the last crop. When farmers rotate crops and exchange their seeds, it happens between neighbours and relatives in 70% of cases. Women were more involved in seed selection for landraces in both the sites, and also for hybrids in the EH. In the CH men are more involved accessing seeds from the market, but women still play an important role in decision making relating to seeds. This shows the important role that women play in mountain agriculture.

Society is in transition in both regions, but the remoteness and inaccessibility of mountain regions, together with rich indigenous knowledge and biocultural heritage has played a critical role in stemming the loss of agrobiodiversity and traditional culture. Traditional fare is cooked with some regularity in the CH but only limited to festivals and ceremonies in the EH. However, communities in the EH still continue their collective

[16] NITI Aayog (2017) India Three Year Action Agenda 2017–18 to 2019–20. Government of India.

activities and traditional festivals and beliefs, and are undergoing a revival, unlike in the CH where revivals are sporadic and extremely slow. One reason for this is extensive outmigration of a relatively well-off and influential section of village communities, who used to previously contribute to festivals.

Most farmers in both regions have observed more extreme and unpredictable weather in the last few decades, including more erratic rainfall, drought and floods, increased temperatures, increased pests and diseases, and a decline in water availability. The majority of households surveyed (79% in both sites) noticed significant increase in extreme weather conditions, making climate change an important concern. This has reduced crop productivity and food security. However, the response and impacts have been different in the two sites. Farmers in the EH reported that the decrease in yield has been marginal, while a third of farmers in the CH claimed a drastic reduction in productivity. This may be partly because the EH farmers have been more actively innovating to change and adapt their cropping systems.

These communities are confronting the many challenges related to climate change with ingenuity and innovation. Both communities report that the need to address ecological risks and changes, save labour, and adapt to market needs are some of the most important stimuli for innovation. People have developed a wide range of biocultural innovations, including technological, market and institutional innovations, based largely on traditional knowledge or a combination of traditional and external knowledge. These have enabled them to improve their food security, climate resilience and incomes, and maintain crop diversity. These innovations include new higher-yielding crop varieties and cultivars, changes in cropping practices, and new and modified collective institutions for farming and marketing.

Several factors are at play in the development and spread of these innovations. There are 'people' factors where innovation is largely based on the traditional knowledge of individual champion farmers — particularly elders. In the CH, these pioneering individuals are responsible for most of the technological innovations, like cultivating crops near homes, new ways of composting, a new variety of radish and the reintroduction of lost crops. Institutional factors help adapt ideas to the specific circumstances of the region through existing or new institutions like the Self Help Groups, which work mostly with women, and receive grants from the state governments to enhance livelihood and other micro-credit schemes. Informal and formal networks often become a source of collective innovation. These consist of kinship relations, and occasions where people gather to work together, attend ceremonies, celebrate festivities and gather on social platforms, as well as interaction with external actors such as scientists and other institutions. There are also community-level factors where resource use is coordinated at a community level and collective decision making is in place, as in the case of the crop protection committees in the CH.

In the EH, where communities are more close-knit, networking and community-based innovations are more abundant and more widely adopted. They include early uprooting of maize and collectively growing paddy seedlings for planting, collectively improved variety of black rice bean and the reintroduction of mustard, the domestication of broomstick grass and the development of a new cardamom cropping system and a locally developed variety of cardamom. In the EH, a market-oriented agriculture has developed, as there is surplus to sell and farmers have adopted cash crops that are suited to their agroecological niches like ginger, broomstick grass and cardamom. In the CH, declining returns to agriculture have prompted large-scale outmigration, made worse by crop depredation by wildlife. A thinning social fabric and declining interest in agriculture has led to lower levels of adoption of innovations, and innovations are dominated by the need to save resources.

It is evident that promoting innovation to meet climate change and other challenges means building on local and traditional knowledge systems, based on constant observation and experimentation, sustaining biocultural heritage and customary practices, and maintaining the momentum of continuous exchange within and between communities. Several innovations, such as new varieties and improved composting, have helped to enhance resilience as well as food security. Others, such as crop protection committees, have built on traditional communitarian ways and have effectively enhanced food production.

9.2 Recommendations

Based on the understanding gained through extensive interactions with the communities, this study has identified recommendations for further action and improved policy support to strengthen smallholder innovation systems, agrobiodiversity and climate resilience.

New crop varieties developed by farmers should be formally registered to protect farmers' rights, promote benefit sharing and encourage further innovation and the conservation of local crop diversity. The new variety of radish developed by a farmer in the CH, and the new black rice bean cultivar developed by the community in the EH should be registered under the PPV&FR Act, 2001. Efforts were made and the relevant physiological data were duly compiled in the required format, but these two crops are not yet included in the list of approved species eligible for registration as farmers'

varieties, so a request has been sent to the Protection of Plant Varieties & Farmers' Rights Authority. The Authority should expand the list to include all minor, marginal and underutilised crops. Additionally, the black rice bean cultivar developed by the Lepcha farmers of Lingseykha could be registered as a Geographic Indication, given its very specific geographic location — this should be explored.

