ISSN 2071-0992

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ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT SERIES

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Food and Agriculture Organization of the United Nations (FAO)
Kathmandu, Nepal

Food and Agriculture Organization of the United Nations Rome, 2014

ISBN 978-92-5-108133-4
E-ISBN 978-92-5-108134-1

ACKNOWLEDGEMENTS

This technical report on Managing climate risks and adapting to climate change in the agriculture sector in Nepal was prepared based on the experiences and lessons learned from the FAO project "Strengthening Capacities for Disaster Preparedness and Climate Risk Management in the Agriculture Sector" (TCP/NEP/3201) and the FAO-UNDP joint project on "Enhancing Capacities for Climate Change Adaptation and Disaster Risk Management for Sustainable Livelihoods in the Agriculture Sector" (UNJP/NEP/OO5/UNJ) implemented in six districts of Nepal between 2008 and 2012.

The report was written by Selvaraju Ramasamy, Natural Resources Officer, Climate, Energy and Tenure Division of FAO based on a detailed analysis of the project outputs and additional data together with a comprehensive review. Selvaraju Ramasamy was responsible for overall technical supervision of the project as Lead Technical Officer (LTO). Specific technical contributions were provided by national experts –Krishna Raj Regmi and Chiranjibi Adhikari (field demonstration of good practice examples), D.B. Singh (climate change and livestock), Rabi Singh (disaster database management in agriculture), Janak Lal Nayava (consultations for the development of a priority framework for action) and Urmila Simkhada (gender).

The FAO field monitors, Baburam Gautam (Arghakanchi), Narendra Rana (Kapilvastu), Budhi Pokharel (Udaypur), Awadh Deo (Siraha), Nirmala Pandey (Banke) and Rishikesh Dhakal (Surkhet), contributed greatly to the demonstration of climate risk management and adaptation practices at the community level. The district-level officials and community representatives from the project districts are to be credited for the prioritization and community mobilization activities of the project. The Nepal Agricultural Research Council (NARC) provided research support to demonstrate improved and stress-tolerant varieties of rice, wheat and maize in several locations of the pilot districts.

Practical Action, Nepal conducted situation assessment and baseline study for the project. The study team comprised of Gehendra Bahadur Gurung, Dhruba Gautam, Shankar Barsila, Subas Adhikari, Krishna Gautam and Rajesh Sah. The Practical Action Consulting (PAC), Asia has implemented the activities for preparation of District Disaster Risk Management Plans

(DDRMPs). The PAC team consisted of Naragopal Rai, Guna Raj Shrestha, Krishna Gautam, Madhavee Pradhan, Jhalak Prasad Bhattarai, Shree Prasad Dawadi, Nabaraj Lama and Alex Morcrette. Moushumi Shrestha and Pooja Shretha provided coordination support.

Nepal Development Research Institute (NDRI) conducted district level hazard and vulnerability mapping. The work was coordinated by Nawa Raj Khatiwada, and Tara Nidhi Bhattarai. The field-work was conducted by a team comprising of Punya Prasad Regmi, Laxmi Prasad Devkota, Samir Dhakal, Sanjeeb Sapkota, Smriteekala Panta, Krishna Gautam, Rajesh Sah and Man Bahadur Kshetri. Special appreciation is also due to Michele Marconi, GIS Specialist for assisting in further analysis and mapping; and Daniela Mora for preparing project website and good practices database.

Special thanks are due to Hari Dahal, National Project Director, formerly Joint Secretary in the Ministry of Agricultural Development for his leadership and effective coordination of project implementation. Appreciation is also due to Bishnu Aryal and Lilaram Poudel (the then DDGs, Planning of DOA), project managers for smooth implementation of the project. D.M. Pokhrel and Bidya Pandey in the Gender Equity and Environment Division of MOAD and Kanchan Raj Pandey in the Department of Agriculture (DOA) are acknowledged for their contribution during implementation of the project.

At the national level, several experts and colleagues contributed for successful implementation of the project. Special thanks are due to Vijaya Singh and Jwala Panday, UNDP, Ananda Kumar Gautam, Nepal Agricultural Research Council (NARC), Kamal Prakash Budhathoki, Department of Hydrology and Meteorology (DHM), Nepal for their valuable feedback and support during the consultations and project implementation.

The contribution of FAO technical officers Stephen Bass, Thomas Osborn, Henri Josserand, Thomas Hofer, Ilaria Sisto and Klaas Dietze is acknowledged greatly for their technical backstopping during different phases of project implementation. Lakshman Gautham (formerly), Binod Saha, Assistant FAOR (programme), Abhaya Singh (formerly), Shrawan Adhikary and Arjun Thapa, Programme Officers in FAO (Nepal) deserve due appreciation for their project management, administrative and logistics support. Sincere thanks go to BuiThi Lan, former FAO Representative for overall supervision of implementation of the project and to Somsak Pipoppinyo, FAO Representative in Nepal for motivation and support to upscale the project interventions.

ABSTRACT

The agriculture sector plays a critical role in the Nepalese economy, contributing more than 33 percent to Nepal's gross domestic product and engaging more than 65 percent of its population. The sector is highly exposed and vulnerable to extreme climate events and the impacts of climate change. Agricultural production is constrained by frequent natural disasters – floods, droughts, landslides, intense rain, hailstorms and cold and heat waves. Such climate-related events have put fragile agricultural ecosystems at risk. The impacts on agriculture of climate change and related extreme events often lead to food insecurity for poor and marginalized populations groups, including women and children.

Projected future scenarios of climate suggest that climatic conditions in Nepal will worsen, which may imply even more frequent occurrences of climate-related extremes and negative impacts on food production. However, by adopting the right measures, it is possible to adapt effectively to the challenges posed by climate change. Such measures require a comprehensive approach that includes strengthening the capacities of institutions and delivering need-based services to farming communities.

In response to the Government of Nepal's request, FAO assisted the Ministry of Agricultural Development (MOAD) in strengthening capacities for climate risk management and climate change adaptation in the agriculture sector through a project under the Technical Cooperation Programme (TCP) and a joint programme (UNJP) with the United Nations Development Programme (UNDP). The report builds on the experiences and lessons learned from these projects over the period 2008–2012. In addition, the document includes additional details to provide a comprehensive understanding of climate variability and change in Nepal and their impact on agriculture. The report also highlights technical and policy options for coping with and adapting to the impacts of climate variability and change.

Chapter 1 presents an introduction, outlining gaps and need-based interventions for improving climate risk management and adaptation. **Chapter 2** explains climate and its variability in Nepal, including past trends and future climate change projections. The chapter also highlights the uncertainties of climate change projections, and issues associated with practical decision-making. **Chapter 3** describes the vulnerability and impacts of climate change

on the agriculture sector, including the impacts of recent extreme climate events, and highlights the need to base interventions in climate risk management and adaptation on local communities' perceptions of climate risks.

Chapter 4 provides a detailed description of the institutional context for managing climate risks and adaptation. Enhanced technical capacities, linkages to research and development, improved coordination mechanisms and inclusiveness are considered key aspects for the successful delivery of need-based services to farmers. **Chapter 5** highlights the need to strengthen the collection and analysis of data and information for managing climate risks and advancing adaptation. The chapter provides an overview of data and information requirements, existing data and information systems in Nepal and ways and means of improving data and information for the planning of climate risk management and adaptation.

Chapter 6 provides a comprehensive typology of coping and adaptation strategies and practices for managing current risks and building the necessary knowledge and good practices for advancing adaptation over the longer term. The good agricultural practices demonstrated to farmers highlight the need for a fundamental shift in approach from reactive emergency response to proactive climate risk management in the short to medium term, and to adaptation in the medium to long term.

Chapter 7 presents the features of existing policies, plans, strategies and programmes that are relevant to agriculture and food security, disaster risk management and climate change adaptation. The chapter also examines the issues and opportunities for mainstreaming climate change concerns into broader agriculture and food security policies, plans and strategies; and agriculture and food security priorities into disaster risk management and climate change policies and plans.

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By Ramasamy Selvaraju

160 pages, 16 figures, 17 tables, 10 pictures
FAO Environment and Natural Resources Service Series, No. 22 – FAO, Rome, 2014

Keywords:
climate variability and change, impacts, agriculture and food security, coping, adaptation, technical and policy options

CONTENTS

EXECUTIVE SUMMARY

The climate of Nepal varies greatly in both time and space. Observed climate data from the 1960s onwards indicate consistent warming and increases in maximum temperatures averaging 0.04–0.06° C per year. Warming is more pronounced in high-altitude regions than in the *terai*. Annual precipitation data show large inter-annual variability. Monsoon (June – September) precipitation data for raingauge stations of Nepal showed both increasing and decreasing trends and do not show consistent long-term trends.

Climate change is expected to bring additional threats of greater magnitude. Climate change projections forecast that mean annual temperatures will increase by an average of 1.2° C by 2030 and 1.7° C by 2050, compared with the pre-2000 baseline. Regional circulation models project even greater increases in mean annual temperatures: 1.4° C by 2030 and 2.8° C by 2060 – and both rises and falls in mean annual precipitation rates, with no clear trends. Climate change projections indicate that the main impacts are likely to include significant warming and uneven and erratic distribution of precipitation, leading to increased frequency of extreme weather and climate events, including floods and droughts. It is likely that new areas will be affected by a variety of different climate-induced threats, exacerbating the negative impacts of climate events.

The agriculture sector is highly exposed to climate extremes. Several factors make Nepalese agriculture particularly vulnerable to increasing climate variability and climate change. Increasingly frequent and intense hydro-meteorological hazards, high dependency on agriculture – with few opportunities for diversifying income sources – rapid population growth, shrinking farm size in the *terai* region, and continued unplanned agriculture in areas prone to climate risks are likely to increase the exposure and loss of livelihoods, unless countermeasures are put in place. High exposure and low adaptive capacity pose a major challenge to the agriculture sector, which is expected to suffer livelihood losses and the reduction of crop and livestock production.

Climate change is likely to affect agriculture-dependent livelihoods and – ultimately – food security. Per capita food availability is declining over the years, because the population continues to increase while the performance of the agriculture sector remains almost stagnant. The average per capita agricultural landholding is less than 0.8 ha, enabling farmers to produce only about six months' food consumption from their farms in low-production environments; about 42 of the country's 75 districts face food deficits every year. According to calculations based on models, the likely impacts of climate change on agricultural production include a 17.3 percent drop in production from a temperature increase of 2.5° C, and these figures do not include the additional negative impacts of extreme climate events. Observation of the impacts of recent extreme climate events suggests that clear production declines result from even slight changes in temperature and rainfall regimes. Nepal's vulnerable farming economy is facing risk because the reliability of stream flow is declining; rainfall deficits from November to April adversely affect winter and spring crops; rice yields are particularly sensitive to climatic conditions; and climate change poses a threat to food security through the loss of local landraces and traditional crops, while also having negative effects on biodiversity.

