ICIMOD Working Paper 2014/1

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FOR MOUNTAINS AND PEOPLE

Adapting to Climate Change for Sustainable Agribusiness in High Mountain Watersheds

A case study from Nepal

ADB

About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

ICIMOD gratefully acknowledges the support of its core donors:
The Governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Switzerland, and the United Kingdom.

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Adapting to Climate Change for Sustainable Agribusiness in High Mountain Watersheds

A case study from Nepal

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International Centre for Integrated Mountain Development, Kathmandu, Nepal, December 2014

Published by
International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal

ISBN 978 92 9115 298 8 (printed)
978 92 9115 299 5 (electronic)

Printed and bound in Nepal by
Hill Side Press (P) Ltd, Kathmandu, Nepal

Production team
Shradha Ghale (Consultant editor)
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Photos: All photos by Nabin Baral except pp 41, 43, 48 by Abhimanyu Pandey

Citation: Kotru, R; Choudhary, D; Fleiner, R; Khadka, M; Pradhan, N; Dhakal, M (2014) *Adapting to climate change for sustainable agribusiness in high mountain watersheds: A case study from Nepal*. ICIMOD Working Paper 2014/1. Kathmandu: ICIMOD

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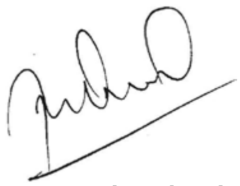
Foreword

Due to several climatic and non-climatic factors, high mountains are changing all over the world, and Nepal is no exception. The High Mountain Agribusiness and Livelihood Improvement Participatory Action Research (HIMALI PAR) Project was started as a prelude to the High Mountain Agribusiness and Livelihood Improvement (HIMALI) project. The HIMALI project is supported by the Asian Development Bank (ADB) and is currently being executed by the Ministry of Agriculture Development (MOAD) through its Department of Livestock Services (DLS).

As part of the HIMALI PAR Project, MOAD had entrusted ICIMOD to carry out research on 'Adapting to Climate Change for Sustainable Agribusiness in High Mountain Watersheds'. I am pleased to learn that ICIMOD is publishing the findings of the research.

Although carried out with limited budget over a short two-year period, the research has made some very important findings. These findings will be useful not only to HIMALI project but also to communities and agencies like MOAD that work with communities in areas most sensitive to climate change. On behalf of MOAD, I take this opportunity to thank the ADB and ICIMOD, as well as the agencies and individuals from the centre to community level who have contributed greatly in the completion of this project.

The HIMALI project has steadily been working to improve mountain communities' resilience to climate change. The value chain selection criteria and sustainable agribusiness practices suggested in this research will, I believe, guide the project team in selecting promising business plans and awarding agribusiness development grants. I am hopeful that MOAD and ICIMOD will continue to share knowledge and strengthen their collaboration in the future.



Jaya Mukunda Khanal
Secretary, MOAD

Preface

Local communities in the Hindu Kush Himalayas (HKH) are facing numerous challenges owing to various social and environmental changes. Their existing coping strategies have become inadequate for them to deal with the effects of climate change. In this context, we at ICIMOD are striving to generate evidence-based knowledge about adaptation in the HKH region.

Communities in the HKH heavily depend on mountain resources such as springs and water, forests, and land, which in turn yield high valued agricultural and other products like medicinal herbs, fruits, vegetables and nuts, and other forest products. Yet, realizing the benefits of these for mountain people is often difficult. One of the key practices that help mountain communities connect to markets and sustain their livelihoods amid environmental challenges is agribusiness. Agribusiness drives local economies, empowers people and helps strengthen local coping strategies. Adaptation initiatives in the HKH should hence include agribusiness as a key component.

With that in view, ICIMOD carried out a participatory action research (PAR) under the High Mountain Agribusiness and Livelihood Improvement (HIMALI) project in early 2010. Supported by the Asian Development Bank and the Ministry of Agriculture Development, the project was implemented in two of the remotest districts of Nepal – Jumla and Mustang. The HIMALI-PAR project aimed to identify adaptation measures needed to promote mountain agribusiness by consolidating local coping strategies. The research was conducted over a two-year period spanning four growing seasons, in collaboration with ICIMOD's partners in the two districts. The learning and recommendations of the research team are included in this publication.

Using a multi-stakeholder approach, the HIMALI-PAR project identified future climate change trends and documented local communities' perceptions of climate risks and vulnerabilities. It also provided climate-adaptive agribusiness and livelihood technology packages and built the capacity of local communities and farmers to utilise the packages. A specifically developed framework of climate change adaptation parameters was used for the analysis. Potential and pro-poor value chain products such as apples, local beans and medicinal plants (akarkara) in Mustang and off-season vegetables in Jumla for agribusiness development were identified in the two pilot watersheds in close consultation with local farmers, local cooperatives, and local line departments, and these products were used as a basis for developing participatory agribusiness plans. In both pilot areas, a variety of improved packages of agricultural practices (e.g., integrated pest management, tunnel technology, poly houses, sprinkler irrigation, improved germplasm of apple varieties) were tested and demonstrated in target households with the aim of improving the productivity and resilience of the local products in the face of climate change. These technologies enabled the locals to manage pest and diseases and to efficiently use water and land for cash crop production.

The research findings clearly show that mountain agribusiness can be adapted and made financially rewarding by building capacity of stakeholders, through institutional strengthening, introducing technologies and demonstrating climate smart investments. . The research will go a long way in triggering further innovations.

David Molden, PhD
Director General, ICIMOD

Acknowledgements

The authors would like to acknowledge the efforts and contributions of the many people from different disciplines who have provided invaluable background information and data for this publication. They express their gratitude to the Asian Development Bank (ADB) for the continued support and funding for the HIMALI PAR project, including this publication. We thank the Ministry of Agriculture Development (MOAD) of the Government of Nepal (GON), the numerous line departments in the districts of Mustang and Jumla that were involved in the project, and the project's partner organizations – the Local Initiatives for Biodiversity, Research and Development (LI-BIRD) in Mustang and the District Development Committee-Local Development Fund (DDC-LDF) in Jumla – for their support and contributions to the participatory action research. Special thanks are due to the many community members, farmers, researchers, and representatives of government and non-governmental organizations who actively participated and engaged in the action research and local and national consultations carried out during this project. We would also like to express our sincere thanks to the many ICIMOD colleagues who have contributed to this project.

Acronyms and Abbreviations

ACAP	Annapurna Conservation Area Project
ADB	Asian Development Bank
ADS	Agriculture Development Strategy
AEC	Agro Enterprise Centre
CBO	Community-based organization
CBS	Central Bureau of Statistics
CFUG	Community forest user group
DADO	District agriculture development office
DDC	District development committee
DFO	District forest office
DLSO	District livestock office
FNCCI	Federation of Nepali Chambers of Commerce and Industry
GCM	General Circulation Model
HIMALI	High Mountain Agribusiness and Livelihood Improvement
HKH	Hindu Kush Himalayas
IPM	Integrated pest management
LI-BIRD	Local Initiatives for Biodiversity, Research and Development
LDF	Local Development Fund
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
MAP	Medicinal and aromatic plant
MOE	Ministry of Environment
MOAD	Ministry of Agriculture Development
NARC	National Agriculture Research Centre
NCEP	National Centers for Environmental Prediction
NGO	Non-governmental organization
NTFP	Non-timber forest product
PAR	Participatory action research
PRA	Participatory Rural Appraisal
RCM	Regional Climate Model
SDSM	Statistical Downscaling Model
SNV	Netherlands Development Organization
THDC	Temperate Horticulture Development Centre
VDC	Village Development Committee

List of Plants with Vernacular and Scientific Names

akarkara	*Anacyclus pyrethrum*
caragana	*Caragana versicolor*
cocksfoot grass	*Dactylis glomerata*
fourwing saltbush	*Atriplex canescens*
kutki	*Neopicrorhiza scrophulariiflora*
jatamansi	*Nardostachys grandiflora*
juniper	*Juniperus communis*
naked barley	*Hordeum vulgare*
poplar	*P. tremula*
satuwa	*Trillidium govanianum*
gheu simi (bean)	*Phaseolus vulgaris*
yarsagumba	*Ophiocordyceps sinensis (syn. Cordyceps sinensis)*

Executive Summary

This publication reflects the findings and learning from a programme of participatory action research (PAR) carried out between 2010 and 2012 in two geographically and climatically different mountain watersheds in the districts of Mustang and Jumla in Nepal. The study was conducted under the High Mountain Agribusiness and Livelihood Improvement (HIMALI) investment project, which is funded by the Asian Development Bank (ADB) and implemented by Nepal's Ministry of Agriculture Development (MOAD). The PAR component was implemented by ICIMOD through local partner organizations: Local Initiatives for Biodiversity, Research and Development (LI-BIRD) in Pangling watershed of Kagbeni VDC (village development committee) in Mustang, and the District Development Committee-Local Development Fund (DDC-LDF) in Lorpa watershed of Dillichour VDC in Jumla.

The HIMALI PAR project aimed to identify climate change adaptation priorities and provide input to the design of effective local watershed management plans to ensure the sustainability of agribusiness for the local communities. The learning from the project is intended to support the development of climate change adaptation strategies for sustainable, socially equitable, and gender-responsive livelihood development that can be replicated and included in the HIMALI investment project and other similar initiatives.

The project used a participatory, community-based, local multi-stakeholder approach combined with climate change downscaling to identify future climate change trends, assess local communities' perceptions of climate risks and vulnerabilities, test climate-adaptive agribusiness and livelihood technology packages, and enhance the capacities of farmers and local communities to operationalize the packages. Potential value chain products for agribusiness development were identified in the two pilot watersheds in close consultation with local farmers and their institutions, and these products were used as a basis for developing participatory agribusiness plans. In both pilot areas, for the first time a variety of climate-adaptive agricultural practices (e.g., integrated pest management, tunnel technology, poly-houses, sprinkler irrigation, improved germplasm of apple varieties) were tested and demonstrated in target households with the aim of improving the productivity and resilience of local products in the face of climate change. These technologies proved to be indispensable tools for managing pest and diseases and enhancing the use and management of water and land for the production of cash crops.

In both pilots, the main determining factors for addressing climate change were ecosystem vulnerability and resilience, the coping capacity of local farmers and institutions, and communities' linkages and networks with the agribusiness environment. These factors were the basic tenets used to develop the climate adaptation methodology. In particular, it was observed that water scarcity and climate variability are key factors that must be effectively addressed to facilitate sustainable agribusiness production. The analysis emphasized the importance of gender aspects in agriculture, local institutions, and governance mechanisms.

Using a watershed approach as an entry point for developing options to secure and sustain the water resource base proved essential for ensuring the development of sustainable agribusiness options. The research also recognized the important role of women farmers in local climate-adaptive development, which needs to be fully harnessed. Local institutions – the key stakeholders in such development contexts – in the pilot areas need to be further strengthened to enable them to provide long-term support systems for local farmers. The private sector could play an important role in agribusiness development, but its long-term engagement will be determined by the local infrastructure and the market potential of niche products. The methodology for climate change adaptation tested in the study proved to be a suitable framework for undertaking this type of context-specific analysis, but it is recommended that it be further improved and refined through scaling up in other contexts and permanent sample sites of larger size. To ensure that the agribusiness proposals and watershed plans are sustainable, they must be screened and supported through local public schemes. The research findings can help better target policy and development efforts aimed at promoting and sustaining high mountain agribusiness in Nepal. It would be wise to address the specific local context and build on existing ways of coping and locally available technologies rather than imposing adaptation interventions designed and driven by external agencies.

1 Introduction

Agriculture is an important production sector in the high mountain areas of Nepal. It is inextricably linked to the availability of water and watershed-based natural resources. It creates employment opportunities, provides options for income generation and diversification, sustains the livelihoods of mountain communities, and contributes to food security in areas that often lack adequate infrastructure development and income opportunities. Particularly for the communities in remote, high mountain areas of the Hindu Kush Himalayan (HKH) region, the practice of agriculture and agribusiness is closely linked to and dependent on the goods and services provided by watersheds, such as water, energy, flood control, timber, and non-timber forest products (NTFPs). These communities are highly vulnerable to climatic and non-climatic changes because such changes threaten the sustainability of the resource base and can directly affect their sources of income and wellbeing.

Climate change is a particularly noteworthy and ever growing challenge. Even small shifts in temperature can jeopardize the fragile balance of natural environments, which are defined by extreme climatic conditions, steep topography, and a wide variety of ecological zones and associated microhabitats with distinct biodiversity. Climate change is mainly felt through water deficits and an increasing variability in water availability. While overall there is still high uncertainty about future climate change scenarios, especially at the local level, climate change projections across the HKH region indicate an increase in temperature, with an increased number of extremely hot days, as well as a wide range of changes in precipitation and an increase in heavy precipitation events (CICERO and ISET 2010).

Local communities in the mountain areas of Nepal are already experiencing major changes in climate, which have manifested in terms of reduced water availability, rising temperatures, and a shift in growing seasons – all of which impact agricultural production. Climate change is seen as a major threat to poor mountain communities, especially women, who have limited assets and influence in the public sphere and experience discrimination on the basis of gender, caste, and ethnicity (Dankelman 2002). Understanding the needs and knowledge of both men and women farmers, testing technologies of climate adaptive agricultural production with the participation of men and women, learning from technological experimentation, and scaling up of good practices can provide useful approaches for enhancing gender-differentiated capacities to adapt to climate change (Meinzen-Dick et al. 2011; Nelson and Chaudhury 2012). Local farmers have started to adapt indigenous approaches in agricultural production under changing climatic conditions, for example, by introducing new crop varieties and halting the plantation of other types of crops, changing grazing practices, and adjusting irrigation. Nevertheless, the challenges posed by increasingly rapid and unpredictable climatic changes are expected to overwhelm the often limited capacity, knowledge, and resources of local communities and institutions in remote and underdeveloped areas (ICIMOD 2009).

Despite the challenges, the Government of Nepal and donor organizations see agribusiness as a production sector with high potential to provide mountain communities viable options for securing and improving their livelihoods and incomes and alleviating poverty. To achieve this, however, indigenous agricultural production will need to be modified and adaptive approaches tested. This is the rationale behind the participatory action research (PAR) described in this publication. The PAR activity was part of an investment project on High Mountain Agribusiness and Livelihood Improvement (HIMALI) funded by the Asian Development Bank (ADB) and implemented by Nepal's Ministry of Agriculture Development (MOAD). The aim was to use a PAR

approach in two pilot mountain watersheds to identify climate change adaptation priorities and develop climate-proof watershed management plans that will ensure the sustainability of agribusiness development for local communities. The learning from the PAR is intended to support the development of climate change adaptation strategies for sustainable, socially equitable, and gender-responsive livelihood development that can be replicated and included in the HIMALI project, as well as in other similar initiatives.

About the Participatory Action Research

The HIMALI PAR project was implemented between 2010 and 2012 by the International Centre for Integrated Mountain Development (ICIMOD) together with local partners in Nepal – Local Initiatives for Biodiversity, Research and Development (LI-BIRD) in Mustang and the District Development Committee-Local Development Fund (DDC-LDF) in Jumla. Based on relevant criteria (Annex 1) two pilot areas were selected: Pangling watershed in the Kali Gandaki River valley in Kagbeni VDC in Lower Mustang, and Lorpa watershed in Dillichour VDC in Jumla. The PAR focused on integrated watershed and rangeland management and aimed to identify climate change adaptation priorities for agribusiness that could be scaled up after field validation for use in the HIMALI investment project. The results are described in detail in the project report (ICIMOD 2012) with highlights listed in Annex 2. The four main outputs of the project were

- downscaled climate change impact modelling and analysis of associated risks for the pilot areas;
- community-based climate impact assessment in the pilot areas;
- climate-adaptive agribusiness and livelihood technology packages; and
- enhanced capacity of vulnerable rural communities and local producer organizations to operationalize the climate-adaptive technology packages.