Community seed banks have been established in both the regions and are serving a critical need for seed access and the conservation of threatened crop diversity. Many seeds that had gone locally extinct have been brought from other places in the region and some have become extremely popular. However, with the rise in extreme weather events, there is always a risk of crop failure. There is a need to share seed collections with other institutions, such as local and regional research stations of the Indian Council of Agriculture Research, and farmers' collectives in the region. The cooperation and safeguards required in this seed exchange are not clear to the communities and some guidance and mechanisms need to be developed for this.

Traditional institutions continue, particularly in the EH region, but are at times unable to address some of the newer challenges. Some also lack compatibility with the new statutory provisions, such as having a written constitution, democratic decision making, and a bank account. Therefore, space for new institutions has been created. In the CH, the movement of women's Self Help Groups is becoming strong with capacity building under SIFOR. New opportunities for community enterprise, such as developing and marketing biocultural products, and supplying nutritious grains and cereals, need to be strengthened. The crop protection committees formed to ward off depredation by wildlife and stray animals are quite effective, but need to be complemented with more long term measures, such as fencing. A 3.3 kilometre wall and barbed wire fence has been built in Chinauna project village in the CH. The proposal was developed and pursued by SIFOR, and the state government sanctioned six million rupees (US$ 100,000) to implement it. This is the first fence of its kind in the state. More proposals to the government need to be developed and pursued, building on the success of the crop protection committees.

In the Eastern Himalayan region, the West Bengal Government has established the Mayel Lyang Lepcha Development Board (MLLDB), giving a boost to the traditional *Sezom* and *Yak-Thung-Sung Chumfo* institutions. They are being entrusted with more diverse tasks, such as the revival of traditional language, foods and festivals. The MLLDB's interventions have been extremely supportive in revitalising biocultural heritage agriculture. As the investment by the MLLDB grows and more programmes are implemented by the traditional institutions, capacity building will be needed in several aspects, such as formal accounting and legal compliance, in order to safeguard its long-term credibility and effectiveness.

In Lingsey and Lingseykha, almost 1,000 ha of land is being managed by the Lepcha and the Limbu community, according to agro-ecological principles. This biodiversity hotspot, endowed with extraordinary richness of biodiversity and habitats, has the potential to serve as a gene reserve for *in situ* conservation of agricultural biodiversity and resilient landraces, and a sanctuary for other biodiversity and cultural traditions. It needs recognition and safeguards against unplanned development interventions such as roads, canals or the diversion of land for other purposes. At the same time, the livelihoods of local communities need to be strengthened in a way that makes the area flourish as a biological and cultural diversity hotspot. Drawing from other partners in the SIFOR project, such as ANDES, who have experience in the successful Potato Park in Peru, work to establish a biocultural heritage landscape (as a bean, rice or orchid park) has been initiated in the EH region. The biocultural landscape should be recognised as a Biodiversity Heritage Site under India's national biodiversity act (Biological Diversity Act, 2002).

Many traditional landraces, such as dryland paddy, have strong resilience to climatic changes. They therefore offer excellent opportunities for participatory plant breeding to develop new varieties that are both more resilient and higher yielding. Farmers have enthusiastically embraced the effort of reviving dryland paddy cultivation through the SIFOR project, including a systematic trial over three years in farmers' fields, using over 40 parameters and involving 36 traditional paddy varieties. Such participatory action-research needs to be undertaken more widely by formal institutions.

Many traditional practices and innovations have proved to be pioneering and effective. The scientific community should be sensitised to the role of traditional farmers as a peer group with valuable local and ancestral knowledge, rather than just being viewed as recipients of external scientific knowledge. Participatory action-research and plant breeding involving traditional farmers and scientists would generate new ideas and create synergies between ancestral and modern knowledge to confront new challenges. Often, innovations by individual farmers have not spread far. A system to recognise local biocultural innovation in scientific circles would lead to giving it a respected place in official extension and thus improve the reach of these innovations. Support for participatory plant breeding should become mainstream in agricultural policies and programmes, particularly in marginal areas such as mountains.

Traditional farmers in the Central and Eastern Indian Himalayas have observed significant climatic changes in recent years, reducing agricultural productivity. They have responded by innovating to increase resilience and yields, using traditional knowledge, biodiversity and external knowledge. This report explores key trends in livelihoods, food security, crop diversity and biocultural heritage across ten communities; the biocultural innovations developed in response to climatic and socioeconomic changes; and the social factors that have supported biocultural innovation.

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