Communities adopt various coping mechanisms to deal with the impacts of climate change. In recent years, seasonal and permanent migration has become more common, leading to increased workloads for family members left behind – particularly the elderly, women and children. The fear of losing crops and agricultural livelihood assets to various risks is causing many rural people to shift from on- to off-farm occupations, with repeated crop failure forcing them to sell their land at low prices and divert to small-scale businesses. There is also evidence that the increasing trend in climatic risks is resulting in conflict over resource sharing between indigenous and migrant populations. The coping practices adopted by communities to reduce these impacts are not enough to address the challenges.

Comprehensive approaches to climate risk management and climate change adaptation are essential for Nepal's agriculture sector. As climate impacts are highly localized, responses should be adapted to the local context of natural resource endowments, livelihood activities, vulnerability patterns and adaptive capacity. Efforts to respond to climate change should build on local perceptions of climate risks and existing coping strategies. A comprehensive approach should be adopted to address current problems through climate risk management in the short to medium term, slowly switching to adaptation interventions in the medium to long term.

It is therefore important that policy-makers and agriculture support services assess current and future climate-related risks, vulnerability patterns, and livelihood groups to identify suitable risk management and adaptation practices and contribute to the preparation of plans and frameworks for action. Institutional innovations, participation and inclusiveness, strengthened technical capacity of government and local institutions, and enabling environments at the national, district and local levels – with clear roles and responsibilities for coordination, local implementation of actions and monitoring and evaluation – are crucial.

Efforts to manage climate risks and adaptation require data and information on crops, cropping systems, soil, water, livestock, fisheries, socio-economic conditions and the impacts of climate variability and climate change. Existing data and information systems provide a starting point for building robust systems that provide information on hazards, vulnerability and risks, for the monitoring of food security and weather and climate events. Promoting proactive risk management at the local level requires the standardization of data collection, enabling institutional mechanisms, technical capacity development and systematic updating of databases. Advances in weather and climate forecasting provide opportunities for managing risks proactively at the local level, but people-centred and localized climate services need to be strengthened by building user interface platforms. Improvement of climate observation and monitoring networks in vulnerable areas is essential to enhance weather and climate information services.

The community-driven, bottom-up approaches clearly demonstrate that concrete actions for managing current risks and addressing underlying vulnerabilities are a priority in preparing for future risks and enhancing adaptation. Good practices for climate risk management include promotion of agricultural service systems to facilitate community-based seed storage and maintenance, adoption of drought- and high temperature-tolerant crop varieties, management of high- and low-temperature stress, crop diversification, and integrated approaches to hazard risk reduction.

Resource conservation is pivotal to promote adaptation and resilience in agriculture. Resource conservation practices include rainwater harvesting and soil moisture conservation; improvement of degraded land; protection from riverbank cutting and inundation; slope stabilization and management; conservation of biodiversity and traditional crops; promotion of conservation agriculture in rice–wheat systems, improved crops and cropping systems, multi-storey cropping and agroforestry systems; sustainable use of forest resources through community forest user groups; and alternative energy sources for households.

Short-term risk management practices in the livestock sector include vaccination against contagious animal diseases, deworming against internal parasites, and the use of animal relief camps during disasters. Livestock performance can be improved by introducing new grass and legume species, planting multipurpose tree species, improving support services in livestock areas, cultivating fodder grasses and legumes (summer and winter perennials), and improving animal sheds. Opportunities to facilitate adaptation and mitigation synergies in the livestock sector include improving manure management and promoting the production and use of biogas at the community level.

The practices identified at the local level and through the involvement of agricultural research and extension systems are not completely new, but capacity building is needed to ensure that climate issues are considered in the planning and implementation of these practices. The participation of agricultural support institutions and farming communities is essential in facilitating policy advocacy, especially for the implementation of a national priority framework of action for climate change adaptation and disaster risk management, and of local risk reduction plans. Field-level actions contribute significantly to mainstreaming the priority agriculture sector interventions in programmes and plans, especially the National Adaptation Programme of Action and the Priority Framework for Action of the Ministry of Agricultural Development. Cross-cutting elements – capacity building, gender considerations and policy advocacy – are central to successful planning for managing climate risks and advancing adaptation in the agriculture sector.

ACRONYMS

ADB	Asian Development Bank
ADS	Agricultural Development Strategy
APP	Agricultural Perspective Plan
BRCH	Building Resilience to Climate-related Hazards
CAP	community action plan
CBA	community-based adaptation
CBO	community-based organization
CBS	Central Bureau of Statistics
CBSPS	Community-Based Seed Production and Storage
CCA	climate change adaptation
CCCM	Canadian Climate Change Model
CFUG	community forestry user group
CIMMYT	International Maize and Wheat Improvement Center
DADO	district agricultural development office
DDRC	district disaster relief committee
DDRMP	district disaster risk management plan
DHM	Department of Hydrology and Meteorology
DISSPRO	District Seed Self-Sufficiency Programme
DLS	Department of Livestock Services
DLSO	District Livestock Services Office
DOA	Department of Agriculture
DRR/M	disaster risk reduction/management
FAT	Farmers' acceptance test
FFS	Farmer Field School
FMD	foot-and-mouth disease
FNSP	Food and Nutrition Security Plan of Action
GCM	General Circulation Model
GDP	gross domestic product
GLOF	glacial lake outburst flood
HFA	Hygo Framework for Action
HMRP	Hill Maize Research Project

ICIMOD	International Centre for Integrated Mountain Development
IFC	International Finance Corporation
IPCC	Inter-Governmental Panel on Climate Change
IPM	integrated pest management
JT	Junior Technician
JTA	Junior Technical Assistant
LAPA	local adaptation plan of action
MOAD	Ministry of Agricultural Development
MOE	Ministry of Environment
MOEST	Ministry of Environment and Science and Technology
MOFSC	Ministry of Forest and Soil Conservation
MOHA	Ministry of Homes Affairs
MPFS	Master Plan for the Forestry Sector
MPI	Max Planck Institute for Meteorology
NAPA	National Adaptation Programme of Action
NARC	Nepal Agricultural Research Council
NCVST	Nepal Climate Vulnerability Study Team
NeKSAP	Nepal Food Security Monitoring System /Nepal Khadhya Surakshya Anugaman Pranali)
NFC	Nepal Food Corporation
NLFS	Nepal Labour Force Survey
NLSS	Nepal Living Standard Survey
NRRC	Nepal Risk Reduction Consortium
NSC	National Seeds Company
NSDRM	National Strategy for Disaster Risk Management
NSSD	National Strategy for Sustainable Development
NTIS	Nepal Trade Integration Strategy
PFA	Priority Framework for Action
PPCR	Pilot Programme on Climate Resilience
PVS	participatory varietal selection
RCM	regional climate model
REDD	Reducing Emissions from Deforestation and Forest Degradation
RIMS	Resource Identification and Management Society

SALT	slope agriculture land technology
SDC	Swiss Agency for Development and Cooperation
SPCR	Strategic Programme for Climate Resilience
SPI	standardized precipitation index
SRI	System of Rice Intensification
TCP	Technical Cooperation Programme
TPS	True Potato Seeds
TWG	Thematic Working Group
TYIP	Three-Year Interim Plan
UMMB	Urea Molasses Mineral Block
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VDC	village development committee
WFP	World Food Programme
WUA	water user association

CHAPTER 1

INTRODUCTION

Nepal is prone to a variety of recurring climate-induced risks such as floods, drought, hailstorms, avalanches, glacial lake outburst floods (GLOFs) and heat and cold waves. Poor and marginalized population groups residing in rural areas are usually the hardest hit by these natural disasters. Agriculture, the principal economic sector, which employs 65 percent of the population, is highly exposed and most vulnerable to these extreme climate events.

Global climate change constitutes an additional threat to the already deprived rural population heavily engaged in agriculture. Observed annual temperature time series show an increasing trend over recent decades. Nepal's average annual mean temperature has been increasing by 0.06°C per year, with more pronounced increases at higher altitudes (mountains) and in winter that at lower altitudes (*terai*) and in summer. There is a general increase in temperature extremes, with hotter days becoming more frequent and cooler nights less frequent.

Farming communities are already using several coping strategies to manage climate risks. These strategies include changing crops, such as growing vegetables instead of grain crops; diversifying enterprises; and rainwater harvesting measures. Existing coping strategies are clearly insufficient to manage the current risks of climate variability and climate change, and to serve the vast numbers of people facing climate-related uncertainty and impacts. The poorest people, particularly women, are the least able to adapt, because they lack the resources to undertake new activities.

Losses and damage resulting from climate risks are attributed to insufficient public awareness, lack of – or inadequate – preparedness, lack of proactive risk management practices, low levels of technical expertise and skills in adaptation to climate change, and lack of reliable data and information, all of which enhance the vulnerability of agriculture-dependent livelihood activities to climate risks. There is little effort to addressing climate risks in agriculture at the policy level because climate variability and change issues are inadequately integrated into agricultural development policies, plans and programmes.

Current initiatives to address climate-related risks are heavily oriented towards reactive emergency response. To save agricultural livelihoods, there is urgent need for a shift from this reactive approach to proactive climate risk management in the short to medium term and adaptation and resilience building in the longer term. Such a shift is currently under way, but requires strong cross-sectoral participation and innovative location-specific practices. In response to the need to strengthen the institutional and technical capacity of the Ministry of Agricultural Development (MOAD), the Food and Agriculture Organization of the United Nations (FAO) provided technical assistance to promote climate risk management and adaptation at the community, district and national levels. This project focused on four critical gaps, and aimed to manage climate risks and advance climate change adaptation.

First, the project addressed MOAD's institutional and technical capacity at the national and district levels – particularly within its line agencies – to address climate risk management proactively from an agricultural perspective, including the emerging challenges of adaptation to climate change. The project catalysed a process for improving MOAD's positioning as a key partner in the implementation of new strategies for climate risk management, and mainstreamed adaptation into MOAD's sustainable agricultural and rural development planning. Building institutional and technical capacity within MOAD will also provide a comparative advantage for representing the agriculture sector in implementation of the National Adaptation Programme of Action (NAPA).

Second, project activities sought to strengthen data and information for climate risk management and adaptation, tailor existing weather and climate information products to the needs of local farmers, and facilitate farmers' decision-making at the local level. As there are significant gaps in the management and use of data and information for proactive risk management and adaptation planning, project activities were geared towards strengthening currently available data and information rather than investing in the development of new products and services.

Third, the project introduced and demonstrated, through a guided learning-by-doing process at the community level, a set of locally adapted, innovative and gender-sensitive technologies for climate risk management and adaptation in the agriculture sector. The aims of these demonstrations were to enhance: i) local awareness of proactive risk management and adaptation; ii) local communities' resilience to the impacts and unpredictability of climatic extremes, which are expected to increase in intensity and frequency because of climate change; iii) livelihood assets, on-farm employment and household food security; and iv) the active participation of agriculture sector institutions and the most vulnerable men and women in implementing appropriate good practices.

Fourth, the project played a catalytic role in ensuring close interaction and coordination among line agencies at the district and national levels. Experiences from local interventions were integrated into comprehensive district risk reduction plans, adaptation programmes of action and priority frameworks for MOAD to replicate good practices in different ecoregions: *terai*, mid-hills and mountains.