Promoting and safeguarding agribusiness in a changing climate requires an approach to natural resource management that takes into account the increased complexity of ecosystem change processes as influenced by a changing climate, as well as the changing human interface in the use of such ecosystems across watersheds. There are multiple stakeholders as agribusiness value chains are governed by a range of business actors, including the producer community, public actors, and their associated programmes. The PAR approach must capture this institutional diversity. This calls for an effective delivery mechanism that enables collective thinking, strategic planning, and adapted actions and investments in natural resource management, as well as improved coping strategies and mechanisms at multiple levels of service delivery and decision making. Given the limited research period of two years, ICIMOD's approach was to use an outcome-oriented PAR relying on the following:

- Local multi-stakeholder processes
- Community-based climate risk and vulnerability assessments
- Downscaled climate change trends in pilot districts
- Assessment of local coping strategies

Main features of the PAR pilot study areas

The above aspects were analysed through a participatory rural appraisal in which all the pilot households participated. Target households for action research were identified based on initial socioeconomic (e.g., wellbeing ranking, see Annex 3) and resource (e.g., rangelands) assessments, after which key agrotechnologies associated with agribusiness were tested. Accordingly, the socioeconomic assessments of Pangling and Tallo Lorpa differed greatly. The most prominent differences related to population and population density. As shown in Table 1, Pangling had

Table 1: **Number of households in pilot areas (Lorpa and Pangling)**

Pilot area (district)	Number of households	Male population	Female population	Total population
Tallo Lorpa (Jumla)	70	212	203	415
Pangling (Mustang)	35	101	83	184

less than half the population and exactly half the number of households as Tallo Lorpa. The district of Mustang is one of the most sparsely populated in Nepal, with a population of only 15,225 projected for 2011 (ICIMOD 2012). Comparatively, Jumla is more densely populated, with a population of 101,223 projected for 2011 (ICIMOD 2012). Census data analysed by the Central Bureau of Statistics (CBS 2003) illustrate the performance of individual districts against development indicators as well as an overall composite development index. Mustang ranked 14th out of the 75 districts in Nepal in terms of overall development, which places it in the most developed quartile. Jumla ranked 68th, indicating its least developed status in Nepal.

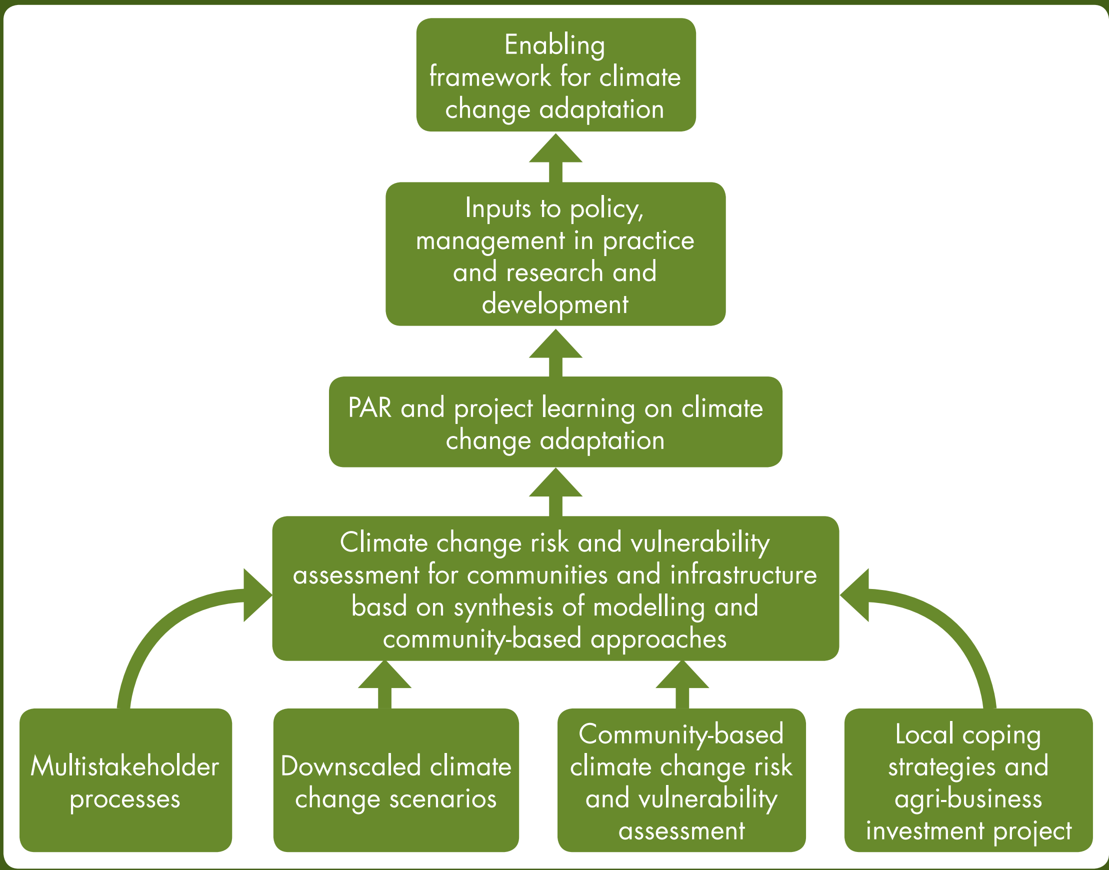
Pangling and Tallo Lorpa are both agriculturally based villages. However, Mustang is substantially better off than Jumla in terms of access to improved sources of drinking water, child dependency ratio, child malnourishment, school enrolment, literacy, and cereal crop yield. In general, the low productivity in Mustang as compared to Jumla is compensated by its rich tourism potential and the resulting economic benefits enjoyed by local people. The high-quality apple exports from Mustang further increase local incomes. Initial analysis indicates that communities in Jumla are relatively disadvantaged.

Just over seven per cent (7.3%) of Nepal's population lives in mountain regions. However, they use less than one per cent (0.3%) of the country's cultivated land (Gill 2003). Mountain regions also suffer from extreme temperatures, short growing seasons, slow growth rates, and poor soils (Gill 2003). Furthermore, the agricultural advancements of the green revolution have been relatively ineffective in mountain regions, and the increase in productivity has been small compared to that in the plains (Rasul and Karki 2007). Local livelihoods in the HKH, including in the pilot areas, are generally linked to forests and scrub vegetation, which, according to locals, have become degraded over the past decade as a result of poor management. Staple food deficiency is common in Nepal's mountain regions and is experienced in varying degrees in Pangling and Tallo Lorpa.

Pangling is surrounded by 28 hectares of cultivated land. The main crops grown there include buckwheat, barley, oats, potato, beans, and apples (ICIMOD 2012; Khanal et al. 2011; Sthapit and Dhakal 2010). Between November and April, minimum air temperatures in the area are below the tolerance range of staple crops, hence the short growing season (ICIMOD 2012). The community faces a cereal crop deficit of 17.86 tons (Khanal et al. 2011); however, cash crop sales amounting to NPR 1.6 million per year more than compensate for this deficit (Sthapit and Dhakal 2010; ICIMOD 2012). As a result, food insufficiency is rarely an issue. Livestock complement crop production in Pangling (Lama 2010). There are more than 350 livestock units in Pangling (Khanal et al. 2011), which include mainly goats as well as cattle, sheep, and mules. These livestock provide adequate manure for less than half (11.4–15 ha) of Pangling's agricultural land (Khanal et al. 2011); however, increasing the number of livestock would put stress on the rangeland.

The main crops grown in Tallo Lorpa are maize, barley, wheat, millet, potato, and beans (ICIMOD 2012). Minimum and maximum air temperatures for these crops are generally below the optimal range throughout the growing season (ICIMOD 2012; Whiteman 1985). Lying under the influence of western disturbances, this location receives regular winter precipitation, which facilitates two crops a year. Tallo Lorpa lies at the upper limit of where two crops can be grown in a year. This condition is tenuous, and whether the first crop ripens before the second crop can be planted depends on how conducive and consistent the weather conditions in each season are. Crops on south-facing slopes generally have a greater chance of ripening in time. However, land in this part of Tallo Lorpa is limited and already heavily cultivated. These challenging conditions combined with small landholding size (Whiteman 1985) limit food production in the area. Tallo Lorpa produces sufficient cereal crops for its population, and a proportion of this is sold in the market, generating around NPR 465,000 in revenue (ICIMOD 2012). Much of this

Figure 1: **ICIMOD's approach to climate change adaptation in the HIMALI PAR Project**



revenue is spent on non-food items, which could result in a food shortage. Some community members relate food security issues to population growth over the past decades; however, others say food security actually improved during that time (Gawith 2013).

Building on local multi-stakeholder processes

Worldwide, multi-stakeholder processes have been recognized as valid mechanisms for developing and implementing socially inclusive and environmentally responsible management practices for sustainable development. These processes help ensure equitable access to information and people's involvement in discussions, and thus promote inclusive decision making. They help create a balance between the rights, needs, and aspirations of different stakeholder groups (Nussbaum 2010). While inclusive decision making ensures broader ownership of decisions taken, multi-stakeholder processes can also support the recognition of voices, and participation, of disadvantaged individuals, groups, and institutions that are affected by decisions and actions related to the management of natural resources (Grimble 1998).

The PAR approach made use of the knowledge produced by both scientists and local communities to address the collective concerns of various stakeholders (see Annex 4). Pilot district-level consultation with all major line departments, participatory rural appraisal with community members, selection of agribusiness technologies, and design and delivery of local capacity building packages brought several key stakeholders together. Finally, the preparation of agribusiness plans with inputs from key stakeholders allowed for local participation.

Community-based climate risk and vulnerability assessments

The vulnerability and capacity assessments were guided by the hypothesis that climate change is already taking place, is observed by mountain communities in the HKH, and is directly affecting their livelihoods and production base. Climate variability and change are not new phenomena. Mountain communities have developed a wide range of adaptive strategies as part of their lifestyles. However, experts suggest that the exacerbated pace of climate change and the increasing frequency and intensity of climate-induced hazards exceed mountain communities' capacity to adapt on their own in a timely fashion. Vulnerability to climate and socioeconomic changes and other drivers is not homogeneously distributed across mountain communities. Women, the poor, and other marginalized groups such as the elderly and indigenous communities have been found to be particularly vulnerable to climate change as a result of their limited access to assets, influence, control over resources, and networking to access services and institutional support (Gautam et al. 2007; Skinner 2011). At the same time, women are still underrepresented in local decision-making forums and lack the support and services they require, notwithstanding their potential to contribute to agricultural production and local economic development (Meinzen-Dick et al. 2011).

Mountain communities often require external support to scale up and diversify their existing knowledge and skills so that they can respond adequately and in a timely fashion to changes in the environment. However, the institutional linkages that can help marginal farmers adapt to climate change are often weak, and support systems provisioned by public schemes and investments, including private investment, are almost inaccessible for remote mountain communities (Macchi 2011).

Methodology

The research design aimed to assess communities' vulnerability to climate change, their adaptive capacity, and how these variables impact the livelihood production base. Climate change vulnerability in Pangling and Tallo Lorpa was investigated using a combination of quantitative and qualitative approaches (Bryman 2006) that have been successfully applied in the rural mid-mountains of Nepal (Dixit et al. 2009). In a process spanning two years, the research team applied ICIMOD's community-based climate vulnerability assessment methodology (Macchi 2011) in general meetings, appraisals, and focus group discussions of all pilot communities, as well as in quantitative and qualitative assessments of target households (e.g., apple farmers and irrigation users).

Downscaling Climate Change Trends

Despite uncertainties regarding the future scenario, there is evidence that climate change has resulted in considerable impacts on the environment and the economic and social life in mountain areas. These impacts are projected to grow in the future. Climate change is expected to affect the hydrology in mountain regions through changes in the timing, amount, and form of precipitation and in evaporation and transpiration rates and soil moisture, which in turn may spur droughts and other extreme climatic anomalies (Tsering et al. 2010). The most widely used approach in regional climate impact studies is to combine the output of General Circulation Models (GCMs) with an impact model (Devkota 2010).

Downscaling techniques

Dynamic downscaling involves the nesting of a higher resolution Regional Climate Model (RCM) within a coarser resolution GCM. The RCM uses the GCM to define time-varying atmospheric boundary conditions around a finite domain, within which the physical dynamics of the atmosphere are modeled using horizontal grid spacing of 20–50 km. The main advantage of RCMs is that they can resolve smaller-scale atmospheric features such as orographic precipitation. Furthermore, RCMs can be used to explore the relative significance of different external disturbances caused by changes in terrestrial-ecosystem or atmospheric chemistry. Weather typing approaches involve grouping local meteorological data in relation to prevailing patterns of atmospheric circulation. Climate change scenarios are constructed either by resampling from the observed data distribution (conditional on the circulation patterns produced by a GCM) or by generating synthetic sequences of weather patterns and then resampling from observed data. Climate change scenarios are generated by using stochastic approaches including revised parameter sets scaled in line with the outputs from a host GCM. Transfer-function downscaling methods rely on empirical relationships between local scale predictions and regional scale predictions (Devkota 2010).

Downscaling of regional climate change scenarios was carried out for the districts of Jumla and Mustang using GCMs based on predictor sets from the United States National Centers for Environmental Prediction and the Hadley

Table 2: **RCMs whose products have been diagnosing in Nepal**

RCMs	Space resolution	Time resolution	Base period	Projected period	IPCC Scenarios
HadRM2	50x50 km	Monthly	1981–2000	2041–2060	1% per year compound increase of CO_2 from 1990 level
PRECIS	50x50 km	Daily	1961–1990	2071–2100	A2 and B2
RegCM3	50x50 km	Daily	1961–1990	2041–2069	A2

Center Regional Climate Model focusing on B2 and A2 global emission scenarios.[1] The Statistical Downscaling Model (SDSM) was chosen for the present study. The SDSM – a decision support tool for the assessment of regional climate change impacts – is a hybrid of the stochastic weather generator and transfer function methods developed in the United Kingdom. This model enables the construction of climate change scenarios for individual sites on daily timescales, using GCMs with high grid resolution (Devkota 2010). The daily observed data for basic climatic elements, rainfall, and surface air temperature in Jumla and Mustang were collected from the Department of Hydrology and Meteorology (DHM), Government of Nepal.

Altogether 22 GCM products were diagnosed in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) experiments. However, only six models (Table 2) were found to have a reasonably realistic representation of monsoon variability and, hence, are recommended for the HKH region. Considering all the practical constraints, this study adopted statistical downscaling techniques utilizing GCM products from Hadley Centre (HadCM3) and Canadian Centre for Climate Modelling and Analysis (CGCM2) for scenarios generation.

A synthesis of downscaled modelling and community-based climate risk and vulnerability assessments informed the PAR and the recommendations for adapting local coping strategies relevant for climate change adaptation in the pilot areas. The National Adaptation Programme of Action to Climate Change of Nepal (MOE 2010) has placed both PAR districts in the moderate category of climate change vulnerability (Table 3).

Table 3: **Placement of PAR districts as per the ranking of vulnerability indices (ranging from 0 [very low] to 1 [very high])**

Moderate (0.356-0.600)	Sankhuwasabha, Baglung, Sindhuli, Bhojpur, Jumla, Mustang, Rolpa, Bajhang, Rukum, Rauthahat, Panchthar, Parbat, Dadeldhura, Sunsari, Doti, Tanahu, makwanpur, Myagdi, Humla, Bajura, Baitadi, Bara, Rasuwa, Nawalparasi, Sarlahi, Sindhupalchok, Darchula, Kaski

Source: Climate change vulnerability mapping of Nepal (MOE 2010)

Results and conclusions of downscaling

Downscaling of temperature in Jumla and Mustang using HadCM3 predictors captures the observed annual cycles very well. However, a small bias is present in both places. On the annual scale, the cold bias between downscaled and observed maximum (and minimum) temperature in Jumla and Mustang is 0.43°C (0.01°C) and 0.55°C (0.59°C) respectively. This suggests that the results of the SDSM temperature downscaling are trustworthy and slightly better in Jumla than in Mustang. For the end of the twenty-first century, downscaling for Jumla projects an increase in maximum (and minimum) temperature of 2.44°C (2.17°C) for low (B2) and 3.39°C (3.06°C) for high (A2) emission scenarios. Similarly, for the same century, downscaling for Mustang projects an increase of maximum (and minimum) temperature of 2.39°C (1.70°C) for low and 3.25°C (2.39°C) for high emissions. These outcomes show that the maximum temperature increase is higher than the minimum temperature increase, suggesting an increase of future daily temperature range, in both Jumla and Mustang. The downscaled frequency of hot and cold days shows a significant increase in the frequency of hot days in summer and a slight decrease in the frequency of cold days in the winter in both Jumla and Mustang.

[1] Emission scenario A2 describes a very heterogeneous world with continuously increasing global population focused on self-reliance and preservation of local identities, primarily regionally-oriented economic development, and more fragmented and slower per capita economic growth and technological change (compared to other scenarios). Emission scenario B2 describes a world in which emphasis is on local solutions to challenges of economic, social, and environmental sustainability, the burgeoning global population (but at a lower rate than A2), economic development at intermediate levels, and less rapid and more diverse technological change (compared to the B1 and A1 scenarios). The B2 scenario is oriented toward environmental protection and social equity, and focuses on local and regional levels (IPCC 2000).

This suggests that the influence of emission scenarios will lead to the expansion of the hot season (February to November in both locations) and contraction of cold season (October to April in Jumla and September to June in Mustang) by the end of the twenty-first century. High intensity precipitation of 70 mm per day in Jumla and 33 mm per day in Mustang can occur once in a decade. However, precipitation of 100 mm per day in Jumla and 50 mm per day in Mustang are extremely rare events (Devkota 2010).