The gaps identified through this consultative process were addressed through an integrated approach combining climate risk management and adaptation, which tend to reinforce each other. The integrated approach is based on an understanding that Nepal's climate is already changing, extreme climate events are increasing and further changes are expected in the future. Vulnerable populations' concern regarding how to manage current climate impacts – most of which are conditioned by climate variability – provides enormous scope and opportunity to address future anticipated impacts by engaging all relevant stakeholders.

Integrated approaches that combine both risk management and adaptation facilitates the implementation of responses to current extreme climate events and better planning to improve adaptation for future long-term changes. This approach is cross-disciplinary, helping interventions to address climate risks at multiple levels. This approach focuses attention on enhancing the capacity of institutions and communities to adapt to shifting contexts and to manage current and anticipated/unanticipated risks.

This report presents the scientific basis of climate variability and climate change in Nepal and measures to address them in agriculture and provides consolidated results, major outcomes and lessons learned from the project, for strengthening and scaling up to similar regions of Nepal.

CHAPTER 2

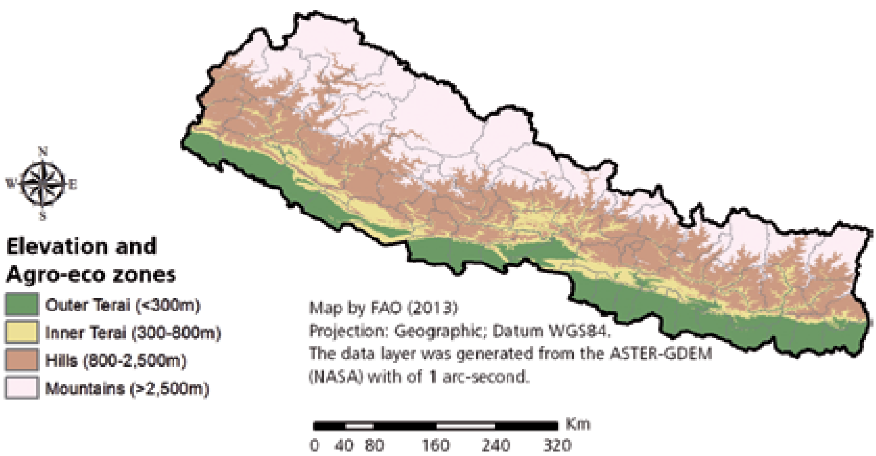
CLIMATE VARIABILITY AND CHANGE

2.1 CLIMATE AND CLIMATE VARIABILITY

The climate of Nepal varies greatly from south to north because of the vast altitudinal variation. Within a short span of about 193 km, altitudes range from 60 to 8 848 m above mean sea level, giving the country diverse agro-ecological zones – mountains, hills and *terai* (Figure 2.1). Regional climate variations are largely a function of elevation. The national average mean temperature is about 15 °C, increasing from north to south apart from in mountain valleys. Maximum temperatures occur in May and early June, and the temperature starts to decrease from October, reaching its minimum levels in December and January. Although the temperature decreases with height, there are also spatial variations; southern plains (*terai*) are the hottest parts of the country, where the maximum temperature reaches more than 45 °C during summer, causing heat waves.

FIGURE 2.1

Elevation and agro-ecological zones of Nepal



Average rainfall is 1 800 mm, with rainfall decreasing from east to west. The northwest corner of the country has the lowest rainfall, as it is situated in the rain shadow of the Himalayas (Figure 2.2). Rainfall also varies with altitude. Although annual rainfall is abundant, its distribution is of great concern and exposes the country to floods and droughts. About 80 percent of annual precipitation falls between June and September under the influence of the summer monsoon.

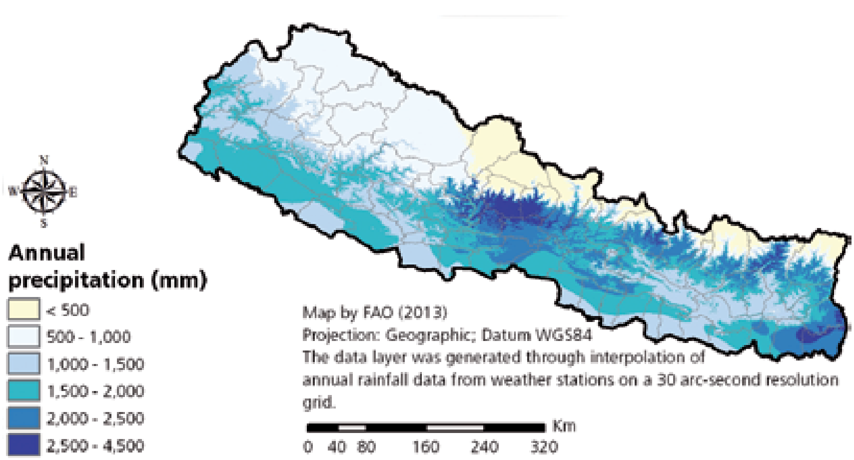
High-intensity rainfall events during the monsoon season leave the country highly susceptible to floods, landslides, flash floods, debris flows and slope failures, while droughts are common in some regions at other times of year. Prolonged breaks in the summer monsoon cause severe drought. The winter months of December to February are relatively dry, with few spells of rain. Winter rainfall decreases from the northwest, both southwards and eastwards. In April to May, the country experiences pre-monsoon thundershower activities. The months of October and November are considered the post-monsoon season of transition from summer to winter.

2.2 CLIMATE TRENDS IN THE HIMALAYAN REGION AND NEPAL

Information on climate trends in the Himalayan region is very important to Nepal because of the country's highly fragile environment and vulnerability

FIGURE 2.2

Annual precipitation (mm) in Nepal



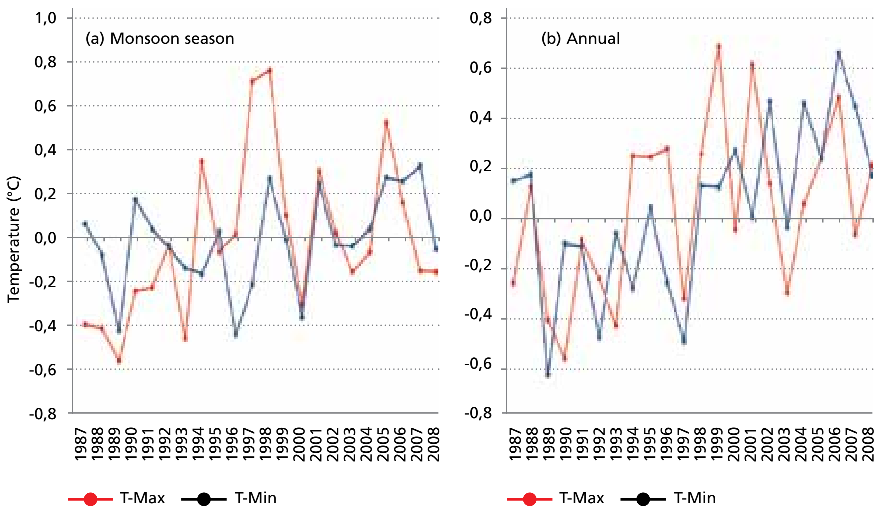
to climate change. The Tibetan Plateau also plays an important role in the climate of the region, including in Nepal. Long-term analysis of temperatures in the northwestern Himalayas during the twentieth century reveals a significant rise in air temperature of about 1.6 °C, with winter temperatures increasing more rapidly than summer ones. The diurnal variation in temperature shows an increasing trend in the northwestern Himalaya (Bhutiyani *et al.,* 2007) and the upper Indus Basin covering the Hindu Kush Mountains (Fowler and Archer, 2006).

The Tibetan Plateau – north of the Himalayas, with an average elevation of more than 4 000 m above mean sea level – has shown trends similar to those of the high-altitude Himalayas. Analysis of temperature series by Liu and Chen (2000) showed that the main portion of the plateau has experienced statistically significant warming since the mid-1950s, especially in winter. The linear rates of temperature increase over the Tibetan region during the period 1955 to 1996 are about 0.16 °C/decade for the annual mean and 0.32 °C/decade for the winter mean, exceeding those for the rest of the Northern Hemisphere at the same latitudinal zones in the same period. Wu *et al.* (2007) reported an averaged trend for the increase in annual near surface air temperature on the Tibetan Plateau of 0.02 °C/year during 1971–2000.

Results of analysis of maximum temperature data from 49 stations in Nepal for the period 1971 to 1994 by Shrestha *et al.* (1999) revealed a warming trend since 1977, ranging from 0.06 to 0.12 °C/year in most of the middle mountains and Himalayan regions, while the Siwalik and *terai* (southern plain) regions showed warming of less than 0.03 °C/year. These results indicate that the mountainous regions are warming faster than the plains. Overall temperature in the country is found to be rising at the rate of 0.41 °C/decade (Government of Nepal, 2004a). McSweeney *et al.* (2008) reported that the average number of hot nights per year has increased by nine, while the average number of cold days decreased by 19 (5.2 percent of days in the year); the average number of cold nights per year decreased by 32 (8.7 percent of nights in the year) between 1960 and 2003. Results of analysis of daily temperature data for the 36 years from 1971 to 2006 by Baidya *et al.* (2008) showed an increasing trend of relatively higher magnitude in mountainous regions compared with the *terai* belt, which may be associated with the occurrence of prolonged fog in the *terai* region. Further analysis of

FIGURE 2.3

Maximum and minimum temperature trend (1987-2008) in Nepal



maximum and minimum temperature data from 24 stations in Nepal for the period 1987 to 2008 showed an increasing trend in all agricultural seasons (Figure 2.3).

Precipitation data from Nepal for the last three decades of the twentieth century show large inter-annual and decadal variability throughout the country. Shrestha *et al.* (2000) reported that the precipitation records for Nepal do not show distinct long-term trends, agreeing closely with the precipitation records from northern India. However, the precipitation trend analysis for the same period on the Tibetan Plateau shows an increasing trend, mainly in the southern plateau, while most stations in the northern Tibetan Plateau indicate decreasing trends (Wu *et al.*, 2007). Observations of precipitation in Nepal show high correlation with the Southern Oscillation Index and indicate a strong inter-annual variability associated with El Niño Southern Oscillation (Shrestha *et al.*, 2000).

Analysis of rainfall data for 80 stations throughout Nepal indicates that annual precipitation over the country is decreasing at the rate of 9.8 mm/decade (Government of Nepal, 2004a). Recent studies show that most of the southern plains (*terai*) and western Nepal have observed a negative trend (with maximum decreases in the *terai* belt of central Nepal) except for in a few pockets of positive trend. Analysis of long-term (1866 to 2006) precipitation variations in the northwestern Himalaya indicates a significant decreasing trend in monsoon precipitation (Bhutiyani *et al.,* 2010). On the other hand, the hills and mountains of western Nepal and the northern belt of eastern Nepal have shown an increasing trend. McSweeney *et al.* (2008) reported a significant decrease in monthly precipitation averaging 3.7 mm/decade, arising mainly from average monthly declines in June, July and August (of -10.8 mm/decade). One- and five-day rainfall maximums have shown statistically significant increases for December to February and March to May. Precipitation data for the 46 years from 1961 to 2006 showed increasing trends in total and heavy precipitation events at most stations (Baidya *et al*., 2008).