The results and assessments of model calibration and the simulated temperature and precipitation data for in Jumla and Mustang are provided in Annex 5.

Local Coping Strategies

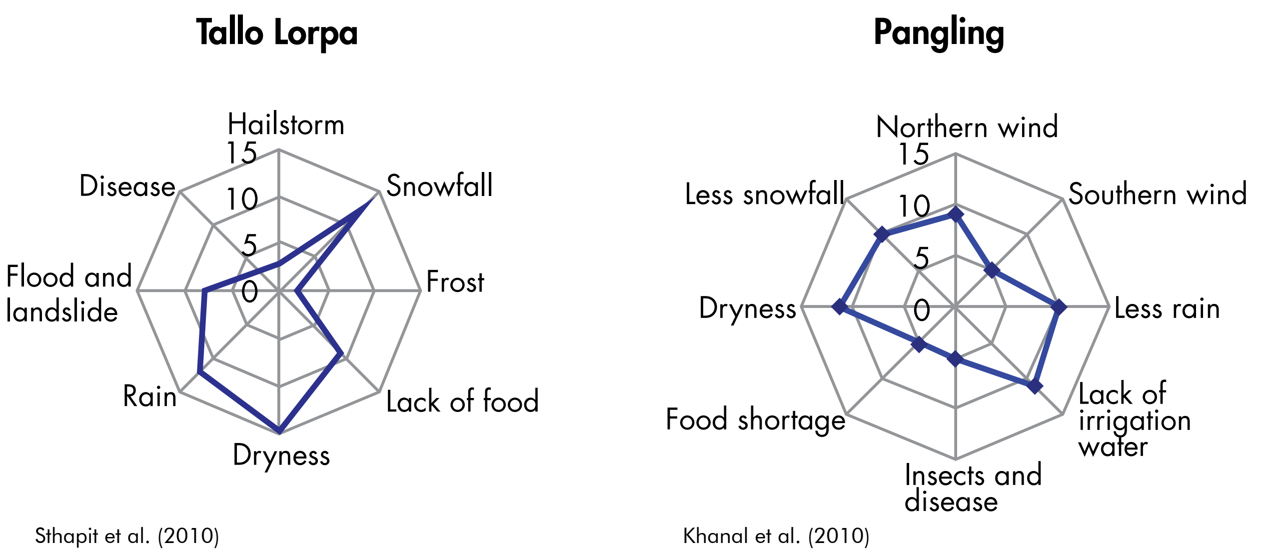
Studies of local coping strategies generally assess how climate risks and adaptation are perceived, evaluated, and then responded to locally (Patwardhan 2003). In the present study, the outputs from the multi-stakeholder processes, community-based climate risk and vulnerability assessments, and downscaled climate change trends were analysed and used to identify potential climate change impacts on various relevant areas such as local hydrology and water resources, agribusiness, and other natural resource based production systems, together with the potential downstream impacts and linkages. Perceptions of local communities, including social and gender aspects, and existing responses and strategies, were further analysed to identify the needs and priorities for future short- and long-term risk mitigation planning and actions.

During an initial period of three months, the team conducted a thorough survey of local resource management systems and existing knowledge about adapting to climate variability in both the pilot areas, Pangling and Tallo Lorpa. Participatory techniques were used throughout and information gathered was triangulated (Sthapit and Dhakal 2010). Further, quantitative and qualitative research was conducted to examine the two communities'

vulnerability to water stress in the face of climate change. The research used total household survey (all households in pilots) and combined physical scientific and social scientific enquiry (Gawith 2013).

Figure 2 shows vulnerability spider charts from Tallo Lorpa (Jumla) and Pangling (Mustang) based on community discussions. The vulnerability spider chart clearly shows that a 'lack of irrigation water' and 'dryness', followed closely by 'less rain' and 'less snowfall', are the community's main environmental concerns. In comparison, Tallo Lorpa is a water-rich community in terms of absolute availability of water. Average annual flow in the Ghatte Khola is 292 litres per second, ranging between a monthly average minimum of 99 litres per second in February and maximum of 866 litres per second in August. Domestic water is supplied to the community through 14 private taps and six public taps. In the past, water was diverted from the Ghatte Khola by eight irrigation canals. While some irrigation continues, these canals have largely been abandoned due to cropping change from barley to maize and potatoes (ICIMOD 2012).

Figure 2: **Vulnerability spider chart negotiated by members of the community. Higher values indicate higher perceived vulnerability**



2 Profiling Selected Agribusiness Options

Agricultural Development in High Mountain Areas

The majority of people in the high-altitude Himalayas depend on subsistence agriculture and local natural resources for their livelihoods. Around 90% of farmers in these areas rely on marginal and small landholdings (Jodha 2000; Choudhary et al. 2011). In Nepal, about 76% of the 4.17 million households own agricultural land and 72% have livestock and poultry. Around 40% of household landholdings are classified as marginal (<0.5 ha) and 47% as small (0.5<2 ha), only 13% are larger than 2 ha (SSMP 2007). In many cases, households use other ecosystem goods to augment their income and food resources (e.g., extraction of non-timber forest products from nearby forests). The great geographical diversity provided by high-mountain conditions in terms of biodiversity, climate, topography, and culture offers these areas a comparative advantage for producing a variety of niche products for home consumption and sale. During the 1990s, the Government of Nepal initiated reforms to move towards a more market-oriented economy and the devolution of financial and judicial responsibilities and power to the local level to formulate and carry out plans related to infrastructure, agriculture, and rural development (under the Local Self Governance Act 1999).

The 1995 Agriculture Perspective Plan (APP) and subsequent plans such as the Agriculture Development Strategy (ADS) that has been developed (MOAD 2012) provide the latest national framework for agricultural development in Nepal. Agricultural growth is considered the key to poverty reduction and the ADS envisions competitive,

sustainable, and inclusive agriculture that brings economic growth, improved livelihoods, and food and nutritional security. It stresses the point that growth of agricultural-based activities will have rural non-farm effects and imply increased employment in non-farm activities such as agroprocessing, storage, trade, food service, production services, and agrotourism. Higher economic growth of the agricultural sector will contribute to higher GDP. In particular, the vision indicates that, to the extent possible, marginal groups should be included in programmes and the sharing of benefits from agricultural development. Agricultural GDP grew by an average of 3% during the Agriculture Perspective Plan period (1995 to 2010). The ADS envisions that agricultural growth will accelerate, and as a result GDP per capita in agriculture will increase sufficiently, leading to poverty reduction and improvement of living standards in rural areas.

As mentioned earlier, the major staple food crops grown in the PAR pilot areas were barley, millet, wheat (in Jumla), and buckwheat (in Pangling). Beans or 'gheu simi' (*Phaseolus vulgaris*) were the most common pulse crops in Jumla; and potato and apple were the main cash crops in both pilot areas. Cultivated vegetables such as cabbage, cauliflower, carrot, coriander, chilli, and radish were mostly consumed and sold locally. Farmers in the pilot villages in Jumla commonly collect medicinal and aromatic plants (MAPs) like yarshagumba (*Ophiocordyceps sinensis syn. Cordyceps sinensis*), 'satuwa' (*Trillidium govanianum*), 'kutki' (*Neopicrorhiza scrophulariiflora*), and 'jatamansi' (*Nardostachys grandiflora*). A few MAPs are known to be cultivated, such as 'akarkara' (*Anacyclus pyrethrum*) in Mustang. The farmers also keep sizeable flocks of sheep and goats, as well yak and 'chauri' (yak-cattle) for wool, meat, and dairy products.

Selection of Potential Products and Agribusiness Planning

Potential value chains for the two PAR pilot areas were selected using the criteria shown in Table 4. The agribusiness products were then shortlisted using a priority ranking process with the members of the cooperatives in the two areas. This was the first time that the farmers' cooperatives had undertaken extensive agricultural production and marketing planning to improve the benefits from agriculture.

The potential agribusiness opportunities identified were (i) production of MAPs; (ii) development of value-added apple products such as apple chips and apple juice processing with cooperatives and private entities; (iii) support for vegetable seed production and linkages with the private sector; and (iv) support for other local agricultural products such as vegetables for trade.

Table 4: **Criteria for selection of agri-products**

Criteria	Description
Market demand and growth potential	Evidence of strong effective demand for the products Buyers have a ready market for the products but are unable to meet demand
Potential increase in income and value addition	Projected increase in sales, profits, or returns to labour Potential for farmers' groups to add value to raw materials and gain higher earnings Gender appropriateness in terms of time, labour, and ensuring opportunities for women farmers to gain income and participate in decision making in the value chains
Potential for employment generation	Potential for enterprises to create new employment opportunities as the sub-sector develops or expands
Potential for increases in productivity and linkages	Potential for technologies or management systems to increase the productivity and earnings of enterprises in the sub-sector Potential for forward/backward linkages with the private sector
Government or donor interest/ existing support programmes	Government interest in a sub-sector (can translate into positive linkages with government services and favourable policies) Existing programmes that can provide synergy and complementary activities

Source: Revised from USAID 2004; NIRAS 2010

Using the ranking process, farmers in the Pangling Cooperative chose fresh apples, akarkara roots, and local beans for their first lines of production (Annex 6, Tables 1.1 and 1.2). The cooperative's technical activities included efforts to utilize both traditional and more advanced plant technologies to produce new cultivars of apple. At the time of the study, two apple varieties (red delicious and golden delicious) were planted by most farmers in the Pangling watershed. Beans have the advantage of utilizing both summer and winter cultivation seasons; akarkara can be grown in apple orchards throughout the year and, according to the farmers, requires less water than other crops. Intercropping with beans increases soil nitrogen content, while intercropping with akarkara increases the effective use of water, which is particularly important in water scarce areas like Mustang. Therefore the farmers' strategy was to apply a combination of technologies by intercropping beans and akarkara with apple, with bean crops in close to half of the apple orchards and akarkara in many or most of the remaining orchards. The risk of including akarkara is that it is prone to infestation with white grub, which damages the plant roots; the cooperative planned to control these pests with organic pesticides. The cooperative envisioned that akarkara could be a high revenue venture with market prices running in excess of NPR 300 per kg at the time of the study. If akarkara production proves successful, it could become the main endeavour in Pangling. Farmers also planned to introduce the processing of smaller apples to chips and juice.

In Lorpa, farmers selected beans, garlic, and chilli for direct sale, and carrot, broad-leaved mustard (rayo), coriander, and chilli for seed production (Annex 6, Tables 1.3 and 1.4). The cooperative envisioned organic vegetable seed production as becoming a high-revenue venture for Jumla in the near future. The cooperative's first lines of production will be carrot, broad-leaved mustard, and coriander seed, and garlic and chilli as vegetables. The technical activities will include efforts to utilize both traditional and more advanced plant technologies to produce new vegetable cultivars. Bean crops have the advantages of utilizing both summer and winter cultivation seasons, garlic is harvested in June and July, chilli is harvested in September, and the vegetable seeds can be collected between October and December. Therefore the farmers' strategy was to combine these products, thus spreading activities throughout the year.

Climate Change Adaptation Framework for Mountain Agribusiness

ADB (2005) stresses the need to identify risks faced by a development project, or any other specified natural or human asset, arising from climate variability and change and to reduce these risks to acceptable levels by implementing long-lasting, environmentally sound, economically viable, and socially acceptable changes in one or more of the following stages in the project cycle: planning, design, construction, operation, and decommissioning. In the case of the PAR pilots, therefore, it was important to synthesize the participatory learning in order to come up with a framework that can be used to determine which agribusiness initiatives can potentially adapt to short- or long-term climate change variabilities.

Technologies to be tested were determined on the basis of the problems and constraints identified by local communities during the participatory rural appraisal (PRA) (see Annex 7 for the synthesis of the PRA in Jumla). Accordingly, adaptive agribusiness knowledge and technologies aimed at improving the productivity and resilience of selected value

chains were tested and demonstrated in consultation with the local communities and local government during the two consecutive years. The practices were selected based on the initial PRA and vulnerability assessments, the communities' coping strategies, ongoing local programmes, and the potential for addressing climatic changes such as increasing temperatures and increased variability in precipitation and water availability. In both the pilot areas, the practices were implemented on a very small scale, which means that scaling up will have further implications including the need for increased inputs (such as a more consolidated participatory process, labour, water, fertilizers, plant material, and equipment), as well as the need for technical support and funding for the investments, improved infrastructure, capacity building, and rehabilitation of the ecosystems that are required. Given the limited availability of water, success will depend on climate-smart water use and water saving practices. For this, support will be required from institutions outside the communities such as line agencies, non-governmental organizations (NGOs), and donors. The selected practices were also discussed with the relevant line departments locally, and all suggestions were used to calibrate the field-testing of such practices with different types of farmers (based on wealth ranking). Arrangements for the follow-up of the progress in the field were made through local partners.

The practices tested and demonstrated in Mustang (Pangling) included a new apple germplasm imported from India, production of vegetable seedlings and medicinal plants, integrated pest management (IPM) in apple production, farmyard manure production using black plastic as a cover, vermicompost production, mulching around apple trees, drip irrigation in vegetable production, construction of contour trenches/pits and stone bunds for soil moisture conservation, production of fourwing saltbush (*Atriplex canescens*) seedlings developed from seed imported from Baluchistan Province, Pakistan, where it was successfully transplanted in highland rangeland areas, study of local grasses for fodder production, rangeland vegetation rehabilitation by fencing and planting atriplex, and the construction of a dipping tank for livestock treatment. The preparation and use of biobriquettes was introduced to reduce the use of already scarce fuelwood in the area. Practices that proved to be particularly successful and profitable were the use of small-scale drip irrigation in vegetable production and the application of IPM in apple orchards. Drip irrigation was only tested on a very small scale and will need to be scaled up and applied over a longer period and with other crops to ascertain its viability. IPM showed positive results for apple production with reduced losses from insects and disease, improved quality and quantity of apple production, and increased net earnings from the apple orchard.

The practices tested and demonstrated in Jumla (Tallo Lorpa) included new a apple germplasm imported from India, farmyard manure production using black plastic as a cover, comparative studies on the production of bean and potato varieties, summer vegetable production, off-season vegetable production using plastic tunnel and greenhouse technology, preparation and use of biobriquettes, garlic production, and river bank and gully protection by planting salix and walnut. Practices that proved to be particularly successful were improved bean varieties such as 'rojmeri', production of cocksfoot grass (*Dactylis glomerata*) to enhance livestock fodder supply in winter, and the production of vegetables during winter using plastic greenhouses. Farmers were particularly interested in the greenhouse technology as it allows them to grow crops during winter, which they were not able to do before.

Following the test and demonstration activities, both cooperatives developed agribusiness plans incorporating improved water and soil management – such as drip irrigation and the construction of water harvesting ponds – and planting of local species with the aim of ensuring the sustainability of agricultural production. The cooperatives bore all the costs of capacity building and management and 20% of the costs of the inputs for irrigation, nursery development, and construction of a business facility centre, with the remainder provided by the HIMALI project. The planned activities will help increase income opportunities for communities in these comparatively poor mountain areas by developing mountain niche products and improving the resource base through sustainable watershed management practices and orchard and rangeland improvement. The application of appropriate agricultural technologies, value addition, and promotion of market linkages through enhanced local institutional and management capacity is expected to significantly improve the income of these marginal mountain people (ICIMOD 2012).

3 Linking Watershed Management with Agribusiness

Climate and Non-climate Induced Watershed Vulnerabilities

Pangling watershed lies in the Kali Gandaki valley in Kagbeni VDC, Lower Mustang. It receives relatively little rainfall and is subject to strong winds. The area is dominated by rangeland, with only small areas of forest and arable land. Water, fuelwood, and other forest resources are scarce and their availability is further reduced by the increasing demand from the three local communities of Pangling, Phalyak, and Dhagarjun. Agricultural production relies entirely on irrigation, and the watershed is being increasingly used at unsustainable levels, with overgrazing and overharvesting of fuelwood and timber leading to ecosystem degradation (ICIMOD 2012).

The situation in the Lorpa watershed is somewhat different. The watershed lies in a remote part of Dillichour VDC in Jumla and is shared by two main communities, Upper Lorpa and Lower Lorpa. It has large areas of forest, less rangeland, and a small area of agricultural land in the flat part of the lower catchment. Ecosystem degradation is increasing rapidly; the forest area has decreased substantially over the past five years, with increased fragmentation and an overall reduction in cover equal to 11% of the total watershed area (Uddin et al. 2012). The unsustainable extraction of timber and fuelwood without appropriate reforestation is mainly a result of inadequate governance and insufficient capacity of the local community forest user groups to control deforestation effectively and enforce rules and regulations (Zaleski 2011). The rangeland also shows signs of small-scale localized degradation due to overgrazing, with bare areas that are prone to soil erosion (Fleiner and Kotru 2012b).