2.3 FUTURE CLIMATE CHANGE PROJECTIONS

Studies on future climate change projections for the Himalayan region and Nepal are limited because of the lack of long-term climate records and the uncertainties related to downscaling of General Circulation Models (GCMs), which, however, are currently the best option for assessing climate change.

Government of Nepal (2004a) showed that the rise in average annual temperature will be in the range of 2 to 4 °C across Nepal, with a doubling of atmospheric carbon dioxide (CO_2). The temperature rise will be greater in western Nepal than other regions, with the winter season increase reaching 2.4 to 5.4 °C in Nepal's far-western region. Agrawala *et al.* (2003) reported that significant and consistent increases in temperatures are projected for Nepal across various climate models, with somewhat larger increases for the winter months than the summer months (Table 2.1). For all seasons, the rising gradient is from east to west. Overall, the temperature in the country is found to be rising at the rate of 0.41 °C/decade (Government of Nepal (2004a).

There is evidence of increasing occurrence of intense rainfall events, an increase in flood days and generally more variable river flows. These changes are consistent with a range of climate change models and are predicted to continue into the future. The summer monsoon is likely to become more intense, with increasing occurrence of heavy rainfall events, while winter precipitation is predicted to decline. Widespread glacial retreat is expected to continue, resulting in significant changes to hydrological regimes (flows) and increased risk of GLOFs. As glacier melt accelerates, increased runoff can be expected initially and followed by a steady decline.

TABLE 2.1

Climate change projections for Nepal

PARAMETER	2030	2050/2060[a]
Agrawala *et al.* (2003)[b]		
Annual mean temperature (°C)	1.2 (0.27)	1.7 (0.39)
Temperature change (DJF)	1.3 (0.40)	1.8 (0.58)
Temperature change (JJA)	1.1 (0.20)	1.6 (0.29)
Annual precipitation change (%)	5.0 (3.85)	7.3 (5.56)
Precipitation change (JJA)	9.1 (7.11)	13.1 (10.28)
Precipitation change (DFJ)	0.8 (9.95)	1.2 (14.37)
McSweeney *et al.* (2008)[c]		
Annual mean temperature (°C)	1.8 (0.9–2.2)	2.8 (2.0–3.7)
Temperature change (DJF)	1.8 (1.2–2.7)	3.2 (2.1–4.7)
Temperature change (JJA)	1.5 (0.7–2.1)	2.5 (1.6–3.6)
Annual precipitation change (%)	1.0 (-21 to +14)	6.0 (-21 to +31)
NCVST (2009)[d]		
Annual mean temperature (°C)	1.4 (0.5–2.0)	2.8 (1.7–4.1)
Annual precipitation change (%)	0 (-34 to +22)	4.0 (-36 to +67)
Monsoon precipitation change (%)	2.0 (-40 to +143)	7.0 (-40 to +143)

Notes: **a** data from McSweeney et al. (2008) and NCVST (2009) represents projected changes by the 2060s;
b data based on the MAGICC/SCENGEN analysis. Values in the parenthesis represent standard deviation;
c results are based on A1B scenario. Values in the parenthesis represent the range of minimum and maximum;
d results drawn from analysis of 15 GCMs. Values in the parenthesis represent the range of minimum and maximum

NCVST (2009) summarized climate change projections from GCMs for Nepal. The results showed that increase in temperature are lower in the monsoon and post –monsoon seasons than in winter and pre –monsoon. Further, it was summarized that projected annual precipitation does not show a clear trend with both increases and decreases; though monsoon rainfall projections vary widely, more models suggest an increase than a decrease. Winter precipitation projections showed a tendency for a decrease. The GCM projected precipitation scenario against observed precipitation values shows that the rainy season in Nepal will be more intense, with a particularly noticeable increase in June and July, and that winter and spring will be drier than they are now. Climate models also project an overall increase in annual precipitation, but with high standard deviation. The increase in precipitation during the summer monsoon months (June, July and August) will be more pronounced, with a slight increase in winter precipitation also reported (Agrawala *et al.*, 2003).

For this study, further analysis was carried out with data from the ECHAM5 model (Max Planck Institute for Meteorology [MPI]), which was also used for the IPCC fourth Assessment Report. The model was selected because of its relevance to the region (Connolley and Bracegirdle, 2007); a detailed description of the methodology for downscaling the data for the current and future periods is presented by Hijmans *et al.* (2005). The results of the analysis are presented in Table 2.2.

TABLE 2.2

Climate of Nepal in 2050, according to scenarios A1b and B1

PARAMETER	A1b	B1
Mean summer temperature	Will increase by 3–4 °C in the western and central *terai* and by 2–3 °C in the eastern *terai*. The hills and mountains will experience a more heterogeneous situation.	Will increase by 2–3 °C in the *terai* zone. Hill and mountain zones will evolve more heterogeneously and many areas might show increases of 1–2 °C.
Mean winter temperature	Changes will be similar to those for the summer season. The western *terai* might show an increase of 3–4 °C, and the central and eastern *terai* one of 2–3 °C.	Will increase by 2–3 °C in the western *terai*, while the eastern *terai* might show an increase of 2 °C.
Annual rainfall	The hill zone will experience a rainfall decrease of more than 100 mm, especially in the eastern region. Overall, the country will experience annual rainfall decreases of between 20 and 100 mm.	Annual rainfall will decrease by more than 100 mm in eastern Nepal and by between 20 and 100 mm in other parts of the country. The only stable exceptions might be the central and extreme western *terai* and the central mountain zone.
Monsoon rainfall	Will have a similar spatial pattern to the present. The strongest decrease will be in eastern Nepal. The western mountain zone and the central *terai* might maintain their current rainfall levels.	Will decrease in eastern Nepal, while other region will appear almost stable or with minor changes. The eastern region will lose more than 100 mm of rainfall during the monsoon season, while the central mountain zone will increase its rainfall values.
Contribution of monsoon rainfall to annual rainfall	The contribution will decrease in the eastern region, particularly in the mountain zone; and will increase by 1–3% in the western mountains.	The contribution might not change in the *terai* zone, except in eastern parts, where it might decrease, as in the eastern mountain zone.

In conclusion, scenario A1b is characterized by a strong change in temperature, which is fairly uniform in the *terai* belt, but heterogeneous in other zones (Figure 2.4). Both monsoon and annual rainfall are expected to decrease, mainly in the hill zone of the eastern region. Scenario B1 is characterized by changes in rainfall and its temporal distribution. The temperature will increase, but less than in scenario A1b.

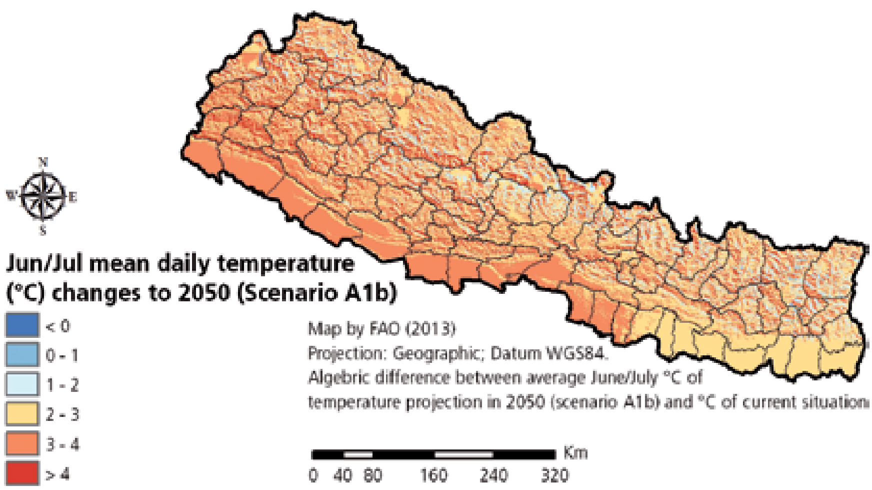
According to scenario A1b, rainfall decreases are expected especially in the hills zones of eastern and western regions. Together with the temperature rise, this will exacerbate the drought phenomena, with a significant impact on agriculture. The agriculture sector may be affected by water stress, while the reduced rainfall will probably decrease the number of flood events. However, to confirm this more detailed model, consideration of daily rainfall is required.

Scenario B1 predicts comparatively lower June/July mean daily temperature changes across Nepal. The model forecasts a rainfall decrease, mainly in the eastern region of the country. Given these changes, drought frequency may not increase significantly in the *terai* region, except in eastern parts. However, there are uncertainties in the model projections for evaluating hydrological processes.

Kulkarni *et al.* (2013) applied the Hadley Centre's high-resolution regional climate model PRECIS (Providing Regional Climate for Impact

FIGURE 2.4

Mean June/July daily temperature (°C) changes in 2050 compared with present, under scenarios A1b



Studies) to subregions in the Hindu Kush-Himalayan region – western, central and eastern Himalaya. The central and eastern Himalaya regions partly cover Nepal on the west and east, respectively. The key projections from these efforts were that monsoon rainfall may decrease over the central Himalaya region (western Nepal) in the near future (2011–2040), whereas there may be a 5–10 percent increase in rainfall in the eastern Himalaya (eastern Nepal). The ensemble projected changes in seasonal rainfall (2011–2040) showed decreases over central and eastern Himalaya. Average temperatures are projected to rise by 1–2 °C in 2011–2040; increases in mean annual temperature may be greater in central than eastern Himalaya.

Regional projections of the northern Indian climate by Mathison *et al.* (2012) using two different regional models (REMO and HadRM3) concluded that the ensemble members demonstrate that the models represent the general processes and climate of the region although the observed patterns in rainfall and temperature are not replicated exactly. The models project that the temperature increase in northern India would be between 2 and 4 °C, but the precipitation projections are more variable.

The following is a summary of anticipated changes in temperature, precipitation and runoff based on a review of current literature:

- Overall, temperatures will increase throughout Nepal, especially at high altitudes and during the winter season
- The numbers of days and nights considered hot by current climate standards will increase
- There will be a wide range of mean annual precipitation changes across the ecoregions of Nepal, with the tendency varying according to different scenarios and models
- Downstream river flows would be higher in the short term, but lower in the long term because of a shift from snow to rain in the winter months
- Extreme weather events will increase, especially floods during the monsoon season and the duration of droughts during the winter months.

2.4 UNCERTAINTIES IN CLIMATE CHANGE PROJECTIONS AND ADAPTATION PLANNING

General Circulation Model (GCM) outputs are highly uncertain over complex topography such as the Himalaya (IPCC, 2007). A cold bias is generally observed in the simulated temperatures, while precipitation estimates are affected by high uncertainties (Manning *et al*., 2013). Downscaling GCM outputs for the Himalaya region is a difficult exercise (Manning *et al.* 2013), and analysis of ensemble members from regional projections has shown that they represent the general process and climate of the region although the observed patterns in rainfall and temperature are not replicated exactly (Mathison *et al*., 2012). Recent developments in GCMs, including the improved representation of the topography in the models, are likely to reduce uncertainties in the dynamic downscaling outputs. Statistical downscaling applied to GCM outputs is very sensitive to the models' uncertainties. Better availability of quality observation data for statistical downscaling could help improve the accuracy of RCM results.

Because of the highly complex topography and orographic rainfall associated with meso-scale weather systems in high-altitude areas such as the Himalayas in Nepal, GCMs' performance in simulating observed spatial patterns, means and standard deviations is very inconsistent (Kumar *et al*., 2013). Projections of changes in precipitation patterns in mountain areas are unreliable in most GCMs because the effects of topography on precipitation are not adequately represented. Despite the progress in reproducing some of these mechanisms in coupled ocean–atmosphere models, deficiencies remain, preventing good simulations of these large-scale modes of variability. However, several studies indicate that the higher resolution of RCMs and GCMs can represent observed meso-scale patterns of precipitation that are not resolved in coarse-resolution GCMs (Yasunaga *et al*., 2006).

In light of the uncertainty associated with climate change projections, it is often difficult to translate model-based projections directly for practical decision-making. As regional climate projections and downscaling are often strongly dependent on the climate data and scenarios used and the assumptions made, the availability of long-term data with reasonably good spatial representation is crucial for ensuring reasonable interpretations of climate change scenarios for decision-making. The development of robust ways of applying uncertain climate projections to agricultural decision-making will be crucial in the planning of future management options. A community-centred, bottom-up approach and model-based analysis are good ways forward that address the risks of current and advanced adaptation and resilience for the future.

CHAPTER 3

VULNERABILITY AND THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE

3.1 AGRICULTURE AND ITS VULNERABILITY

3.1.1 Hydro-meteorological hazards

Agriculture-dependent livelihoods are frequently exposed to a variety of climate extremes such as floods, droughts, hailstorms, thunderstorms, cold waves and heat waves. Floods and landslides are particularly regular phenomena in Nepal because of the country's undulating topography. Pest and disease outbreaks in plants and animals are another major concern.

About 90 percent of crop loss in Nepal is caused by weather or meteorological events. Of all hydro-meteorological hazards, drought has the most severe impact on crops. Between 1971 and 2007, nearly 850 000 ha of crops was lost to weather- and climate-related events: droughts accounted for 38.9 percent of lost agricultural crops, and floods for 23.2 percent (UNDP, 2009). Disaster impact to the agriculture sector is on the increase. However, since the 1990s the impact has risen dramatically. Visible reasons are the increase in the occurrence and intensities of damaging meteorological hazards.

Flash floods, prolonged periods of inundation, and river-bank cutting devastate life, livelihoods and property for poor and marginalized communities. The problem of flooding is exacerbated by flood control embankments and urbanization, which constrict natural drainage patterns in several smaller river basins. Increasing rainfall intensities and changes in the timing of precipitation, especially over recent decades, have exacerbated flooding (Moench and Dixit, 2007). The primary reason for flooding has been reported as high rainfall during the monsoon combined with interventions that block drainage. Saturated soil and excess overland flooding that river channels cannot accommodate spill on to the land adjoining riverbanks, causing prolonged inundation, loss of crops and land, and other damage.

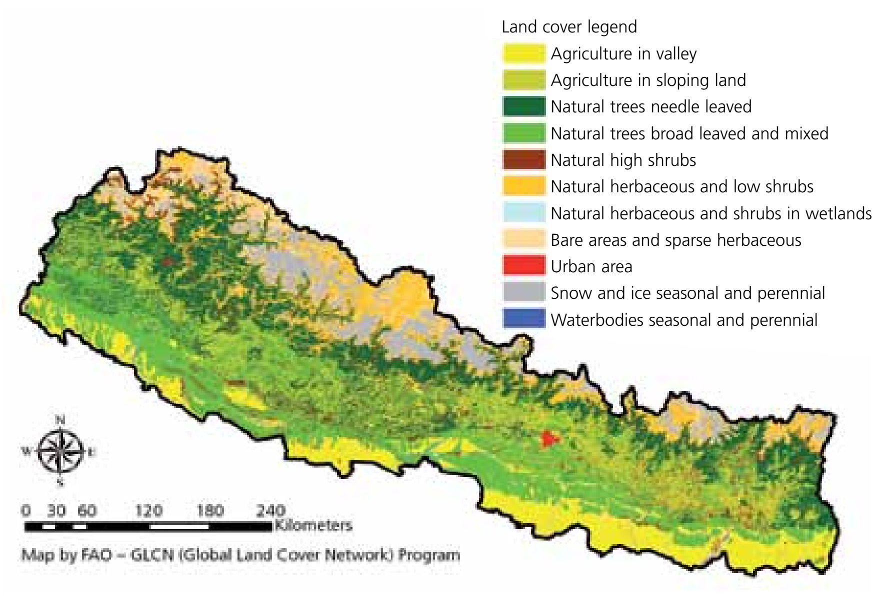
3.1.2 Land use and land cover

Nepal's agricultural lands are divided into three agro-ecological zones: the lowlands of the *terai*, the hills and the mountains. According to FAOSTAT (2012), about 20 percent of the country's total land area (3 million ha) is cultivated; 40 percent is forest including shrub land (5.8 million ha); and about 12 percent (1.7 million ha) is under grassland and pasture. The area under permanent crops is 0.12 million ha, and about 1.0 million ha of agricultural land is uncultivated. Because of the country's abrupt topographical changes, only about 20 percent of the total land area is cultivated, with cropping intensity varying from one to three crops per year. A detailed land-use and land cover map is presented in Figure 3.1.

The *terai* plains constitute 43 percent of total cultivated land. The mountains generally lie above 1 800 m, and only 2 percent of mountainous land is suitable for cultivation. As the mountain region is mostly steep, rugged and cold, it is sparsely populated, and raising livestock is the main occupation of mountain people. Rice, maize, wheat and millets are the main cereal crops.

FIGURE 3.1

Land use and land cover map of Nepal



Note: Classes represented in the map are a generalization of the original 35 land cover classes for the Himalaya region.

Rice is the primary crop (1.6 million ha), cultivated predominantly in the plains and at lower elevations; wheat (0.7 million ha) is grown in the *terai* and the valleys of the Himalayas; and maize (0.87 million ha) is the principal crop of the hilly regions.

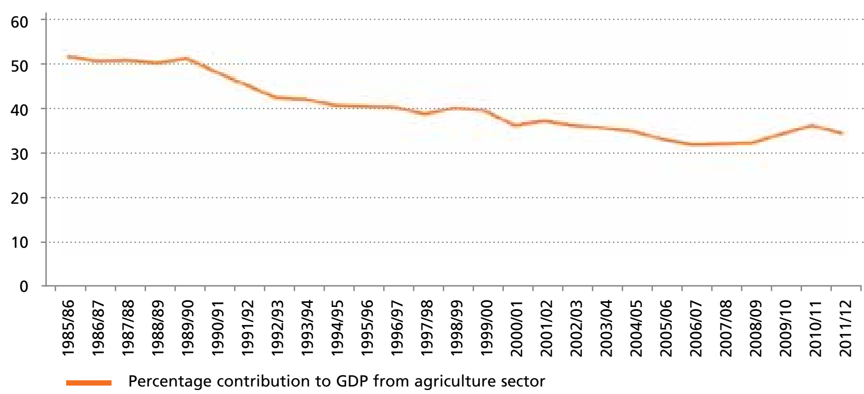
Land degradation from unsustainable land use severely limits crop productivity. Overgrazing, deforestation and unsustainable farming practices have all contributed to widespread topsoil erosion and nutrient loss, leading to frequent landslides in the hills and floods in the lowlands. Agricultural livelihood activities and the severe impacts of climate variability have placed tremendous stress on the mountains' fragile ecosystems, with deforestation leading to erosion and flooding that threaten the livelihood assets of farmers throughout the country.

3.1.3 Dependence on agriculture and low diversity of income sources

Agriculture remains Nepal's principal economic activity, engaging more than 65 percent of the population and contributing 32.8 percent of total gross domestic product (GDP) (Figure 3.2). The ratio of total agriculture holdings to the total number of households indicates that almost 80 percent of households possess some form of agricultural holding. Agriculture in Nepal has long been based on subsistence farming. Prior to 1980, Nepal was able to meet all of its domestic cereal needs, but as population growth outpaces

FIGURE 3.2

Percentage contribution to GDP from agriculture sector



Source: Data from MOAD, 2012

agricultural productivity, it has been forced to rely heavily on food imports, primarily from India and other countries in the region.

3.1.4 Production variability

The seasonal nature of farming and its sensitivity and exposure to climatic variations and extremes contribute to inter-annual variability in crop yield. The productivity of rice and wheat has shown significant inter-annual variability over the past (Figure 3.3). This can be attributed to several factors: most production is achieved through rainfed agriculture, and landholdings are extremely small, with the vast majority of farms covering less than 0.5 ha each.

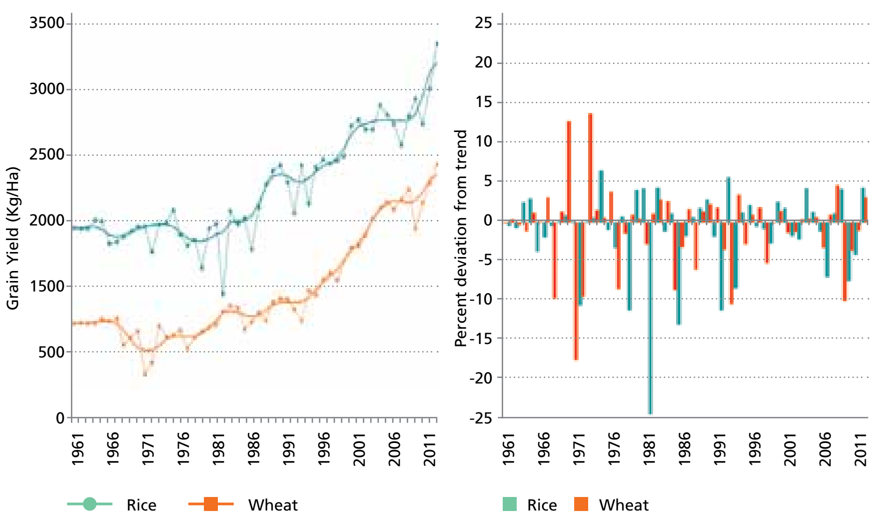
About 1.5 million ha produces 5.1 million tonnes of rice (paddy); wheat and maize together take up a similar land area, with harvests of 1.8 million tonnes and 2.2 million tonnes respectively (FAOSTAT, 2012). The production of cash crops increased substantially in the 1970s, and sugar cane, oilseed, tobacco and potatoes are contributing to agriculture sector growth.