The pilot communities in both watersheds are aware of climate change impacts; they are experiencing reduced snowfall, more variable or reduced rainfall, and increasing temperatures. These changes have resulted in reduced availability of water, reduced soil moisture, drying up of water sources, prolonged dry periods, and an increase in pests and disease, which are affecting crops and livestock. Location and site-specific differences include increased duration of the northern wind in Mustang and an increased number of hailstorms in Jumla. The overall shortage or variability in water has had an impact on agricultural production and agribusiness as it necessitates frequent changes in planting time and irrigation, leads to increased moisture stress, which limits crop performance, and increases the need for drought-tolerant crop species. The changes in temperature are also affecting crop production.

Regional climate change scenarios were downscaled to the districts of Mustang and Jumla using a daily time series from 1961 or 1964 to 2000 as a base. The findings confirmed most of the communities' observations. They predict warmer days in all seasons for the twenty-first century, and altered or increasingly variable precipitation (Devkota 2010). Mustang is predicted to witness an overall increase in annual precipitation and high-intensity rainfall events, whereas Jumla will witness a decrease in the same. It is expected that the number of hot days will increase and the number of cold days will decrease, while the overall daily temperature range is predicted to increase in Mustang. In Jumla, the daily temperature is expected to increase in winter and spring and decrease in summer and autumn. These findings indicate an extension of the growing season, with frost ending earlier in spring and starting later in autumn. The moisture demand is expected to alter in relation to the projected changes in temperature. Hence, the import of an apple germplasm from Himachal Pradesh, India, and its local testing is being done keeping in view the above climate anomalies.

These high mountain watersheds, with their diverse microclimates and ecological processes, are highly vulnerable to climatic changes such as altered precipitation patterns and temperature, as well as non-climatic changes such as land use change and environmental degradation resulting from deforestation, overgrazing, and other factors. In both watersheds, there is limited local capacity and resources needed to effectively address these challenges, and networks with other institutions and linkages to markets are still underdeveloped. This has an impact on the communities' vulnerability, coping capacity, and physical and institutional access to markets. In Pangling, the communities face particular challenges resulting from the seasonal migration of men and youth to urban areas in neighbouring and foreign countries for trade, education, and employment. Outmigration exacerbates the workload of the women left behind (Khadka 2011b). In Lorpa, the communities face particular difficulties in accessing support and services provided by government or non-governmental institutions outside the area, while their local institutions seem to be poorly connected with other institutions at the village and district levels. Since the local communities largely depend on the watershed's natural resources for their livelihoods, they are vulnerable to the climatic and non-climatic changes that affect these resources.

The PAR and capacity building activities helped raise awareness about the critical situation in the watersheds, the available options for improving the status of key ecosystems and reversing degradation, particularly in relation to the increasing variability of water resources, and about how this can benefit the communities and enable them to adapt better to climate change and improve their livelihoods.

Integrating Climate Change Adaptation in Watershed Management

In vulnerable mountain areas that are prone to climate change impacts, watershed management will have to take into account existing local resources, capacity, and networks. Based on participatory learning with pilot communities, climate models, and a tested set of local technologies, a framework for climate change adaptation for watershed management was developed for the two pilot areas (Figure 3). A context-specific approach was used based on four critical building blocks: the farmers' coping capacity, the institutional adaptive capacity, the agribusiness environment, and ecosystem resilience. This approach recognizes the role of resilient ecosystems and their functions, the coping capacities and resources of farmers and local institutions, and the linkages to the agribusiness environment in developing sustainable agribusiness solutions in a changing climate and environment. It offers the advantage of being specifically developed in the context of the two pilot watersheds, and thus of addressing their unique characteristics.

The pilot watersheds were analysed so as to address the following questions:

- How vulnerable and resilient are their key ecosystems and how sustainably are they being managed?
- Is the adaptive capacity of local farmers and institutions sufficient to enable them to cope effectively with change?
- How well are the local communities linked with the agribusiness environment?

A specifically developed framework of climate change adaptation parameters was used for the analysis; the parameters are summarized in Table 5.

The information on the prevailing vulnerability, resilience, and adaptive capacities in the pilot watersheds – gathered from the pilot communities, field assessments, and analysis of remote sensing data – was used as a basis for recommending potential interventions to reduce vulnerabilities and leverage the potential to improve climate change adaptation.

A five-year watershed management plan was prepared for each of the pilot watersheds in close

Figure 3: **Climate Proofing Integrated Framework**

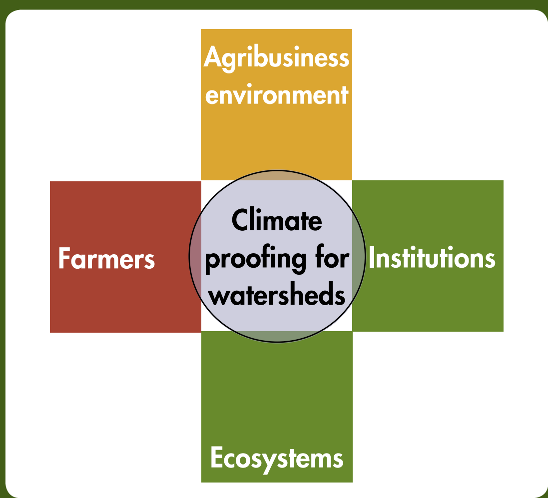


Table 5: **Parameters of the HIMALI PAR climate change adaptation framework**

Parameters	Ecosystem	Sub-criteria
1: Ecosystem vulnerability and resilience	Forest ecosystems	Well-stocked or intact (canopy cover >70%)
		Medium stocked or moderately degraded (canopy cover 40-70%)
		Understocked or degraded (canopy cover 10-40%)
		Non-forest area (canopy cover <10%)
		Forest regeneration
		Management type and pressures
	Rangeland ecosystems	Closed rangeland (vegetation cover >70%)
		Open rangeland (vegetation cover 40-70%)
		Sparse rangeland (vegetation cover 10-40%)
		Rangeland regeneration
		Management type and pressures
	Agro-ecosystems	Soil quality
		Water quality
		Water quantity/availability
		Productivity
		Management type and pressures
	Water resources	Water quality
		Water quantity
		Management type and pressures
2: Farmers coping capacity	Awareness/knowledge about climate change and its impacts	
	Existing capacities and resources/technologies	
	Networking aspects	
	Decision-making capacity of local farmers/farmer groups	
3: Institutional adaptive capacity	Decision-making capacity of local communities	
	Collective capacity for planning, implementation, and monitoring	
	Networking with local and external stakeholders/institutions	
	Availability and accessibility of funds	
4: Agribusiness environment	Government programme investments and policy support	
	Private mechanisms to give technical support	
	Market and investment potential	

Source: ICIMOD 2012

consultation with local stakeholders and pilot community members. A district-level validation of the plans was undertaken with all the key stakeholders. The plans explore climatic and non-climatic challenges and opportunities with the aim of developing climate change adaptation options and ways to enhance local resilience in the face of climate change. They build on the evaluation of the climate change adaptation parameters and the PAR carried out under the project, taking into account the tentative agribusiness plans developed by the pilot communities. Overall, the watershed management plans provide a guiding framework for addressing climatic and non-climatic drivers of change and sustainably managing natural resources in the pilot watersheds, in particular their key ecosystems, namely, rangelands, forests, and agroecosystems. The aim is to increase the productivity of the different land uses while supporting the local people in fulfilling their basic needs and leveraging agribusiness options and productivity. The implementation of plans will help reduce climate change vulnerability, increase the long-term sustainability of agribusiness options, and improve livelihoods. They can be used by the pilot communities, local institutions, and development partners in future planning and management of the local watershed resources.

In sum, watershed-based agribusiness plans should be about leveraging locally available coping knowledge and technologies rather than imposing adaptation interventions and investments designed and driven from outside. The above participatory planning process has revealed that in times of excessive climate variability, farmers need to spread their farming across the year rather than farming during one or two seasons, as is commonly practised. This, of course, will require a different type of water use and management. What is also noteworthy about the above plans is that their effectiveness has been determined on the basis of remote sensing analysis and technological trials, as well as on community wisdom. The above four parameters could hence provide a basis for screening and amending future investments and interventions in the agribusiness sector, keeping climate change adaptation in view. The conclusive logic behind improving the local institutional capacity as part and parcel of climate change adaptation is at least as important as technological innovations, whereas upscaling the latter will require the former aspects to be strengthened.

Sustaining Watershed Services to Support Sustainable Agribusiness

One of the key issues to be addressed in the Pangling watershed is the scarcity and variability of water resources. Water is not only needed to fulfil the demand from communities and ensure the viability of the planned agribusiness activities, it is also essential for sustaining the key ecosystems in the watershed that are forests and rangelands.

Access to agricultural land and rangeland differs substantially between Pangling and Lorpa. The Pangling watershed has large areas of flat uncultivated land which, provided it gets adequate nutrients and irrigation, could be used productively (ICIMOD 2012). As a consequence, land area is not a limiting factor for agriculture in this community. The fragility of the surrounding rangeland, however, makes overgrazing by livestock a concern (Sthapit and Dhakal 2010). Private land produces only 26% of domestic livestock fodder needs in Pangling; the rest is fulfilled by grazing on public land (Sthapit and Dhakal 2010). Steppe grazing area in the Pangling watershed is only 72.6% of what is required for sustained grazing by community livestock and as a result, rangelands are being degraded rapidly (Khanal et al. 2011; Sthapit and Dhakal 2010). Stakeholders in the village say that there is sufficient rangeland in the region but much of it may be unavailable due to degradation compounded by the challenging topography in a few places. Representatives from the District Livestock Sales Office stress the need for access paths to rangelands (Khanal et al. 2011).

Lorpa by contrast suffers from geographic limitations while rangeland degradation is less of an issue. All of the flat land in the Ghatte Khola watershed, along with large areas of moderately sloping or steep land, is cultivated. The potential for expanding agricultural space in the watershed is hence limited (Gawith 2013). The key issues in Lorpa are massive deforestation and the variability of water resources. Water availability varies over the year, but regular flows will be needed to support and expand agribusiness activities. The local communities commonly use flood or bucket irrigation for agriculture, but the irrigation infrastructure is poorly maintained, resulting in significant water loss.

Thus, in a changing climate, long-term sustainability can only be ensured through an integrated and adaptive approach to watershed management. Such an approach would recognize the value of the various services derived from the watershed. In the case of the pilot watersheds, particular attention must be given to watershed services linked to agribusiness, and especially the service of water availability. There is a need to ensure continuous flow of water by balancing climate and non-climate induced variability. Meanwhile, local stakeholders need to consider the fact that water flow is interdependent with the ecological conditions of the entire watershed.

The projected climate change scenarios suggest that the need to balance water variability and augment available water will increase. Local water harvesting and storage systems – whether natural (such as springs and groundwater) or constructed (such as ponds) – will become increasingly important. Water use will need to be managed more efficiently. Traditional bucket or flood irrigation is associated with high wastage of water. Drip irrigation has a marked potential to increase water use efficiency for certain crops. In Pangling, drip irrigation used for cauliflower and cabbage production reduced water use by around 30%, while vegetable production increased by 10% or more. Drip irrigation also enables farmers to cope better with fluctuating water availability.

Local stakeholders and communities in a watershed need to better understand the water requirements for different uses and balance them in a more sustainable way. This should include the water needed to sustain the ecosystems, which is still underestimated. The rehabilitation of rangeland vegetation in a small area of the Pangling watershed provided an excellent opportunity to demonstrate the usefulness of allocating water to the environment, in this specific case for the growth of rangeland vegetation as well as *Atriplex canescens*, which are expected to provide multiple benefits in the future, including income generation and reduced soil erosion (Fleiner and Kotru 2012a, Fleiner and Kotru 2012b, Shiferaw 2008).

The activities defined by the pilot communities as part of their watershed management plans are aimed at rehabilitating and sustaining the ecosystems and the services they provide in the watersheds. This will help sustain the resource base and ensure the sustainability of the planned agribusiness activities. In Pangling, the agribusiness activities focus on expanding the production of apples, local beans, and akarkara. This will have major implications for water use for irrigation, particularly as the current water use by community members is already high compared to water availability, and water scarcity is expected to increase further as a result of climate change. The watershed management activities identified for Pangling are summarized in Table 6.

In the Lorpa watershed, the planned agribusiness activities focus on expansion of beans, garlic, and chilli production and production of seeds from carrot, broad-leaved mustard, coriander, and chilli. This will require balancing the variability of water available for agricultural production through activities such as establishing infrastructure for drip irrigation and water harvesting. The watershed management activities identified for Lorpa are summarized in Table 7.

Risks posed by climate change can be reduced to acceptable levels by implementing long-lasting and environmentally sound, economically viable, and socially acceptable changes in one or more of the following stages in the project cycle: planning, design, construction, operation, and decommissioning. After addressing all three sustainability parameters and building institutional capacity, non-climatic issues (e.g., ensuring good natural resource governance) can be addressed through climate-proofing mechanisms.

Table 6: **Watershed management activities in Pangling watershed**

Activities envisaged in the Pangling watershed management plan	
Agriculture	Change of cropping patterns from high to low water demand crops, i.e., mixing naked barley (Hordeum vulgare) with apples and akarkara
	Establish poplar (P. tremula) and juniper (Juniperus communis) windbreaks along field edges mixed with dwarf willows and local leguminous shrubs
	Expand the use of drip irrigation in apple and vegetable production
	Construct additional water storage ponds
Forest	Moderately to severely degraded forest: plant trees and grass
	Intact forest: Control tree felling and grazing until the degraded forest is rehabilitated
Rangeland	Degraded rangeland: control uprooting of caragana (Caragana versicolor), construct contour trenches to increase soil moisture, plant local grasses and Atriplex canescens, partially fence degraded areas until rehabilitated, develop on-farm fodder/forage production using tried-and-tested plant species (e.g. alfalfa)
	Moderately degraded rangeland: reduce number of livestock
	Intact rangeland: protect areas using social fencing
Water	Construct an intake for irrigation canal improvement and strengthen existing canals using high-density polyethylene pipe (covered through earthwork) and concrete

Source: ICIMOD 2012

Table 7: **Watershed management activities in Lorpa watershed**

Activities envisaged in the Lorpa watershed management plan	
Agriculture	Plant grass along terrace risers and on seasonal fallow land
	Expand use of drip irrigation
	Construct plastic-lined water conservation ponds
	Establish live fences to protect agricultural land from grazing
Forest	Degraded forest: plant trees and grass and protect them; control grazing and encroachment
	Moderately degraded forest: stop tree felling for five years, cultivate MAPs, control fire, raise plantations, control encroachment
	Intact forest: thinning and pruning, organize timber harvest in different blocks, promote natural regeneration and raise enrichment plantations in bigger gaps, control fire, collect only dead and fallen branches, control encroachment
	Establish a local forest nursery with mixed species as well as medicinal plant species
Rangeland	Degraded rangeland: control encroachment, plant tested grass varieties, implement rotational grazing
	Moderately degraded rangeland: plant tested grass species, eradicate poisonous grasses, construct a water pond for animals
	Intact rangeland: construct a water pond for animals, construct a rainwater harvesting tank to provide drinking water for herders, construct three wooden bridges while treating the wood being used against water damage
Water	Establish a small drip irrigation network for vegetable production, construct water harvesting ponds (activities are included in the agribusiness plan)

Source: ICIMOD 2012

4 Cross-Cutting Themes

Gender Dimensions

Similarities between Mustang and Jumla

The two HIMALI PAR districts have many socioeconomic and demographic characteristics in common despite their geographic and climatic differences. In both areas, women constitute the main workforce for agricultural production and household activities, including the collection and use of natural resources; men tend to be dominant in public services, trading, agribusiness (e.g., the production of apples, potatoes, meat), and tourism. Women depend on forests and rangelands for fuelwood, fodder, forage, and medicinal herbs and overall household food security. There is an unequal division of labour in agricultural production and natural resource collection and use. For example, women work longer hours than men (16 hours for women and 13 hours for men in Mustang; 18 hours for women and 13 hours for men in Jumla) (Khadka 2011a, 2011b). Deep-rooted social perceptions and gender role norms (e.g., the home is women's domain and market and public spheres are men's domain) limit women's participation in economic activities. There is also a gender gap in education. Literacy rates for boys (aged 5 and above) in Mustang and Jumla are 72% and 62% respectively compared with 53% and 38% for girls (CBS 2011). Gender inequality is also marked in land ownership; only 3.6% of households in Mustang and 2.8% in Jumla have women's ownership of land, which is very low compared to the national average of 10% (CBS 2011).

Other authors have shown that women tend to be more affected than men by climate-related hazards such as floods, droughts, and erratic rainfall due to their limited access to productive resources including land, technology, credit, information, and income (Meinzen-Dick et al. 2011). At the same time, reduction in resources such as drying up of springs and loss of forest particularly affects women as they have to spend more time fetching water for domestic use and collecting fuelwood for cooking and heating (GWA 2006; Meinzen-Dick et al. 2011). Both these gender differences and the potential role of women in enhancing community resilience are often overlooked in local planning processes.