3.1.5 Agricultural infrastructure and inputs

The difficulties of transportation due to mountainous terrain and poorly developed road networks make it difficult to transport surplus agricultural

FIGURE 3.3

Grain yield trends of rice and wheat and percentage deviation of yields from trends (1961–2012)



Note: Analysis based on data from FAOSTAT (2013) products to remote mountain regions within Nepal. Weak institutions and inadequate technical support further limit marketing opportunities. The use of chemical fertilizers, irrigation, infrastructure and technology for increasing agricultural productivity has not been fully implemented. Inefficient use of irrigation water, chemical fertilizers and low-quality seeds, together with a lack of credit facilities, technical advice and mechanization, contribute to the agriculture sector's vulnerability to climate variability.

Approximately 65 percent of arable land in Nepal is rainfed and only 24 percent has access to irrigation systems, making the sector highly vulnerable to climate variability. Land under irrigation increased from 583 900 ha in 1981/82 to 1 254 272 ha in 2012 (MOAD, 2012). Most irrigable land is in the *terai* region. The limited irrigation in the mid-hills and mountains is mainly small-scale surface irrigation and micro-irrigation. Vegetables are cultivated as cash crops in a few areas of the mid-hills with access to markets.

3.2 VULNERABILITY OF AGRICULTURE-DEPENDENT LIVELIHOODS

3.2.1 Livelihood groups and their activities

FAO (2010a) and Practical Action, Nepal conducted an analysis of livelihood groups in two mid-hill and two *terai* districts, focusing on three village development committees (VDCs) in each district and based on interviews with 360 households. The study reported that the major livelihood groups in the mid-hills and *terai* are farmers (including livestock owners), unskilled wage labourers, salaried and skilled workers (with family members relying on remittances), small businesses (petty trade and commerce) and service workers. Nearly 85-88 percent of the inhabitants of surveyed VDCs are involved in agriculture, depending mainly on crops, livestock and homestead gardens; 3 to 7 percent are skilled and unskilled workers, depending on local work at the village level; 4 percent depend on remittances from skilled and unskilled working household members; and 2 percent depend on small businesses, including village-level groceries and local businesses. Very few farm families depend on services, government organizations, non-governmental organizations (NGOs) or the private sector.

As most families have no land, they use other people's land for sharecropping or land rentals. Livestock rearing is a major component of livelihoods and includes poultry, dairy production and farm animals such as cattle, buffaloes, sheep, goats and pigs. Most of the surveyed households in the mid-hills (79 percent) and *terai* (53 percent) have livestock to enhance their incomes, but livestock rearing is affected by controls on grazing on community lands, especially through community forestry, and the shortage of grazing lands.

Traditional fishponds are available, especially in the *terai*, but these resources are abandoned or left unused because of inadequate water availability. Farmers perceive that longer drought periods, sedimentation from flooding and inundation are responsible for the drying up of traditional ponds. In recent years, vegetable farming has been adopted as an alternative income source; most respondents in the mid-hills (55 percent) and *terai* (67 percent) are engaged in vegetable farming, which is more prominent in *terai* districts than in the mid-hills. Some households in the *terai* generate their livelihoods from sales of fuelwood. Horticulture activities are decreasing because of the non-availability of irrigation, with more than 70 percent of respondents in both the mid-hills and the *terai* perceiving that horticulture is no longer a profitable livelihood activity. The main reasons given were lack of irrigation facilities and increasing incidence of diseases and pests.

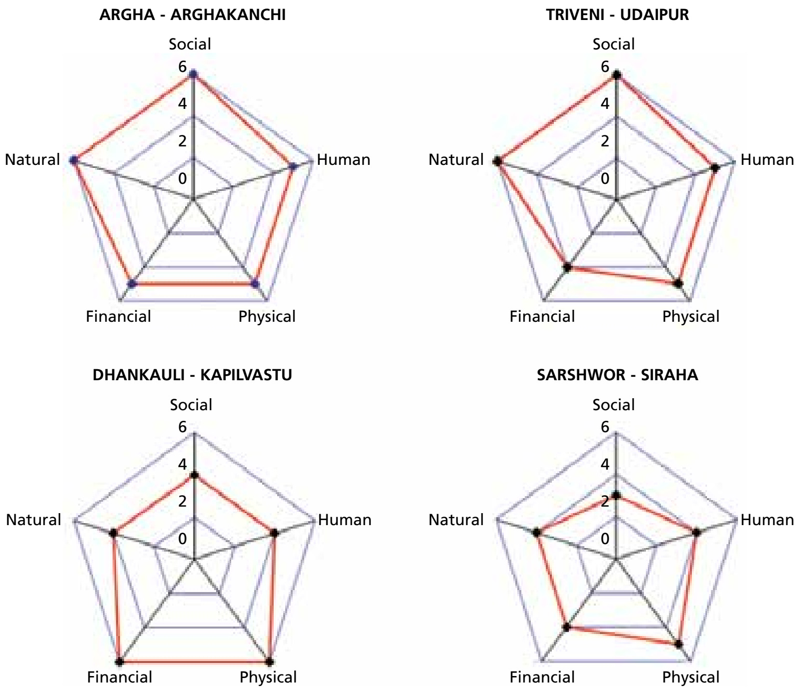
3.2.2 Livelihood assets and access

Livelihood assets refer to the community's resource base. The FAO (2010a) study reported that vulnerable communities in the mid-hills have more access to natural assets than do communities in the *terai* (Figure 3.4). About 59 percent of respondents in the mid-hills and 53 percent in the *terai* perceived that they have unrestricted access to natural resources. Regarding financial assets, the people of the *terai* have better access to cooperatives, credit facilities and on- and off-farm income opportunities than do those of the mid-hills.

Indicators of social assets include strong social bonds, kinship and social networks, solidarity, a sense of honour and belonging, the ability to work together, membership in community-based organizations (CBOs), relationships of trust and cooperation, and the formulation of rules, norms and values to enforce decisions. People have greater access to social assets in the mid-hills than in the *terai*.

FIGURE 3.4

Spider diagrams of household access to livelihood assets in selected VDCs of mid-hills (Arghakanchi and Udaipur) and *terai* (Kapilvastu and Siraha) districts



The availability of basic physical facilities such as roads, electricity and markets, and of agricultural facilities such as houses, implements, orchards and homestead gardens determines the status of physical assets. About 74 percent of respondents in the *terai* stated that they have access to various physical assets, compared with 53 percent in the mid-hills. Human assets include local capacity such as knowledge, skills and experience, the availability of skilled technicians, and the implementation of preparedness plans and programmes. In terms of human assets, the *terai* is better off than the mid-hills.

3.2.3 Vulnerability factors at the community level

Smallholders, landless labourers, Dalits, Janajatis and low-income groups are the most vulnerable to climate variability and change. Even well-off and medium categories of farmers are vulnerable if their land is along a riverbank or in the foothills. Several factors contribute to the vulnerability of these livelihood groups, including the following:

- **Frequent occurrence of floods and landslides:** Houses and cultivated land in flood- and landslide-prone areas (mainly along riverbanks and in the foothills) are the most vulnerable to climate impacts. The destruction of livelihood assets (homes, sheds, canals, roads, weirs and dams) and the sedimentation of cultivated land affect livelihood activities.
- **Dependence on rainwater for irrigation:** Irrigation is one of the most important inputs for improved crop productivity. Farmers who rely on rainwater for irrigation are more vulnerable than those who have irrigation facilities.
- **Small landholdings:** Smallholders are often vulnerable because they have insufficient land suitable for enterprise diversification.
- **Increasing number of landless people:** The *sukumbasis* (landless people) are compelled to live near forests. Although the forest land is productive, these livelihood groups face competition from wildlife, and disputes arise between forest user groups and landless people.
- **Flood and inundation areas:** People living in areas subject to frequent flooding and inundation are particularly vulnerable. Flooding and inundation often damage or destroy productive land and important assets such as houses, livestock and grain stocks.
- **Lack of resources to invest in farming:** Because of their inability to invest more in improved farming, poor farmers are vulnerable to repeated crop failure.
- **Emergence of new diseases and pests:** Epidemics of diseases – such as rust and loose smut in wheat, and late blight in potato – are often the result of abnormal climatic variations. The trend for high temperatures and high-intensity rainfall followed by longer droughts induces outbreaks of many insect pests. Sheath rot and northern blight in maize, aphids in winter vegetables, and ticks, scabies, lice and leaches in animals are considered major problems.
- **Poor knowledge and skills:** Farmers are unable to treat the diseases and pests of livestock, crops and vegetables because of their inadequate knowledge and skills.

- **Lack of on-farm employment within the village:** The search for alternative employment opportunities forces many men to leave the village, mainly for nearby cities in Nepal and India, leaving women, children and elderly people at home.

3.3 IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON AGRICULTURE

3.3.1 Local perceptions of impacts

In the *terai*, the major hazards perceived by farmers are floods, droughts, heat waves, cold waves and frost, and dew/*pala* (winter fog causing blight in potatoes). The areas along riverbanks are affected by sedimentation caused by floods, which – together with landslides – are also the main causes of damage to standing crops and erosion of productive land along riverbanks or in the foothills. These hazards damage community assets such as roads, schools, market centres, irrigation canals, drinking-water systems and forest resources. Droughts cause crop failures, particularly of winter crops (wheat, oilseeds and pulses). Farmers perceive that the frequency of these hazards is increasing, mainly because of changes in temperature and rainfall.

Farmers perceive that irrigation facilities are becoming less reliable because of more frequent and longer droughts, the depletion of forest resources in the Churia area, and irregular rainfall patterns. The longer droughts are responsible for lowering the groundwater table, leading to the poor performance of deep and shallow tube wells in the *terai*. Increasing sedimentation through high soil erosion upstream is creating a seepage problem, leaving farmers unable to divert water from the river into their irrigation canals.

Farmers perceive that knowledge and skills on improved farming – such as selection of crop varieties, seed and nursery management, proper use of chemical fertilizers, off-season vegetable production, soil fertility management techniques and post-harvest technologies – are the key for increasing crop yields. Farmers in the *terai* are affected by the Indian Government's policy of subsidizing Indian farmers for seeds, fertilizers and irrigation facilities, making it difficult for Nepalese farmers to compete in the market.

Local perceptions about changes in monthly rainfall and the negative impacts of decreased rainfall are similar in both the mid-hill and *terai* districts. The changing pattern of hailstorms is observed mainly in the mid-hills, while changing temperature patterns have affected farmers in the mid-hills, the *terai* and the mountains. Communities in mountain ecosystems also face frequent landslides, droughts, temperature increase and changes in rainfall patterns. According to RIMS (2010), local residents in Temrang, Rasuwa have noticed early flowering of rhododendron, absence of winter rain, long droughts and late arrival of the monsoon and snowmelt. Local perceptions of recent climate and non-climate changes include:

- longer winter droughts extending into late spring
- less water in wells, hand pumps and canals
- low productivity of oilseed and pulse crops
- vegetable production affected by increased infestation of insects
- smaller grain size and low quality of lentils, mustard and wheat, mainly because of inadequate soil moisture (and irrigation) during seed formation
- increased incidence of insects, pests and diseases of crops and animals
- more frequent frosts and foggy days in the mid-hills
- more erratic rains and floods during the monsoon in the *terai*
- venomous snakes moving to higher altitudes.