Differences between Mustang and Jumla

Mustang and Jumla differ in other social and environmental characteristics. The majority of the population in Mustang belongs to the Tibeto-Burman-speaking community, which provides women relatively more freedom to participate in decision making in the household. In contrast, the predominant culture in Jumla is Indo-Aryan, which is defined by strong patriarchal values and practices. Compared with other mountain districts, Jumla has higher rates of domestic violence against women, child marriage, and school dropout by girls; a more conventional perception of gender roles and women; and limited access for women to productive assets (land, animals, skills) and employment.

Climate change and the poor condition of natural resources have a more severe impact on women in Mustang than on those in Jumla. In Mustang, the impacts are localized due to microclimatic variability, which remains poorly understood. Mustang has limited rainfall (less than 200 mm annually) and low vegetation cover. Agricultural residues fulfil only 7% of the fuelwood need; the remainder is obtained from forests, pasture, and river driftwood (Sthapit and Dhakal 2011). The rangelands and small forest areas are in poor condition, and women spend two to three hours per day on average to collect fuelwood and cattle dung for cooking and heating. Women in Jumla have better access to resources from the community forests, although the forests are also affected by illegal felling, smuggling, and poor management (Khadka 2011a, 2011b).

Women in Mustang are in a better position than those in Jumla in terms of education, income opportunities (e.g., from fruit production and seasonal migration), access to productive resources (business, land, houses), and

household decision making. Interestingly, women in Mustang continue to be disadvantaged in terms of proactive participation in community decision making. Women's inclusion and participation in collective activities (e.g., farmer's cooperatives, forest user groups) is greater in Jumla. However, it must be added that it is common to find women running enterprises (e.g., hotels, cooperatives) near the pilot area in Mustang. The impression that women may be disadvantaged in Mustang emerges largely from the fact that the village-level customary institutions and governance system in much of Mustang is dominated by men. In most areas, only men can be elected as village leaders, or mukhiyas, and although the village governance body that the mukhiyas head has representatives from all households, these are also mainly or only men. The mukhiyas and village councils decide on natural resource use and management, resolve conflicts, and plan development activities.

Taking gender complexities into account in the PAR facilitation

The HIMALI PAR project sought to identify and test technologies that reduce women's workload and leave them more time to participate in income generating activities and the community sphere. The project carried out a detailed gender analysis of the communities involved in the PAR implementation and identified critical gender issues with regard to mountain-specific agribusiness and local adaptation to climatic and non-climatic change. The project integrated the gender issues into a capacity strengthening approach. For example, the project focused on including both women and men in trainings, workshops, and study tours within and outside the districts. As a result, 250 women and 331 men (from among the PAR communities and HIMALI PAR project stakeholders) attended 36 trainings, study tours, and workshop events carried out between 2011 and 2012. Both women and men took part in the piloting of technologies such as drip irrigation for vegetable production, leguminous forage, biobriquette making, improved beans and agricultural cash crops, and improved farmyard manure production.

Women's participation and capacity development for multiple benefits

The stakeholders' participation process and technology testing had some positive benefits for women. In Mustang, drip irrigation reduced the amount of water used in vegetable production and saved women's time in fetching water for vegetable irrigation. Before the project, growing vegetables was not common in Mustang, and especially in Pangling. The drip irrigation technique tested for vegetable production resulted in two advantages for both women and men farmers. First, they learned about vegetable production techniques that could be used in their home gardens. Women have easy access to and control over these, and the increased vegetable production is important for family nutrition and especially helps women, as they become vulnerable if family members fall sick due to undernourishment. Home gardens are also important in terms of land use, especially for conserving agrobiodiversity and generating small-scale cash crops (Khadka and Verma 2012). Second, some farmers were inspired to become entrepreneurs and found local markets for selling their produce. For example, one couple was able to generate USD 350 from selling vegetables and vegetable seedlings to neighbours and people in surrounding villages, and they used the money to buy goats for cash income and meat.

In Jumla, women farmers were able to generate more income and nutritious food when they experimented with producing improved bean and cash crops suited to the local climate. One woman in Lorpa produced 18 kg of improved beans from 1 kg of seed intercropped with maize; the production was twice as high as with the local bean variety. High-value crops such as garlic and chilli were identified as less labour-intensive. They were found to generate more economic benefits for farmers and to involve less strenuous labour for women as they can be produced in home gardens. In Jumla, cleaning cattle sheds and taking farmyard manure to the fields is primarily a women's responsibility, as social taboos restrict men's participation in these activities. Women found the farmyard manure improvement technique very useful; it saves labour because the improved manure is lighter and easier to carry to the fields. It also has a greater impact on soil improvement, and hence less is required. On average, women used 25 head-loads of improved manure on land that had previously required 50 head-loads of unimproved manure.

In both districts, the biobriquette making technique enabled women farmers to produce an alternative to fuelwood for cooking. In general, women have to travel long distances to collect animal dung and shrub roots from rangelands for fuel (in Mustang) or fuelwood from high-altitude forests (in Jumla). Making biobriquettes from locally available materials (twigs from apple trees, shrubs, weeds, sand) has saved women's time. Using biobriquettes was also found to be much less labour intensive than collecting fuelwood, as preparing briquettes is a relatively simple process and can be easily learned or replicated. This technology is especially useful for higher parts of Upper Mustang that face severe fuelwood shortages.

Governance Dimensions

The relevance of local institutions for adaptation to change

Nepal's Local Adaptation Plan for Action (LAPA) aims to integrate local development processes through local government and local institutions that are linked to national development programmes. To date, 16 districts in Nepal have prepared a LAPA; however, implementation is lagging behind as the government has yet to conduct the needed preparatory work. To strengthen local planning processes, it is important to understand the governance structures and functions of local institutions. More importantly, adaptation to climate change will have to take place at the local level, and therefore it is critical to understand the role of local institutions in shaping adaptation and improving the capacity of the most vulnerable social groups (Agrawal 2010).

Dynamics of local institutions

There are a number of local institutions in the two PAR districts. These institutions vary widely in terms of their role, accountability, governance structure, and of provisioning services and support. The study identified three types of institutions or organizational actors with direct and indirect linkages to the PAR communities: government line agencies, non-state actors, and community-based organizations (CBOs).

Government line agencies are responsible for providing technical and extension services to farmers. They include the Agricultural Development Office, Forest Office (in Jumla), Livestock Service Office, and Soil Conservation Office. However, their presence at the community level and support to communities is sporadic. Local government bodies such as the district development committee (DDC) and the village development committee (VDC) have a greater role in local development processes, but due to the lack of elected bodies in DDCs and VDCs over the last decade, and limited capacity to implement and monitor development programmes, these bodies fail to reach out to and empower smallholder farmers adequately.

Non-state actors such as NGOs, civil society organizations, and the private sector are working in Mustang and Jumla in various sectoral programmes in the areas of agriculture, forestry, health, water, and nature conservation. Mostly guided by external agencies, the roles of non-state actors tend to be limited to the implementation of projects. The capacity of NGOs and civil society organizations to facilitate participatory governance, pro-poor rural development, and social mobilization processes are weak (Subedi and Khadka 2012).

CBOs, both customary and formal, are the main actors at the local level as they have a greater scope and role in the sustainable management of natural resources, developing agribusiness, and building resilience in the face of climate change. These institutions include forest user groups, water user groups, cooperatives, mother groups, vegetable producers groups, herder groups, and health and sanitation groups, and, in Mustang, the mukhiya system. There are fewer CBOs in the PAR areas in Mustang than in Jumla. A total of 36 formal and informal institutions have been established and organized for local development in the PAR areas in Jumla, including community and leasehold forest management groups. However, the awareness and capacity of these groups for inclusive planning and implementation of climate adaptive business plans, establishing market linkages, and sustainable management of watershed resources for livelihood improvement tend to be very weak (Subedi and Khadka 2012). Government support, including in the form of development projects, is generally not sufficient to strengthen the governance of these local institutions for participatory planning and implementation of rural development programmes.

Governance dynamics of local institutions

The governance structure of local institutions is an important dimension in the local environmental planning process, especially in planning for adaption to climatic and non-climatic changes, which involves enhancing the adaptive capacity of smallholder farmers with limited access to assets. Community-based institutions, in particular, can enhance local adaptive capacity with the support of the state and NGOs (Shrestha-Pradhan et al. 2012).

The governance of the formal and informal institutions in the two PAR sites varied in terms of inclusiveness and participation due to their different sociocultural contexts and the different ways in which they emerged and operated historically. The main system in Mustang is the mukhiya system, which comprises a committee composed of local representatives and headed by a village headman, or mukhiya. The committee is elected and serves a term of up to two years; in general, most or all of the representatives are men. Four mukhyias are elected to serve on a rotational basis. In the PAR area only men can become mukhyias. However, the mukhiya institution is aware that women are gaining in importance for local development and conservation and should participate in local planning and decision making. The institution in Pangling village has initiated a conversation among community members aimed at transforming their governance practice to include women in the system. Each village or community has its own nomination and selection rules (Kotru et al. 2012), and a few villages in Mustang have already elected women mukhyias, indicating a willingness of these customary institutions to adapt their governance structure to the changing context. The committee is the sole decision-making body. Mukhiya governance responsibilities range from natural resource management to solving family issues (land separation, divorce, marriage). The committee also acts as the interface between locals and local state or civil organizations. Outside agencies (state or civil organizations) discuss the implementation of development projects and programmes with the local mukhiya committee. Decisions on implementation are made through general consensus among the committee members and community, and are then communicated to the agencies. The ten-year Maoist insurgency is considered locally to have had little impact on the mukhiya system, mainly because of its role in managing local governance with social unity. Outsiders who migrate here for wage labour or share cropping with local landlords are not usually entitled to become a mukhiya (Khadka 2011b). Where there are women-only groups like mother groups, their activities are not oriented towards addressing structural gender issues.

In Jumla, women are often included in local institutions such as cooperatives, community forest user groups, and leasehold forestry user groups, but they commonly play only a token role; meaningful participation in decision making, local planning, and obtaining information related to climate change and markets has yet to develop (Khadka 2011a). Dalits, the most disadvantaged caste group, are also poorly represented and have little or no influence in the formal local institutions.

Despite the large numbers of local institutions in the PAR districts, there is visible environmental degradation and deforestation. Farmers and herders note that they have to travel farther to collect fuelwood, forage, and medicinal herbs compared to 20 years ago. Local state and non-state institutions in this region tend to be less proactive but also often lack the capacity and resources needed to adequately address the prevailing environmental issues.

Sensitizing and capacity strengthening of local institutions through the PAR process

The HIMALI PAR programme adopted a multi-stakeholder, or 'institutional pluralism', approach in order to ensure the recognition of local institutions' role in local development processes in these remote areas, where there is limited presence and capacity of the state and NGOs. The approach emphasized the importance of farmers' collective actions and statutory and customary institutions with regard to climate adaptive watershed management and promotion of high-value products. Farmers have a large amount of indigenous knowledge related to cropping and adaptation to climate change, which can be used in agribusiness development, whereas state and non-state institutions have a limited presence, capacity, or accountability for tackling the complex issues of agribusiness and climate change. As a result, the PAR process placed greater emphasis on raising awareness about agribusiness and climate change in local institutions, and strengthening the capacity of CBOs in business development planning, networking, governance, gender, and climate change issues. The awareness raising and capacity strengthening activities included training events, exchange visits, face-to face dialogue between CBOs and district-level line agencies and the private sector, and adaptive capacity analysis of the institutions.

Assessing institutional adaptive capacity

The PAR process included an institutional diagnosis of 11 different stakeholders in Mustang and 16 in Jumla (Table 8). The main aim was to assess the adaptive capacity and governance structure of local institutions as a basis for designing and implementing climate adaptive agribusiness and watershed management plans. The Adaptation Institutions Livelihoods Framework (Agrawal 2010) was used to analyse existing adaptive practices using criteria such as mobility, storage, diversification, communal pooling, and market exchange. The Institutional Analysis Framework (Ostrom 1998) was used to evaluate the institutions using criteria based on efficiency, equity, accountability, adaptability, and policy outcomes. The key dimensions and results of the analysis for the two districts are presented in Figure 4.

The CBOs in both districts have rules and regulations for managing financial and natural resources, but their capacity seems to be very weak in terms of development planning, tapping external resources (e.g., linking with the private sector for marketing of produce and with local governance bodies to obtain resources), and social inclusiveness. Their planning processes and activities are not oriented towards adapting to socioeconomic and environmental change, and the issue of climate change adaptation is still very new at the district level.

Nepal has not had elections for local government bodies such as VDCs for more than a decade, thus the effectiveness and accountability of the existing local bodies to implement and monitor development projects and programmes is variable. The adaptive capacity of local institutions appeared to be stronger in Mustang than in Jumla in the sense that customary institutions such as the mukhiya system operate with full autonomy and decision-making power with regards to local development planning and natural resource use and management and have relatively strong linkages with government line agencies and conservation programmes. In Mustang, the mukhyia system can be very effective in planning and implementing local development programmes, and government

Table 8: **Organizations assessed in the pilot areas**

PAR Site	Type of organization			
	CBOs and cooperatives	Private sector	Public sector	Total number of participants
Mustang	6	2	3	Men: 15 Women: 10
Jumla	9	4	3	Men: 16 Women: 29

Figure 4: **Adaptive capacity of institutions in Jumla and Mustang, 2011**

Jumla

	Level 1	Level 2	Level 3	Level 4
Category	No capacity/ recognition	Recognizes, has resources	Plans and tools available	Tools used, CB programmes, inst. links
Coping Strategies	√			
Natural Resource Planning		√		
Natural Resource Management		√		
Market Interface		√		
Institutional Capacity		√		

Weak ← → Strong

Mustang

	Level 1	Level 2	Level 3	Level 4
Category	No capacity/ recognition	Recognizes, has resources	Plans and tools available	Tools used, CB programmes, inst. links
Coping strategies		√		
Natural resource planning			√	
Natural resource management			√	
Market interface		√		
Institutional capacity				√

Weak ← → Strong

agencies have to coordinate and consult with the mukhiyas in order to implement programmes or projects. In Jumla, the state is in control of the local development process, but communication between farmers and line departments is weak and there is a lack of coordination among government line agencies to address local issues. This has implications for the ability to smoothly implement development programmes locally.

Stakeholders ranging from the government to NGOs, the private sector, and CBOs function in different roles and with varying degrees of institutional governance, power, willingness, and resources (human skills, finance, networking, and information). In both districts, CBOs were very interested in participating in and benefiting from climate adaptive agribusiness and natural resource management. But they are constrained by having limited information on issues of climate change, inclusive governance, and locally controlled enterprise development and by inadequate access to public services and deliberations by line agencies and non-state actors, as well as the fact that these are not adequately gender-friendly when they are accessible. In addition, the CBOs have so far been unable to establish a strong network among themselves to increase their bargaining power to access timely and quality services from the government and other stakeholders, and to secure markets for farmers.

In Mustang, remoteness, harsh weather conditions, and sparse settlements mean that service providers have only sporadic presence at the village level. The role of CBOs is crucial in tackling climate and other development issues, including community-based enterprise, but their governance and technical capacity need to be strengthened so that both women and men of different classes and castes/ethnicities can be engaged in local development planning and implementation. In Jumla, deforestation and forest degradation problems are inadequately addressed, but CBOs such as community forest user groups are constrained by weak institutional capacity (e.g., lack of transparency on financial resources, exclusion of women from decision making) in addressing the problems in an integrated way. These institutions need support in capacity strengthening so that they can function more effectively.

There are some indications that the newly formed local cooperatives – Pangling Cooperative in Mustang and Chaudha Bisa Cooperative in Jumla – will be able to overcome some of these constraints. These local cooperatives are able to find and contract buyers directly in order to sell local agricultural and forest produce. The Pangling Cooperative has already begun to network with Dabur Nepal – a private sector company with expertise in processing and marketing of MAPs – and they are in the process of developing a formal contract to secure a market for selected high-value medicinal plants.

Engaging the Private Sector and Facilitating Pro-poor and Inclusive Value Chains

In mountain regions, value chain development incurs costs and there are several people and organizations that can take on a role of coordination along the chain. However, at present, coordination is limited. For example, there is little coordination between the private sector and farmers in the PAR areas. The private sector essentially comprises traders based at the district headquarters; they are not engaged in service provision but act simply as agents who aggregate and sell produce to downstream markets. The government extension service is limited and some sellers of inputs such as pesticides and fertilizers provide technical guidance to farmers. The information flow from downstream to upstream areas is poor and controlled by a few downstream actors. Prices fluctuate based on demand and supply and risks are high. Hence, farmers are highly dependent on the local traders as they do not have the financial capability or the networks, infrastructure, and negotiating powers to deal adequately with downstream traders. Furthermore, farmers need cash income from selling their produce in order to meet their immediate household needs. Due to the limited options to sell their produce, farmers are often exploited and do not receive a fair share of the value of their products.

While developing the business plans for the cooperatives at the PAR sites, it became evident that the private sector was not available for, or interested in, engaging in direct business partnerships with the communities. Efforts were made to engage private sector partners from Kathmandu, but none of the companies contacted were interested in buying and selling the products. The agent for Dabur Nepal in Marpha expressed interest as a potential buyer for akarkara, but even in this case there is as yet no contractual agreement. In such a situation, farmers can attempt to increase their benefits by improving their production practices, the quality of their products, and their power to negotiate with the private sector. There are also several coordination mechanisms such as collective production, input sourcing, and marketing through farmers' institutions that can improve the farmers' gains and reduce risks. In the absence of private sector willingness to engage with farmers in a fair and equitable fashion, farmers' institutions need to be strengthened by directing technical and financial assistance to support cluster-based and demand-driven value chain development. Policies can also hinder activities (e.g., the production of NTFPs on farmland) and this needs to be resolved to broaden the scope of agribusiness options in mountain regions. As road access improves, support should be provided for the development of market centres in mountain areas so that the farmers can sell their produce at competitive prices.

In view of this situation, the farmers' cooperatives in Mustang and Jumla have developed specific strategies to produce and market their produce. The sales plan for the Pangling Cooperative is based on the existing market demand for the selected products. The market demand for apples in 2011 was 3,850 tonnes. Local beans are in high demand and farmers sold their entire production in 2011. The market demand for akarkara was 40 tonnes in 2011, as per the information provided by Dabur Nepal's local agent. In the past, apples were sold through middlemen who retained a major share of the profits; the business plan envisages that in future the cooperative will directly contact buyers and traders in regional markets such as Pokhara. Beans will continue to be sold locally to consumers. For akarkara, the intention is to sell the produce directly to Dabur Nepal; contact has been established with the local Dabur Nepal agent, but the cooperative plans to invite Dabur Nepal officials from Kathmandu when developing the final contract.

In Lorpa, garlic, beans, and chilli will mostly be sold locally for fresh consumption, as in the past. The cooperative plans to develop contractual arrangements with the private sector for selling coriander, carrot, and broad-leaved mustard seeds. The demand for seeds is very high; focus group discussions held in 2012 estimated an annual demand of 2,000 kg for carrot, 1,500 kg for coriander; and 1,000 kg for broad-leaved mustard.

5 Conclusions and Recommendations

Despite the limited period available for the PAR, the activities resulted in substantial learning, which could be validated with the local communities, their institutions, and the long-term service delivery agencies of the state. The learning is encapsulated in a number of conclusions, which in turn provided the basis for making recommendations. These can be followed as a framework for improving agribusiness while adjusting to climate change. The conclusions and recommendations are as follows:

A process-oriented participatory action research is a good methodology to assess options for adaptation to change

The HIMALI PAR project showed that action research related to experimentation with technologies for enhancing people's capacity to adapt to climatic and non-climatic changes in remote mountain areas requires an intensive and inclusive facilitation process for both social and biophysical aspects. For this, it is essential to understand the local climatic, environmental, institutional, and socioeconomic contexts, including gender issues, and to involve both women and men farmers from the early stages of experimentation. Many methodologies were tested that can help farmers and related institutions adapt to changing climatic conditions. The bottom-up consultation and action research involving local farmers, service delivery line agencies, local NGOs, and researchers over an extended period of time provided a good starting point for testing adaptation interventions. Although the HIMALI PAR was only implemented over two to three growing seasons, which is a rather short period for testing climate adaptive practices, sufficient information was obtained to use as a basis for developing plans, which can be adapted as more results become available. The analysis of different landscapes with differences in people, cultures, and governance can be useful in integrating locally specific adaptation strategies into agribusiness development. However, such a process also needs integrated working teams that can carry out collective fieldwork rather than working in isolation. Often such a process is faster if relevant local expertise/champions are identified, prepared and integrated in the fieldwork.

Recommendation

Larger scale and longer-term action research with different farmers should be implemented to obtain more representative results on an ongoing basis. This will help in further identification, assessment, and refining of effective and viable climate-smart agricultural and watershed practices. Both participatory approaches and the institutional capacity to practise these in the implementation of community-based projects need to be redefined to ensure broad-based and active participation of local communities and institutions and to address equity and gender aspects.

Leveraging the potential of agribusiness and value chains by enhancing local capacity

The two pilot areas in the HIMALI PAR were shown to have a high potential for agribusiness development, but they also face enormous constraints, many related to their location in remote high mountain areas. Farmers in high mountain areas face many challenges to improving and expanding agricultural production and turning it into a stable business. These include a lack of support and services by government institutions; the low interest of the private sector to engage in long-term contracts with farmers; the lack of networks and linkages to markets and other key actors; inadequate access to resources, capacity strengthening, knowledge, and technologies; and lack of access to market information, all of which hamper farmers' potential to engage successfully in agribusiness development. In other words, a wide range of actors will need to synchronise their work by being more communicative and cooperative in future.

Recommendation

A convergent approach is required to build local capacity and knowledge – including the capacity to cope with multiple challenges, which range from institutional barriers to climatic changes and degradation of the resource-base; to enable farmers' access to and share technologies and infrastructure; and to link farmers with existing best practices/learning networks, support systems, and markets. Local communities and institutions that find it challenging to initiate a sustainable agribusiness venture are likely to require technical support and a motivating intermediary. Detailed recommendations for the project on this topic are listed in Annex 8.

Using the watershed context to ensure sustainable agribusiness development

Overuse of the watershed resources in the pilot areas by local communities is increasing. Natural resources are being exploited at an unsustainable level resulting in progressive/retrogressive ecosystem degradation, which constitutes a risk to the resource-base required for agribusiness development. The adverse impacts on the ecosystems may be exacerbated by future changes in climatic conditions. In particular, farmers are already facing the problem of increasing variability in water availability and are forced to develop coping strategies as they rely on a sustained flow of water for agricultural production.

Recommendation

The resilience of the pilot communities and their watersheds in the face of climatic and non-climatic changes needs to be increased in the long term with the aim of sustaining the resource-base for agricultural production. Developing and implementing context-specific watershed management plans can help to address the issues at hand and ensure the sustainability of any future development activity in these areas such as agribusiness development. Joint implementation of well-coordinated agribusiness and watershed management activities can result in substantial co-benefits, not only by sustaining ecosystems and the services they provide, but also by supporting local communities in the diversification of their livelihoods with improved incomes and thus making them more resilient in the face of climatic and non-climatic changes.

The important role of women farmers in local climate-adaptive development needs to be acknowledged and utilized

Women have a pool of knowledge and experience about the use and management of land, forests, water, and biodiversity resources. Climate adaptive agribusiness would create benefits by including women in the entire value chain process, including local decision making, and addressing the gender differentiated needs of men and women farmers. Compared to women in lowland areas, women in Mustang and Jumla experience a higher degree of marginalization resulting from gender norms, conventional social perceptions of gender roles, gender blind extension services, limited awareness of and access to resources and support systems, and lack of opportunities to participate in markets, training, community leadership, and decision making.

Recommendation

Technology intervention processes in the initial stages should take into account institutional and gender issues and ensure that women participate in, own, and benefit from the interventions and get the opportunity to participate in training events, decision making, and agribusiness activities.

Local institutions are key stakeholders and need strengthening to become long-term support systems for farmers

Local institutions (e.g., CFUG's, apple cooperatives), both formal and informal, are the key actors for identifying and promoting climate adaptive watershed resources management technologies and micro-enterprise activities in remote high mountain areas. Understanding agribusiness and climate change adaptation from the institutional and governance lens is essential for addressing high mountain specific livelihoods, climate, and other development issues in a socially sensitive way. However, this requires greater effort in terms of capacity strengthening of community institutions, and ensuring the linkage to and accountability of government institutions towards providing more effective services that address the needs of both women and men farmers. Capacity strengthening must holistically address the multiple needs of such institutions, from collective decision making to finance management and market negotiation.

Recommendation

The technical and institutional capacity of local institutions, including networking with the private and public sectors, must be enhanced by improving the linkages and collaboration of these institutions with the district-level, preferably indigenous, capacity building service providers. This will help ensure that investments in agribusiness are sustainable, inclusive, and impact-oriented.

Private sector engagement depends on local infrastructure and niche products

Private sector engagement in agricultural production systems in remote high mountain areas is limited due to the lack of road networks, storage centres, finance, market linkages for value-added products, and competition from imported products, as well as the traditionally small-scale production. Although the private sector has a potential role to play in climate change adaptation and mitigation in the area of agribusiness development, its engagement is still not mainstreamed. Unless the private sector sees concrete long-term and viable business opportunities, it is unlikely to invest.

It would be pertinent to engage with large established private sector actors in specialised agribusiness sectors such as dairy products, processed foods, and organic products. There is a need to develop contractual mechanisms that ensure market access for farmers. Contracts with buyers can provide farmers with market information and reduce their risks from market failure, while ensuring fair prices for their produce. There is a need for value chain coordination and facilitation by specialised agencies such as the chambers of commerce, supported by the line agencies, to promote processing and marketing of niche products from mountain regions with a comparative and competitive advantage.

Recommendation

Business opportunities to attract the engagement of the private sector will need to be further explored; for example, by identifying and promoting high-value mountain-specific niche products, improving local capacity, and developing a producer-friendly environment through infrastructure development and other investments.

Climate change adaptation methodology to be applied in different contexts

The climate change adaptation methodology used in the HIMALI PAR proved to be a suitable framework for exploring and developing comprehensive and integrated options towards climate adaptive watershed management, and strengthening the potential of the pilot areas and their communities for climate adaptive agribusiness development based on sustainable management of the watershed resources.

Recommendation

The climate change adaptation methodology used in the HIMALI PAR project should be scaled up in terms of testing and application in different contexts so that it can be further improved and refined. For successful application, it will be critical to ensure that the methodology is adjusted to the specific situation and thus takes into account the context-specific characteristics. As a major step for continued learning, long-term permanent sample sites or plots should be established and used together with the existing HIMALI PAR sites to study the complex dynamics of climate variability, agribusiness, and emerging socio-demographic change.

Research findings to inform policy

The findings of the research are relevant for achieving the vision of Nepal's Agriculture Development Strategy (ADS). The findings highlight the importance of watershed management in increasing the resilience of farming systems in the face of emerging risks, especially those arising from climatic factors.

Recommendation

Watershed management should be prioritized as a strategy in order to increase and sustain the growth from agriculture envisioned in the ADS. The research findings can be used for agribusiness planning, especially for the upstream level activities of production, and institutional and inclusive development. There is a need to create a conducive environment for private sector's engagement and investment in agribusiness, and to promote a cluster-based specialisation in the country, such as the 'one district one product' strategy of the Government of Nepal.

Summary

The local environment for high-mountain agribusiness is changing fast as access to a broad spectrum of services opens new economic avenues. In the action research districts, it was clear that in addition to climate, a host of non-climatic factors will need to be considered to ensure sustainability and quality of yields for upcoming markets. It is evident that different farmers will respond differently to climate variability. In all cases, viable local institutions will play a key role in bringing positive change. These act as a link between the equitable and inclusive practices at the local level and the external services that can leverage local knowledge and skills. The private sector has a key role to play in promoting and sustaining agribusiness in terms of providing technical backstopping, market linkages, and paradigmatic innovations in an increasingly dynamic and demanding market world. Notwithstanding this potential role, the PAR found no evidence at present of any long-term commitment, or willingness to invest, on the part of the private sector. Local institutions, such as the apple cooperative, supported by local intermediaries (NGOs, line agencies) will need to seek private investment on an equitable basis. Further PAR will need to be carried out, preferably at long-term sites, to understand the long-term dynamics between climate variability, agribusiness, local institutional responses, and socio-demographic changes. The parameters identified for promoting climate change adaptation and sustaining local agribusiness have been validated by local communities as well as public and private service providers; they can hence inform decisions on future interventions and investments. Knowledge generated by climate research (e.g., remote-sensing and meteorological data and climate change projections) complements community wisdom and can definitely help people address climate change at the local level. There is great potential for building on local coping strategies and combining community science with modelling and remote sensing approaches to arrive at optimised actions for climate change adaptation and thus support and enhance mountain agribusiness. In areas where changes are likely to continue to occur, the climate change adaptation framework can be used for monitoring and management purposes in support of agribusiness.

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Annexes

Annex 1: **Selection Criteria for Pilots in the Two Districts**

Primary criteria	Agribusiness potential (5 VCs) Degradation gradient Poverty and social inclusiveness scenario Accessibility/Markets
Secondary Criteria	Institutional capacity Watershed unit Willingness of community Conflict free

Annex 2: **Highlights from HIMALI PAR**

Lessons learned

- **Local coping strategies:** Different strategies to counter climate change effects and improve food security are already being adopted. For instance, agriculture-based cash crop production (e.g., potatoes, beans, apples, off-season vegetables), animal husbandry (e.g., sheep/goats, mules/horses), natural resources management based incomes (e.g., collection and sale of Non-Timber Forest Products (NTFPs)), wage labour (e.g., house construction, carpentry, road construction), formal employment (mainly men), and juice and alcohol making and selling (mainly by women) are key livelihood strategies the farmers are adopting to cope with food insecure situations caused by unfavourable climatic conditions and socioeconomic challenges.
- **Local capacities:** It was found that strong local institutions (e.g., Mukhiyas in Marpha and Pangling) that are aware of climatic and non-climatic changes, govern local resources in an inclusive manner, have the capacity to plan, implement and monitor activities, and can articulate their demands to service providers and planned public investments, are in a better position to engage in agribusiness development and comply with the requirements of public programmes such as the HIMALI investment project.
- **Gender aspects:** Women farmers seem to be the most vulnerable group but at the same time, they are the ones to manage local natural resources on a daily basis. Women can hence be considered key actors who need to be engaged in local climate change adaptation measures related to agribusiness promotion.
- **Processes and approaches:** Unless applied by experienced facilitators, a participatory approach alone does not guarantee social and gender inclusion. It is also important to ensure continued flow of information to farmers, community-based organizations and non-government organizations working in the area. Most farmers have understood PAR as a normal development project and therefore had high expectations from the project. Although the PAR programme was oriented towards building the communities' adaptive capacity to implement climate smart agribusiness, the participatory approach is still in its infancy, and the perspectives of gender and social inclusion need to be incorporated more effectively. Externally guided processes, investments, and interventions can hinder the implementation of PAR at the local level.
- **Climate adaptive practices:** For implementing agricultural and watershed practices that enhance ecosystem and community resilience in the face of climate change, the local communities and institutions have initiated small-scale activities that they are committed to implement and support in the coming months, after the project completion. They will still require support in the form of technical guidance as well as equipment, materials, and financial resources. To scale up these activities, it will be important to share and disseminate knowledge and experiences of good practices and approaches with different communities, institutions, and other stakeholders.
- **Feasibility of agribusiness plans:** Local communities and institutions were supported by the project in developing their agribusiness plans. However, they have yet to work out precisely how the plans will be made socially, economically and environmentally sustainable in the long run. In this regard, technical guidance during the process of developing the plan is as important as assessment of the plan's feasibility and sustainability after it has been finalized.

Conclusions and recommendations

- With its limited timeframe (two years) and a relatively low budget, the HIMALI PAR project could only make modest achievements in terms of understanding the impact of climate change on the environment and communities in the pilot areas, identifying and testing climate adaptive agricultural and watershed practices, and enhancing the communities' capacity to cope with climate change impacts with a view towards developing their agribusiness potential. However, since the project was well managed and focused on key aspects, it was able to generate knowledge and learning that can be scaled up and utilised by local stakeholders at various levels and by similar projects and programmes.
- The project has shown that livelihood diversification and improved incomes constitute a pivotal adaptation strategy. Social networks and local institutions will play a vital role in enhancing the adaptive capacity of local communities. Enabling policy is also necessary for the state, scientific community, private sector, and local

community to take appropriate action. Awareness about climate change still needs to be increased, as do cooperation between sectors, communities and other intermediaries.