In recent years, local communities have noticed new, invasive plants in watershed areas. An interesting fact reported by key informants is that invasive species are gradually moving to higher elevations; for example, *Eupatorium odoratum* has been seen at elevations of up to 1 500 m, which can be correlated to the warming trend in the watershed. The flowering period of some of vegetables, such as *Cucumis sativus* (cucumber), *Luffa cylindrica* (chichinda), *Trichosanthes cucumerina* (ghiraula) and *Cucurbita moschata* (pumpkin), is changing and is now a week or two earlier than it was 20 to 25 years ago. A similar phenomenon is observed in fruit trees such as *Citrus limonia*, *Pyrus calleryana* and *Mangifera indica*.

Farmers are planting crops later than they did 20 to 25 years ago, but crop harvest times are the same or even earlier than they were. There are two possible reasons for this: change in crop species, especially improved varieties; and change in climate. Warming of the environment ultimately accelerates the plants' metabolism, which causes early ripening of crops. For example, millet planting used to start in mid-June, with harvest after mid-November, but this trend has changed over the last decade, and planting now starts in July with harvest starting by the end of October.

On the other hand, positive effects from increased climate variability are also being noticed. Farmers in Mustang and Manang districts (high mountain areas) have noticed improved apple sizes. Other farmers are able to grow cauliflowers, cabbages, chilli, tomatoes and cucumbers, which used to require greenhouses to survive. Local fruits have better sizes and tastes (Dahal, 2005). A farmer in the Murza VDC of Myagdi district in western Nepal reported that rice cultivation is becoming possible at higher elevations, currently of 1 800 to 2 400 m (Dahal, 2006).

3.3.2 Gender dimensions of the local perceptions of climate impacts

According to a FAO study (FAO, 2010a), women in the *terai* and mid-hills grow rice, wheat, mustard, vegetables and livestock. Women's groups perceive that lack of water for winter crops is one of the main problems in agriculture. Women report experiencing changes in climate conditions, especially temperature rises and decreases in rainfall; droughts are increasing and affect the productivity of wheat. Winter vegetable cultivation is affected by insects. Women's groups estimate that the food they produce from sharecropping and their own land lasts for less than eight months, and they have to buy food for the remaining period. Women report that about 75 percent of men have gone to the Gulf countries in search of work, leaving women to manage agriculture. The shortage of agricultural labourers, food deficits and lower productivity make women highly exposed to climate risks.

3.3.3 Crops and cropping systems

The impacts of climate change on crops and cropping systems vary according to whether the system depends on the summer monsoon or on snow, ice and glacial melt. Agricultural systems that depend on water sourced from snow, ice and glacial melt will see an immediate increase in water supply, but will also be in greater danger of GLOFs, which threaten crops, water infrastructure and mountain livelihoods in general. Whether such an increase will increase productivity in the short term is unknown. The effects of reduced water storage and the variability of supply from earlier thawing of the snowpack and de-glaciation may be significant, with glacial melt accounting for 30 percent of per capita water consumption in some lowland regions (Eriksson *et al.*, 2009) and increases in temperature causing increases in agricultural water demand. Unfortunately, because these effects are not likely to be felt for decades, the short-term benefits of increased runoff will likely delay the effects of comprehensive long-term proactive management plans.

For systems that depend on the summer monsoon, multiple scenarios are possible because of the uncertainty of the models and the lack of data, with the potential for the monsoon to transition abruptly between "dry" and "wet" states. In the short term, there is more certainty that precipitation is likely to decrease during the summer months as the number of rainy days decreases, although the frequency of intense rainfall events will increase (UNEP, 2008). The increasing variability of precipitation patterns will have a significant effect on crop productivity, as farmers will have to adapt to changing monsoon onset and termination dates. Later monsoon start dates had significant impacts on rice crops in 2009, as many seedlings were lost because of the delay in rainfall, and many others had insufficient time to mature for ensuring a viable yield (Subel, 2009).

The main summer crops of Nepal are paddy, maize and millet, which comprise nearly 80 percent of total national cereal production. In 2009, according to MOAD estimates, paddy production was 0.5 million tonnes less (equivalent to 11 percent) than it was in 2008. This significant reduction was mainly due to the late arrival of the monsoon, which delayed crop planting. Maize, the second largest crop, suffered a production decline of 4 percent. Millet achieved a minor increase, of 2.3 percent, but this was not enough to compensate for the losses in paddy and maize because millet accounts for a very small share of national cereal production.

With the increased intensity of summer monsoon rain events, the risk of flash flooding, erosion and landslides may be increased. With warmer winters, particularly at higher altitudes, less precipitation will fall as snow, accelerating glacial retreat, but also reducing soil moisture and therefore affecting winter crops. However, because of Nepal's diverse topography and range of ecological zones, the overall impacts of climate change on agriculture and ecosystems are likely to be highly variable, depending on location.

The future impacts of climate change on agricultural production as calculated by Cline (2007) suggest an initial increase of production until 2050, caused by carbon fertilization, followed by a decrease of 4.8 percent by 2080, based on the assumption of a positive carbon fertilization effect from a temperature increase of up to 2.5 °C. These figures do not reflect the most likely negative impacts on agricultural production of climate extremes, which are likely to increase in frequency and intensity during this time span.

The impacts of reduced water during dry months are much easier to visualize, as recent winter droughts have continued to show the effects of low water supply. During the drought from autumn 2008 to spring 2009, agricultural systems experienced significantly reduced crop yields, resulting in food insecurity for millions of people. Western regions will be the most detrimentally affected because they rely heavily on winter rains and cannot depend as much on summer monsoon rains, which are less intense in the west because of the natural pattern of rainfall intensity from east to west (WECS, 2005).

An analysis by the Nepal Agricultural Research Council (NARC) using simulation models for major crops such as rice, wheat and maize suggested that rice yields might increase under elevated CO_2 and a 4 °C temperature increase, by 3.4 percent in the *terai* (lowlands), 17.9 percent in the hills and 36.1 percent in the mountains. Wheat production might increase by 41.5 percent in the *terai*, 24.4 percent in the hills and 21.2 percent in the mountains under elevated CO_2, but would be significantly decreased by a 4 °C temperature rise, which would also be expected to cause maize yields to increase in the hills and mountains, but to decrease in the *terai* (Malla, 2008). The simulations perhaps considered ideal potential production conditions mainly conditioned by CO_2 and temperature. However, the scenario may be different if practical management practices being followed by farmers are considered.

Changes in the form, intensity and timing of precipitation and cold and heat waves, prolonged dry periods, the upward expansion of ecological belts, and changes (lengthening or shortening) of the growing season are also expected to affect crop production and the natural resource balance, including the habitats of agro-biodiversity. Changes in the timing, intensity and distribution of precipitation directly affect crop water supply. A variety of impacts can be seen on crops and the natural habitats of crop wild relatives when the temperature range exceeds optimum limits, which vary among plant types. Temperature rises combined with changes in precipitation characteristics can worsen the situation. Thapa and Joshi (2010) concluded that the impact of climate change on agriculture seems to be varied with the temperature and precipitation in different climatic zones.

Poudel and Kotani (2013) applied a stochastic production function approach and concluded that an increase in the variance of both temperature and rainfall has adverse effects on crop production, but impacts are heterogenous depending on the altitude and the kinds of crop. The impacts of climate extremes can have very serious effects on crop growth and production when they coincide with critical crop stages such as flowering. Paddy, which requires abundant water for growth and development, is easily affected by delays in the monsoon and the resulting delays in transplanting. Particularly in the *terai*, wheat yields and production are affected by the November to March temperature regime, but in the hills, wheat yields are more affected by drought than temperature (Nayava *et al*., 2009).

With a doubling of CO_2, wheat production is likely to increase through the adoption of more heat-tolerant varieties. To identify the relation between climate parameters and crop cycles, diurnal variations and short-term temperatures such as the weekly and ten-day means with reference to daily temperatures are needed. Increased minimum temperature has been found to result in poor wheat yield in Bhairhawa (Nayava *et al*., 2009).

3.3.4 Livestock and dairy production

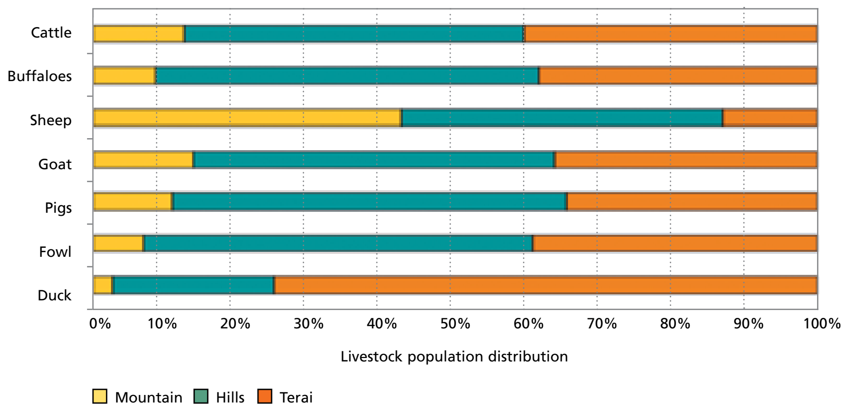
The livestock population is concentrated in the hills and mountains (Figure 3.5). Higher temperatures would likely result in reduced animal weight gain and reproduction and lower feed conversion efficiency in these regions. Most diseases are transmitted by vectors such as ticks and flies, whose development stages are often heavily dependent on temperature. Ruminants are vulnerable to an extensive range of nematode worm infections, whose development stages are influenced by climate conditions (Musemwa *et al.*, 2012).

There is an increase in heat-related mortality and morbidity with higher temperatures during hot summers (ActionAid, 2007). On the other hand, increased temperatures during the winter months can reduce animals' energy requirements. The feed intake of animals is affected by rising temperatures, especially during summer. The dry matter intake of calves can decrease by 5 to 10 percent in summer compared with their winter intake (FAO, 2010b).

Meat and milk products are highly sensitive to fluctuations in storage temperature. An increase in temperature decreases the quality of meat and milk and the hatchability of poultry chicks, while the incidence of

FIGURE 3.5

Livestock population distribution in major ecological regions of Nepal



livestock diseases increases, with higher morbidity and mortality. As ambient temperatures increase, the efficiency of animals' nutrient utilization decreases, along with the digestibility of nutrients. These affects are more pronounced in exotic and cross-bred animals (Ranjhan, 2003). High temperatures in summer cause both ruminants and their herders to suffer heat load during pasture grazing.

As a result of increased temperatures, especially in the mid- and high hills, the breeding patterns of cattle and buffaloes have been changing, and calving seasons will be affected. Cases of infertility and sterility in cows and buffaloes have increased. Prolonged drought conditions have led to concentrations of toxic/antinutritional substances on sprouted fodders, which may poison or cause infertility and sterility in ruminants. Rises in temperature are reported to have caused high prevalence of parasitic diseases (liver fluke and nematodes), ectoparasite infestation and new skin diseases in animals (FAO, 2010b). Lactating cows, buffaloes and poultry birds suffer from heat stress.