- For successful agribusiness development, climate change adaptation is a necessity, but it will entail striking a balance between short-term community and market priorities and long-term state strategies as well as long-term environmental and climatic processes. Although the private sector has an emerging role to play in climate change adaptation and mitigation agribusiness development, its engagement is still not fully relevant or prepared yet and will need further exploration. In other words, the business sector is still following its own priorities rather than that of climate or communities. Finally, larger scale and long-term action research and monitoring and evaluation will be needed to continue identifying, assessing, and refining effective and viable climate smart agricultural and watershed practices.
- The outputs, outcomes, and learning from the HIMALI PAR project provide important inputs to the operationalization of the existing HIMALI investment project and other ongoing or future climate and resilience adaptation related projects in Nepal.
- Any project related to climate change adaptation needs to identify local institutional structures, capacities and coping strategies and build on these elements.
- Participatory approaches in the implementation of community-based projects need to be redefined to ensure a broad-based and active participation of local communities and institutions and integrate equity and gender aspects.
- The HIMALI investment project should build on watershed and agribusiness plans developed under the HIMALI PAR project, which can serve as model plans for replication in other districts of Nepal.
- The HIMALI investment project needs to technically support local communities and institutions that may find it difficult to develop, expand and implement an agribusiness plan that is socially, economically and environmentally sustainable in the long term.
- The HIMALI PAR pilot sites should be promoted as examples of good climate adaptive practices and utilized for dissemination and sharing of knowledge and experiences with other communities and institutions (for example, through exposure trips) as well as for informing and guiding local service providers and agribusiness plan developers and applicants.
- ADB and MOAD should consider such pilot sites as permanent observation and monitoring sites in which outcomes could be measured and evaluated and long-term knowledge and learning about the implementation of such plans could be analysed and applied on a continuing basis.

Annex 3: **Wellbeing Category Assessed through PRA in Tallo Lorpa**

Wellbeing Category		
Better Off	Medium Better Off	Less Better Off
Criteria of Well Being Category		
Food sufficiency for 12 months or more	Food sufficiency for 6–9 months	Food sufficiency for less than 6 months
Household Name and Number		
1. Bhakta Budha	15. Min B. Budha	36. Moon B. Budha
2. Das Budha	16. Prem Budha	37. Siddhi Lal Budha
3. Dhan Sur Budha	17. Bhakta Budha	38. Bishnu Budha
4. Ran B. Budha	18. Nanda Budha	39. Tul B. Budha
5. Krishna Budha	19. Surya Mani Budha	40. Moon B. Budha
6. Kailo Nepali	20. Bhawani Budha	41. Bishnu Budha
7. Devi Lal Budha	21. Panna Budha	42. Nanda Lal Budha
8. Dharma Bistha	22. Rati Man Budha	43. Nanda Budha
9. Mahabir Budha	23. Dip Raj budha	44. Uday ram budha
10. Tul Raj Budha	24. Dane Budha	45. Dal Budha
11. Bishnu Budha	25. Purna Budha	46. Gam Budha
12. Nar B. Budha	26. Jay B. Budha	47. Dume Budha
13. Laxmi Budha	27. Tanga Raj Budha	48. Birkha Budha
14. Bal Budha	28. Saha Dev Budha	49. Shiva Kali Budha
	29. Panna Budha	50. Birka budha
	30. Singh Budha	51. Govinda budha
	31. Birka Budha	52. Harka Budha
	32. Hari Budha	53. Man B. Budha
	33. Bal Budha	54. Raj B. Budha
	34. Moon B. Budha	55. Devi Chandra Budha
	35. Jay Budha	56. Krishna Budha
		57. Ratna Budha
		58. Gobi Budha
		59. Ratna budha
		60. Gobi Budha
		61. Kali B. Budha
		62. Bhim Singh budha
		63. Dal Budha
		64. Chanda Singh Budha
		65. Tul Budha
		66. Nar B. Budha
		67. Mansur Budha
		68. Daan Budha
		69. Lal B. Budha
		70. Bhane Budha
		71. Dal Budha
		72. Rame budha
		73. Suk Budha

Annex 4: **Stakeholder Consultation Process**

Key Events conducted for pilot communities	Participants	Content	When
Training of Trainers (ToT) Workshop	DDC-LDF Jumla, Local project facilitator Jumla, LI-BIRD in Mustang, DADO, DLSO, ACAP, NARC, THDC	Strengthen capacity of local partners on participatory action methodologies and research processes	June 2010
Socio-Technical Exposure Trip	Local project facilitator Jumla; social mobilizers from DDC-LDF Jumla and LI-BIRD; lead farmers from Upper and Lower Lorpa, Patmara, Pangling, and Marpha	Strengthen capacity of local partners and lead farmers for conceiving innovative ideas from successful integrated watershed management and market-oriented agribusiness value chains	February 2011
Orchard management training	Farmers from Upper Lorpa	Promote apple	March 2011
Biobriquette training by ICIMOD	DFO, DLSO, DADO, DSCO, Women District Development Office Pilot representatives; farmers and community members from Pilot villages	Raise awareness about benefits of using biobriquettes, and train participants how to make biobriquettes using different techniques	March 2012
Consultative Workshop/ Training on 'Analysing Community Forests Operational Plan for Sustainable Forest Management'	CFUGs, DFO, local NGOs, and VDC of Jumla	Address existing gaps in operationalisation of CF operational plan, suggest further revision to address climate change and ecosystem services issues	June 2012
Gender integration and institutional strengthening training	DADO, DLSO, WDO, DSCO, NARC, THDC, women, farmers from pilots; in Mustang pilot Mukhiyas were included.	Raise awareness about women as key target group and need to strengthen institutions, and introduce concepts, tools and techniques	February 2012
Rangeland management by ICIMOD	ACAP, DLSO, THDC; members of Marpha Cooperative Group; herders and community members from Pangling, Marpha, Kagbeni, Phalyak, Surkhang VDC	Assess local rangelands and their management, develop measures to improve rangelands Train herders in resources mapping and sustaining rangeland resources	August 2012
Participatory Integrated Watershed Management	Mr Raghu Bir Shrestha (DADO-Mustang); Dr Guru Khakural (DLSO-Mustang); Mr Tilak Raj Chaulagai (DOA-Kathmandu) Mr Devendra Bhagat (DLSO-Jumla)	Enhance conceptual and practical knowledge of participants in participatory integrated watershed management	April 2011
Value Chain Development for Inclusive Growth – training (organized by AEC/ FNCCI, Karuna Institute for Sustainable Enterprise, SNV)	Local project facilitator Jumla, representatives from 2 line agencies of each district	Enhance knowledge and skills of participants in understanding and applying the Value Chain Development approach in the context of economic development/ income generation projects	December 2010

Annex 5: **Temperature and Precipitation**

Jumla

In Jumla observed daily temperature data are available from 1964 onwards. Consequently, observed temperature and NCEP data (as observed predictor variables) from 1964 to 1985 are utilized for SDSM calibration and data from 1986 to 2000 are used for its validation. Observed daily precipitation data are available from 1961 onwards. Consequently, observed temperature and NCEP data from 1961 to 1985 are utilized for SDSM calibration and data from 1986 to 2000 are used for its validation.

Annual cycles of the temperature range between current (1961–1990) and future (2071–2099) periods are presented in Figure 5. The range is smallest in summer, particularly at the peak of monsoon (July and August). In contrast, during the remaining seasons, the range is relatively large. Further, the temperature range will increase during cooler months, and decrease during warmer months and remains almost identical during rainy months by the end of the twenty-first century.

Figure 6 shows the annual cycles of observed and NCEP estimated monthly total precipitation during the independent verification period (1986–2000). The annual cycles of observed and HadCM3 model simulated monthly total precipitation in Jumla is shown in Figure 6, which shows that November and December are the driest, but July and August are the wettest months. Observed and HadCM3 model downscaled seasonal and annual precipitation and their biases are presented in Table 9, where it is shown that in Jumla 54% of the annual precipitation is contributed by summer monsoonal rainfall; however, only 10% of the annual amount is released during winter season. Figure 6 also shows that the large amplitude of the annual cycles due to high precipitation in the peak of monsoon (July and August) is well captured by the model. In general the model underestimates seasonal precipitation amount compared to the observed, except during winter, what it does the reverse. The model underestimates the observed annual amount of precipitation in Jumla by 13 %.

However, the number of days with more than 30 mm of precipitation (high intensity days) during base (1961–1990) and future (2071–2099) periods (Figure 9) shows that such heavy rainfall events are more likely in summer only. Under the influence of low as well as high emissions, occurrence of such high-intensity rainfall days will lessen by the end of the twenty-first century.

Figure 10 depicts HadCM3 simulated dry spell days in Jumla during the base period (1961–1990) and future period (2071–2099), showing the lowest number of dry spell days in summer months, particularly in August, and the highest in November.

Figure 5: **Frequency of hot days (maximum temperature of more than 30°C – left) and cold days (minimum temperature of less than 0°C – right) in Jumla downscaled using HadCM3 predictors for current (1961–1990) and future climate (2071–2099)**

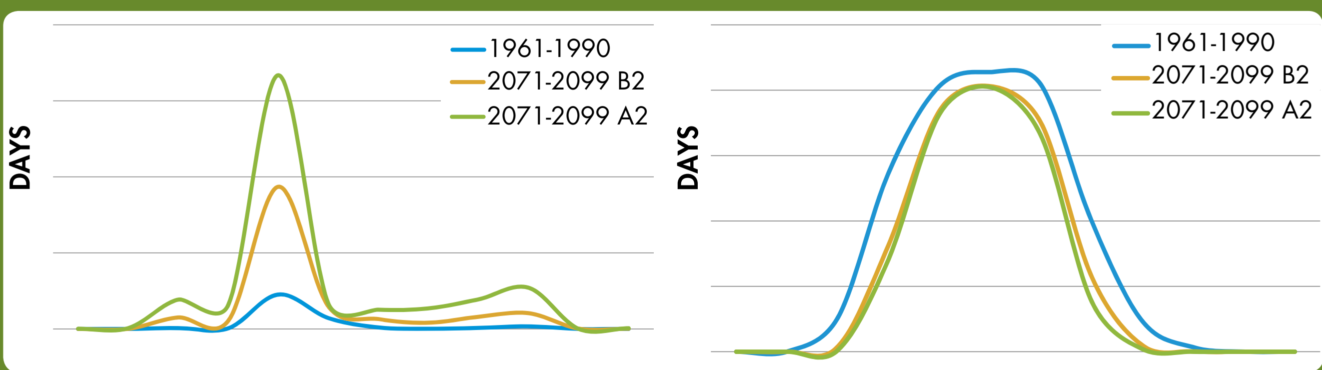


Table 9: **Future temperature scenarios downscaled using HadCM3 predictors in Jumla over the periods of 2020s (2011–2040), 2050s (2041–2070) and 2080s (2071–2099)**

	B2 Scenarios			A2 Scenarios		
	Maximum Temperature					
	2020s	2050s	2080s	2020s	2050s	2080s
Winter	1.07	2.14	3.30	1.02	2.48	4.12
Spring	1.19	1.96	2.91	1.26	2.55	4.56
Summer	0.47	0.94	1.30	0.53	1.07	1.81
Autumn	1.01	1.53	2.23	0.81	1.76	3.05
Annual	0.94	1.64	2.44	0.90	1.97	3.39
	Minimum Temperature					
	2020s	**2050s**	**2080s**	**2020s**	**2050s**	**2080s**
Winter	0.28	0.55	0.78	0.19	0.54	0.96
Spring	0.83	1.44	2.14	0.96	1.93	3.27
Summer	0.90	1.87	2.79	0.95	2.22	3.73
Autumn	1.35	2.05	2.99	1.11	2.41	4.27
Annual	0.84	1.48	2.17	0.80	1.77	3.06

Figure 6: **Annual cycles of observed and NCEP estimated total precipitation in Jumla for 1986–2000 (Independent verification period).**

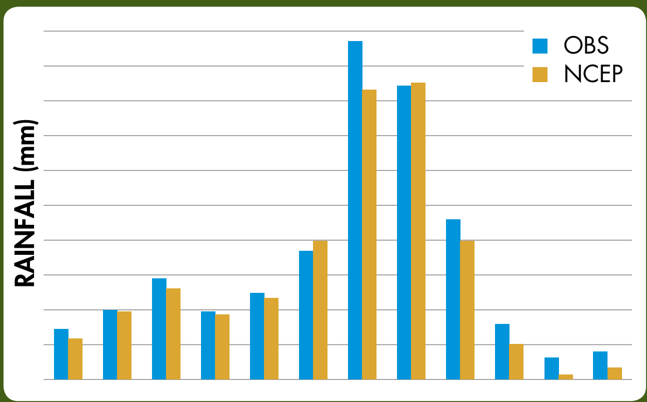


Figure 7: **Annual cycles of observed and HadCM3 downscaled total precipitation in Jumla for 1961–1990 (Base period).**

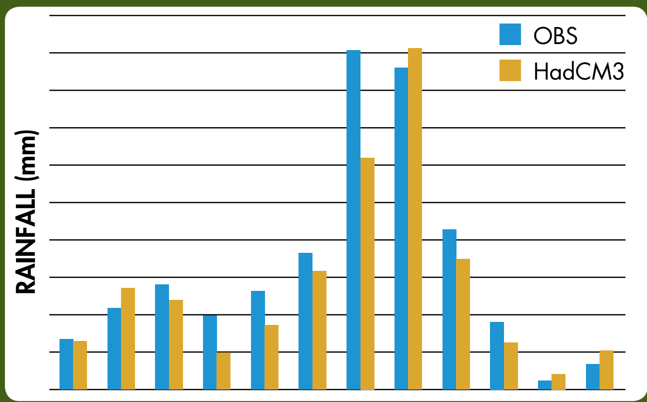


Figure 8: **HadCM3 simulated largest daily precipitation in Jumla during the base period (1961–1990) and future period (2071–2099).**

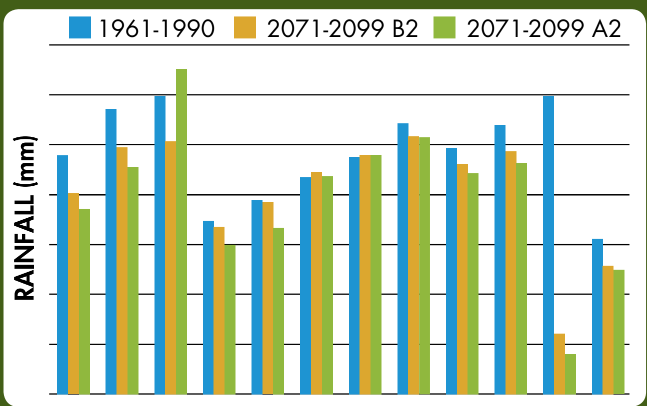


Figure 9: **HadCM3 simulated number of precipitation days with more than 30 mm per day in Jumla during the base period (1961–1990) and future period (2071–2099).**

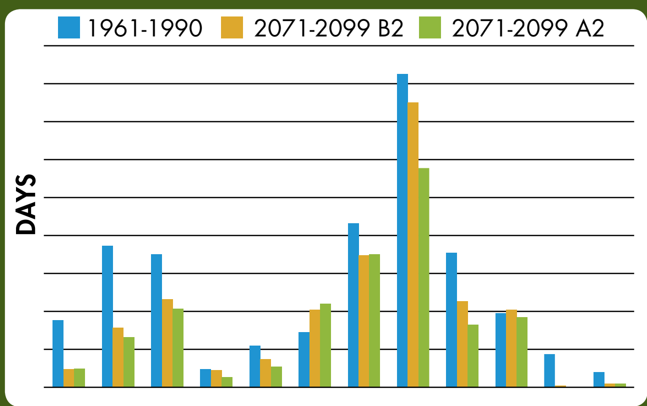
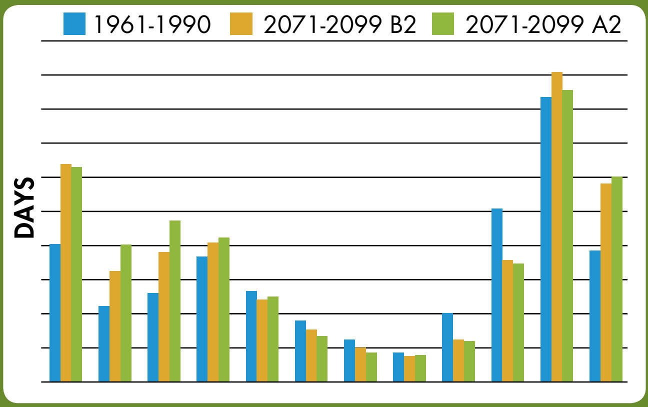


Figure 10: **HadCM3 simulated dry spell days in Jumla during the base period (1961–1990) and future period (2071–2099).**



Mustang

In Mustang observed daily temperature data are available from 1964 to 1994. Consequently, observed temperature and NCEP data from 1964 to 1985 are utilized for SDSM calibration and data from 1986 to 1994 are used for its validation. Figure 12 shows the annual cycles of observed and NCEP estimated monthly total precipitation during the independent verification period (1991–2000). Similarly, seasonal and annual values of both observed and downscaled precipitation are presented in Table 10. The annual cycles of observed and HadCM3 model simulated monthly total precipitation is shown in Figure 13, which shows that November is the driest month, whereas July and August are the wettest months in Mustang. Observed and model downscaled seasonal and annual precipitation and their biases are presented in Table 10, where it is shown that in Mustang 64% of the annual precipitation is contributed by summer monsoonal rain; however, only 7% of that amount is released during spring season indicating low frequency of pre-monsoon thunder activities.

HadCM3 simulated largest 24 hours precipitation amount during base (1961–1990) and future (2071–2099) periods are shown in Figure 11, in which it is depicted that the highest daily rainfall amount observed in Mustang in general is confined to the summer season. The figure also shows that under the influence of low as well as high emissions, a little change in the future scenarios of daily rainfall amount, which is increasing in the months of June, July, September and November, and decreasing in the months of January, March, April and May, is projected by the end of the twenty-first century. The number of days with more than 20 mm of precipitation (high intensity days) during base (1961–1990) and future (2071–2099) periods (Figure 14/15) shows such high rainfall events are more likely in summer. Figure 10 depicts HadCM3 simulated dry spell days in Mustang during the base period (1961–1990) and future period (2071–2099) showing lowest number of dry spell days in July and August.

Figure 11: **Frequency of hot days (left - with maximum temperature greater than 15 °C) and cold days (right - with minimum temperature less than 0°C) in Mustang downscaled using HadCM3 predictors for current climate (1961–1990) and future climate (2071–2099).**

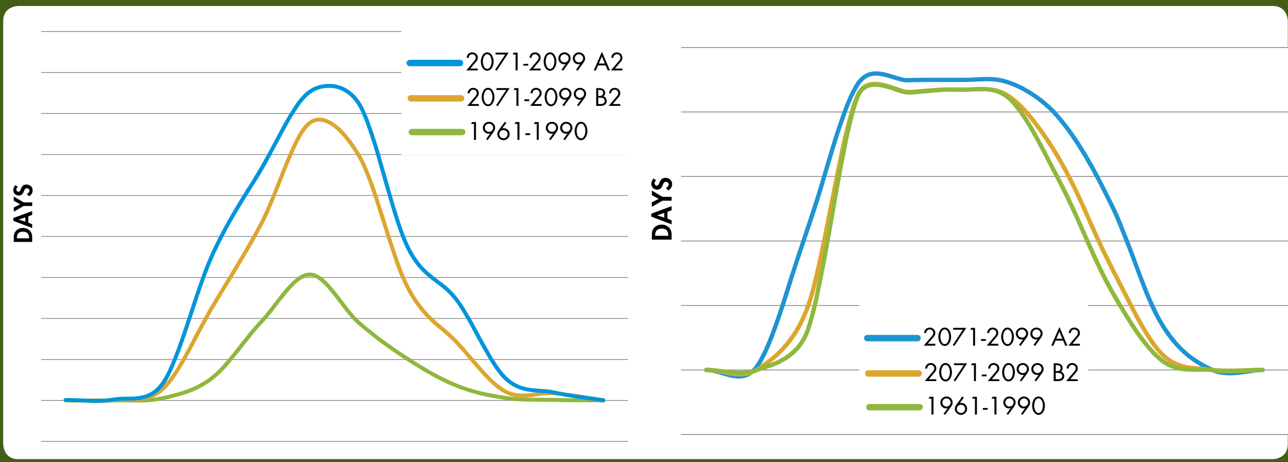


Table 10: **Future temperature scenarios in Mustang downscaled using HadCM3 model predictors over the periods of 2020s (2011–2040), 2050s (2041–2070) and 2080s (2071–2099).**

	B2 SCENARIOS			A2 SCENARIOS		
	2020s	2050s	2080s	2020s	2050s	2080s
	Maximum Temperature					
Winter	0.88	1.89	2.68	0.72	1.93	3.25
Spring	0.95	1.82	2.58	1.12	2.13	3.90
Summer	0.66	1.37	2.17	0.72	1.78	2.88
Autumn	0.76	1.32	2.14	0.55	1.67	2.97
Annual	0.81	1.60	2.39	0.78	1.88	3.25
	Minimum Temperature					
Winter	0.48	1.02	1.40	0.40	0.97	1.68
Spring	0.69	1.31	1.91	0.80	1.54	2.89
Summer	0.49	1.10	1.70	0.56	1.34	2.21
Autumn	0.72	1.18	1.81	0.48	1.43	2.78
Annual	0.60	1.15	1.70	0.56	1.32	2.39

Figure 12: **Annual cycles of observed and NCEP estimated total precipitation in Mustang for 1991–2000 (Independent verification period).**

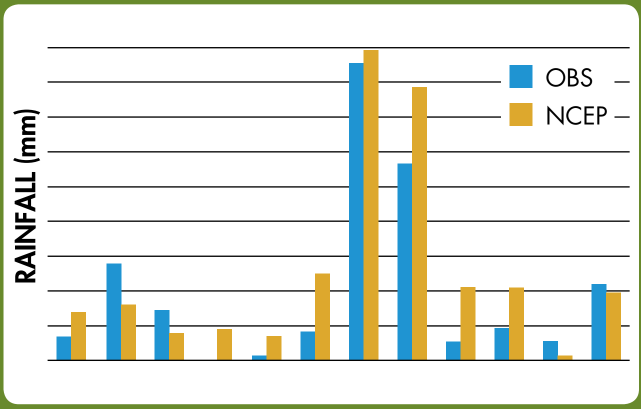


Figure 13: **Annual cycles of observed and HadCM3 downscaled total precipitation in Mustang for 1961–1990 (Base period).**

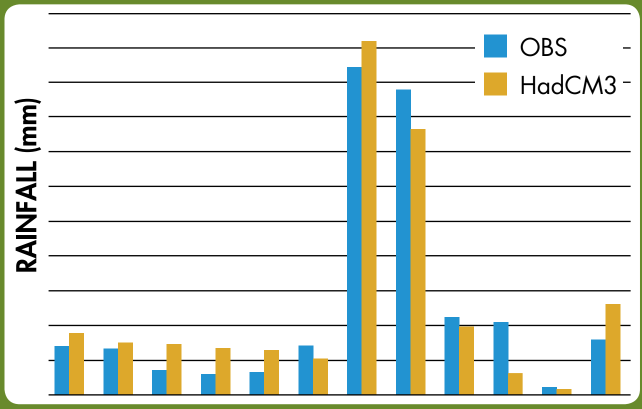


Figure 14: **HadCM3 simulated largest daily precipitation in Mustang during the base period (1961–1990) and future period (2071–2099).**

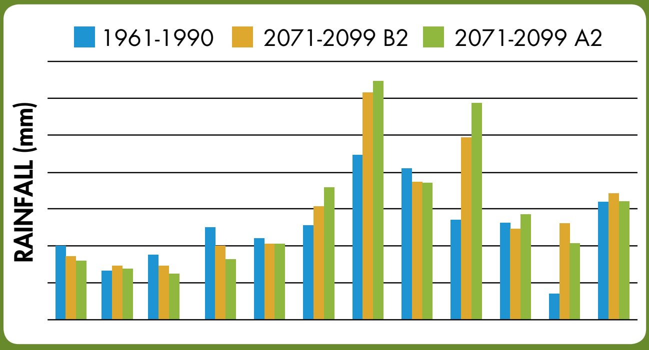


Figure 15: **HadCM3 simulated number of precipitation days with more than 20 mm per day in Mustang during the base period (1961–1990) and future period (2071–2099).**

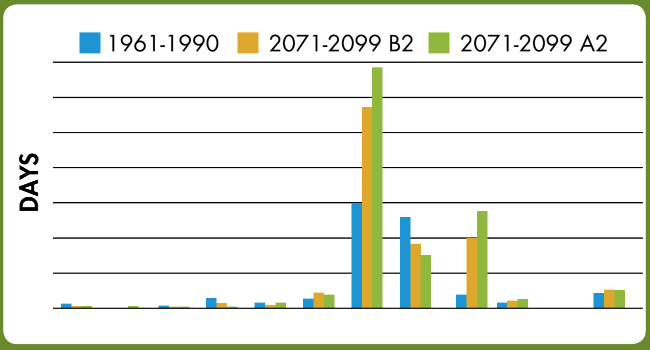
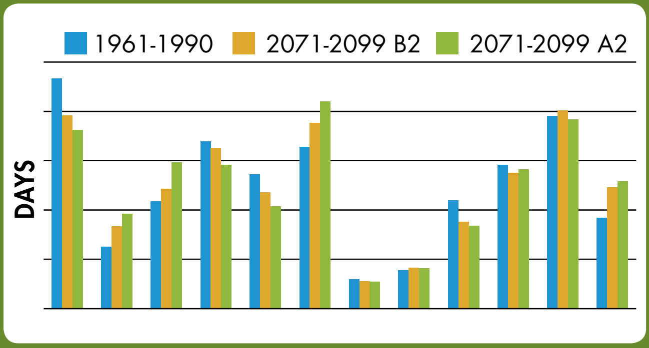


Figure 16: **HadCM3 simulated dry spell days in Mustang during the base period (1961–1990) and future period (2071–2099).**



Annex 6: **Selection of Products in the Two Districts**

Table 1.1: **Ranking of agricultural products in Pangling, Mustang**

Criteria	Priority ranking of agri-products						
	Apples	Barley	Buckwheat	Potatoes	Black and white beans	Maize	Akarkara (MAP)
Market demand and growth potential	10	5	8	6	8	6	10
Potential increase in income and value addition	10	4	6	8	8	4	8
Potential for employment generation	8	5	6	4	6	4	8
Potential for increases in productivity and linkages	8	5	5	5	8	5	9
Government or donor interest/ existing support programmes	10	4	5	8	9	4	10
Total score	46	23	30	31	39	23	45

(Score: maximum = 10, minimum =1)

Table 1.2: **Annual production of three selected agri-products per household and their farm gate price in Mustang**

Agri-product	Pangling (37 HH)		Phalyak (55 HH)		Dhagarjon (50 HH)		Total production (142 HH)
	Qt (kg)	Price (NPR/ kg)	Qt (kg)	Price (NPR/ kg)	Qt (kg)	Price (NPR/kg)	
Apples	1000	52	700	50	500	50	105 tons?
Local beans	60	85	55	90	40	90	7 tons?
Akarkara (MAP)	250	300	100	250	0	0	350 kg*

HH = household, NPR= Nepalese Rupees

*Only two farmers from Pangling and one from Phalyak village have cultivated akarkara (MAP) on their farmland.

Table 1.3: **Selection of products in Lorpa, Jumla**

Criteria	Priority ranking of agri-products					
	Maize	Chilli	Garlic	Beans	Buck wheat	Seed production (carrot, rayo, coriander, and chilli)
Market demand and growth potential	4	8	10	10	6	10
Potential increase in income and value addition	5	9	9	10	6	8
Potential for employment generation	5	8	5	8	6	8
Potential for increases in productivity and linkages	7	5	6	10	6	9
Government or donor interest/ existing support programmes	4	6	7	8	5	10
Total score	25	36	37	46	29	45

(Score: maximum = 10, minimum =1)

Table 1.4: **Production of three selected agri-products per household and their farm gate price in Jumla**

Agri-product	Upper Lorpa (147 HH): Qt (kg) per year	Lower Lorpa (79 HH): Qt (kg) per year	Total (226 HH): Qt (kg) per year	Price (NPR/ kg)	Gross income (NPR) per year
Garlic	15,000	8,000	23,000	100	2,300,000
Local beans	10,000	4,000	14,000	90	1,260,000
Dried chilli	1,000	1,000	2,000	300	600,000
Chilli seed	100	200	300	1,400	420,000
Carrot seed	200	100	300	400	106,500
Rayo seed	28	12	40	600	16,000
Coriander seed	50	30	80	250	16,000

Annex 7: Summary Showing Results from PRA of Jumla

Summary of PRA reports, Jumla

Tallo Lorpa Village

Workload of the village people: People are very busy from June through September. Men remain busy for 240 days and women for 275 days in a year. Many young people of this village go to the district headquarters or to India for seasonal work.

River cutting: Cutting of cultivated land by the river is one of the major problems in the village. Locals apply several protection measures almost every year, but to no avail. The river poses a threat during the monsoon.

Sheep and goat farming: Farmers engage in the traditional practice of rearing sheep and goats. However, grass in grazing land shows a decreasing trend. So, there is a need to introduce new grass or other measures to improve grazing conditions.

Vegetable production: This village is very good for vegetable production but there is not much production up to now because marketing the products is not very easy. A new road that is being built near the village has opened up possibilities. Once the road is operational, the farmers of this village can directly go to the district headquarters to sell their produce. However, people are still not sure how long the road construction will take.

Dry lands: This village has very little water for irrigation. Cultivatable lands remain very dry for more than nine months in a year. Below the village is a river that flows throughout the year. However, farmers do not have the skills or infrastructure required to pump up the river water for irrigation purposes.

Community organizations: There are ten community organizations in this village that have been formed by different projects and NGOs for their project purposes. One household has membership in at least two or three such organizations. While some of these organizations are running, others have become defunct.

Apple farming: There is an increasing trend of apple plantation in this village. There are a couple of private nurseries that produce apple saplings. Farmers are eager to expand apple gardens because they are hopeful that a good road will link the village to Jumla district headquarters very soon.

Condition of forest: There are a few community forests in this village. However, forest users do not have adequate awareness about forest management. On the whole the forests are deteriorating. Locals need orientation on community forest management and other measures to protect grazing lands.

Cattle keeping: Sheep, goat, and cow constitute the main livestock in this village. The number of cattle in the village is increasing due to population growth but the grazing land and grass production is decreasing. Consequently, most of the cattle are not productive. People keep cattle for compost production.

Electricity: There is electricity in the village produced in micro hydro plants. Actually, there are three micro hydro plants in two villages. Out of three, one is not running properly. However, full utilization of available electricity for productive purposes is not there. People use electricity just for the light.

Annex 8: **Detailed Recommendations on Leveraging the Potential of Agribusiness and Value Chains by Enhancing Local Capacity**

The broad recommendation is that a comprehensive and integrated approach is required to build local capacity and knowledge, including the capacity to cope with the multiple challenges ranging from institutional barriers to climatic changes and degradation of the resource base. This would improve farmers' access to technologies and infrastructure, and link farmers with existing networks, support systems, and markets. Communities and institutions that find it challenging to initiate a sustainable agribusiness venture are likely to require technical support and a motivating intermediary.

Specific recommendations for the project are:

- Mobilization of communities: There is a need for strong social mobilization for follow-up actions. The people at the action research sites were found to take decisions on farming and the introduction of new activities in a collective manner. In this case the HIMALI project grants could be better used if local people took a keen interest in engaging in the selected agribusiness value chains.
- Strengthen local cooperatives: The existing business platforms in the form of cooperatives need to be strengthened. For example, in terms of proper planning related to production, storage, local processing, and marketing.
- Varietal selection: There is a need to identity crop varieties that can adjust to stressful conditions such as less water and higher temperatures.
- Understand the markets: The markets for the shortlisted products need to be understood better and their potential to fulfil market demand needs to be studied. This will provide the basic information for cooperatives to prepare their business plans. A diversified portfolio of products could be produced by different farmer families.
- Vertical coordination: There is a need to identify key market players in the private sector who might be interested in the agribusiness value chains. Contractual arrangements for seed production, off-season vegetables, semi-processed products like organic chilli powder, MAPs, apple chips, juice, jams, and others, could be explored.
- Capacity building: will be required for different upstream value chain functions.
- Production: The capacity of local communities to choose crop varieties needs to be enhanced, as does their capacity in production techniques, including land preparation, planting techniques, irrigation, crop protection, and harvesting and post harvest operations.
- Storage: Approaches for storing local produce for market that are suited to the prevailing conditions need to be tested and crop specific standard applications should be developed for mainstreaming among the farmers.
- Marketing: Terms and conditions need to be established for contracts, compliance to timelines and standard operating procedures ensured, and quality management and packaging introduced.
- Semi-processing: Farmers need technologies for drying, grading, and sorting the products. They also need to be trained to collaborate with the buyers on these techniques to ensure that market preferences are built into the production systems.
- Exposure visits: Awareness needs to be raised and knowledge transferred on similar activities that are being practised in other parts of Nepal. An example of such an activity is cash crop farming in Dhading in Kavre. This could encourage farmers to engage in new commercial ventures.
- Promote external facilitation: A key concern is related to who conducts the above activities. There is a need to identify a consortium of local stakeholders who can take up different functions on a cost sharing and profit basis. This will entail establishing an apex body of producer institutions that can form the backward and forward links to the PAR sites.
- External technical support: There is a need to identify how external agencies with technical competency in agribusiness can be engaged in the current PAR.

Annex 9: **Community and Climate Science Comparison**

Climate Science	Community's Wisdom
Increased temperature	Early flowering and maturity
Erratic rainfall	Delayed germination of beans Fruit drop
Increased snow melt	Drying of water sources
Extreme weather events	Landslides, Droughts, Pests

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ISBN 978 92 9115 298 8