Climate change will affect water availability in the future, influencing livestock drinking-water sources and feed and fodder production systems. Animals' water requirements increase during hot summers, because water helps them to lose heat. Prolonged droughts with higher ambient temperatures have caused the drying up of water sources. The drought of 2009 lowered rice yields by 40 percent, which affected the availability of rice straw for ruminants. Water shortages persisted until the onset of the monsoon, causing household members – especially women – to spend much more time and energy seeking and fetching water from distant sources.

Shortages of feed, fodder and water ultimately result in lower health conditions and production potentials among ruminants. Droughts, floods and landslides affect animals' feed supply, health and productivity, and damage many animals every year. As climate hazards become more frequent, infrastructure such as animal sheds are washed away by landslides, floods and inundations, causing heavy economic losses. When roads are submerged under floodwater the marketing of products and input supplies is affected for several days.

The possible impacts of climate change on high-altitude livestock in the Khumbu region have been analysed, based on interviews with herders and local people (Sherpa and Kayastha, 2009). The heavy wool and other specialized thermoregulatory mechanisms of yaks keep these animals alive in extreme conditions at high altitudes, but are a liability in warmer weather (Brower, 1991). In addition, their lack of immunity to lowland cattle diseases makes yaks prone to water- and vector-borne diseases. Yaks can survive in summer pastures at high altitude even during severe winters, as long as there is sufficient fodder, but they cannot withstand the warmer climates at lower settlements in the sub-alpine region, where flies irritate the yaks, forcing them to migrate upslope.

The Sherpas, an ethnic group from the mountainous region, have their own indigenous pastoral land-use and livestock management system. They practise transhumance, which is a system of migrating with their livestock, upslope in summer to settlements called *yersa*, and downslope to lower elevations in winter to settlements called *ghunsa (*Bhattarai and Garton, 2011). Local communities operate this transhumance system through a rotational grazing arrangement called *dee*, which ensures effective management of pastureland and conservation of natural resources.

In Khumbu (northeastern Nepal), livestock depend entirely on rangeland resources, and are left to graze freely on pastures when there is good grazing. During winter and early spring, however, all livestock must be fed fodder to survive. Hard winters and dry summers are considered the most challenging times for herders, as they may face shortages of fodder, with livestock losses resulting from starvation. Many people believe that in recent years, the onset of rainfall in this region has been delayed, affecting pasture growth.

Water is another crucial factor for livestock survival. Yaks prefer rangeland with good grass and sources of water. Recently, water has become a major problem, especially in settlements located a long way from rivers. With no snowfall in winter and no rain in even late spring, water sources dry up, creating water shortages, especially during winter and early spring.

Regarding plant genetic resources, declining forage production in natural pasture – resulting from the poor emergence of grasses and pastoral degradation – outbreaks of invasive species in rangeland, the loss of transhumance systems, and shortages of feed ingredients are among the main climate change impacts and concerns affecting animal husbandry and herders' livelihoods (Pokhrel and Pandey, 2011).

There is also evidence that vector-borne diseases in livestock are increasing, forcing livestock populations to move to higher altitudes (Practical Action, 2008). A critical issue for farmers is the lack of animal feed, which reduces livestock numbers and manure, increasing the dependence on chemical fertilizers. Local livestock breeds are declining because of the introduction of hybrid and conventionally improved breeds. According to farmers, hybrid livestock are more vulnerable to diseases, which cause large losses.

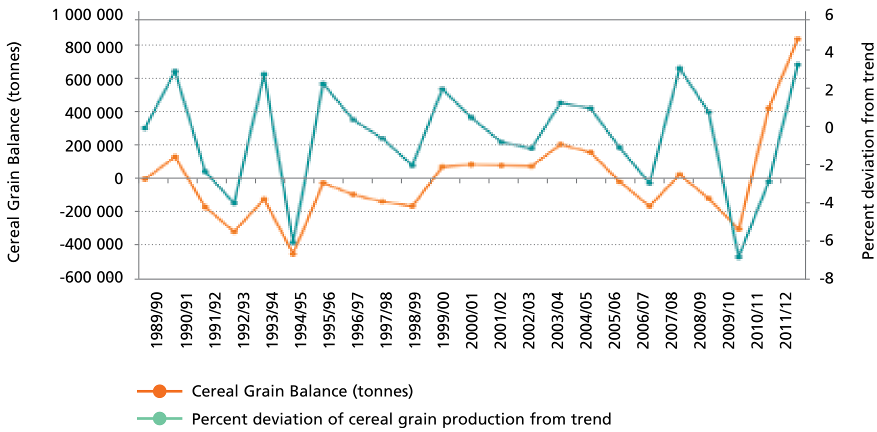
3.3.5 Food security

Of Nepal's population of 27.8 million people, 4.5 million (16 percent) are undernourished (FAO, 2010c). Through its impacts on production, distribution, utilization and sustainability, food insecurity is expected to contribute to additional vulnerability to climate extremes. It is estimated that more than 3.4 million people in Nepal require food assistance because of a combination of natural disasters, including the 2008/2009 winter drought – one of the worst for several decades (MOAC, WFP and FAO, 2009). Negative deviations in foodgrain production cause negative cereal grain balances and are often linked to climate-related extremes (Figure 3.6).

The highest incidences of food insecurity are found in the mountain and hill areas, particularly in remote areas of the Mid- and Far-Western Development Regions and among the most marginalized sectors of society based on gender, caste and ethnicity. Cereal grain balance data from MOAD's publications on

FIGURE 3.6

Cereal grain balance (requirement-to-production) and percentage deviation of cereal grain production from trend



Note: Analysis based on data from MOAD (2012)

statistical information on Nepalese agriculture show that mountains and hills face a cereal grain deficit, as production is less than requirement (Table 3.1). The negative balance is greater in years affected by extreme climate events, such as drought in 2009/2010, than in relatively normal years.

These zones are also considered the most food-insecure and have proportionately higher populations of Dalits and ethnic minorities. People who depend on forest resources have to buy food from outside, and often the income from forest-based livelihood activities is insufficient to meet household food needs. Most of Nepal is mountainous, and there are many pockets of food-deficit areas.

3.3.6 Land degradation

Riverbank cutting and the covering over of grassland with debris and sand have caused soil erosion and loss of vegetation and community pastureland, leading to a shortage of feed for ruminants. Delayed rainfalls (monsoon) and prolonged drought conditions have resulted in the drying up of tree fodder and delayed the emergence of local grasses, adversely affecting the availability of green fodder and resulting in lower physical condition and productivity of animals.

TABLE 3.1
Edible cereal grain balance in ecoregions of Nepal (tonnes)

REGION	BALANCE (REQUIREMENT-TO-PRODUCTION)	
	2009/2010	2011/2012
Eastern mountain	9 970	51 074
Eastern hills	43 586	1 98 128
Eastern terai	17 094	1 51 042
Central mountain	-22 928	15 546
Central hills	-4 26 323	-3 47 863
Central terai	-27 024	1 68 576
Western mountain	-3 410	-411
Western hills	86 085	2 14 440
Western terai	1 21 118	2 12 562
Mid-western mountain	-27 172	-18 764
Mid-western hills	-19 021	45 759
Mid-western terai	31 664	1 61 503
Far-western mountain	-53 677	-31 670
Far-western hills	-95 231	-17 531
Far-western terai	35 297	83 917

Cultivable land soils are expected to be eroded as a direct result of changes in rainfall intensity and distribution trends. In the hills, soil erosion is estimated to be about 24 million m^3 a year, or about 1.7 mm in the depth of productive soil (Lohani, 2007). The rate of soil erosion is expected to increase as climate variability increases, thereby affecting cultivation and production. Other major impacts expected in crop husbandry are declining availability of water for agricultural uses, negative effects on the operation of conventional irrigation systems and decreasing water use efficiency, increased degradation of agricultural and forest land, increased depletion of land from agricultural uses, loss of crop diversity, more disease and pest epidemics, and increased crop management risks. Challenges associated with the poor availability of quality planting materials and technologies for adapting to changing contexts are expected to have adverse effects on crop production and the economic sustainability of farmers (Pokhrel and Pandey, 2011).

3.4 RECENT EXTREME CLIMATE EVENTS AND IMPACTS

Extreme weather events associated with excess and deficit rainfall are the principal cause of natural disasters in Nepal (Table 3.2). The average area-weighted annual precipitation of Nepal is about 1 630 mm, with half of the country lying within the 1 500–2 000-mm precipitation zone (Chalise and Khanal, 2002). High-intensity rainfall often causes flooding and associated landslides.

Continuous rainfall in July 1993 triggered an unprecedented number of landslides and floods in south-central Nepal. A station at Tistung in the Kulekhani catchment recorded 540 mm of rainfall in 24 hours on 19 July 1993 (NCVST, 2009). In 1998, heavy monsoon rains in the Rohini basin in both lower catchments and foothills caused similar flooding.

Unplanned infrastructure also causes severe flooding. For example, on 18 August 2008, a massive flood on the Koshi River breached about 1.7 km of the river's embankment. Far-western Nepal is prone to floods because of unplanned infrastructure development; in September 2008, heavy monsoon rains affected several *terai* districts and inundated agricultural land. The damage was attributed mainly to roads and irrigation canals built in an east–west orientation perpendicular to the north–south flow of the rivers (NCVST, 2009).

Nepal is prone to glacial lake outburst floods (GLOFs), which pose a direct threat to communities living in the high mountains and in lowlands. ICIMOD (2007) reported that Nepal has 2 323 glacial lakes. Climate change results in the melting of glaciers, and the resulting changes could alter the regional hydrological system and pose a major risk to the population living downstream. The melting of glaciers also increases the volume of water in glacial lakes, thereby increasing the threat of a GLOF.

Low rainfall during the winter season affects several agricultural crops. The 2008/2009 winter drought in Nepal was one of the worst on record. According to the Department of Hydrology and Meteorology, rain monitoring stations across the country received less than 50 percent of average precipitation for the period from November 2008 to February 2009, causing decreases in national wheat and barley production. Projections of a wide range of precipitation changes, greater climatic variability and increases in temperature throughout the country suggest that the frequency of winter droughts will increase.

TABLE 3.2

Recent extreme climate events in Nepal and their impacts

EVENT	DATE	CAUSES	IMPACTS
Mid-mountain and terai floods (1993)	19–21 July 1993	Continuous rainfall	Rainfall caused flooding of Bagmati River and its tributaries. Damaged 43 330 ha of cultivated land and 38 small and large irrigation schemes
Terai floods (1998)	June, July and August 1998	Record monsoon rainfall	Flooding and landslides affected 73 of 75 districts. 28 000 ha of arable land were inundated or damaged, causing harvest shortfalls
Koshi flooding (2008)	18 August 2008	Koshi River embankment breaching	The impact was estimated to have cost US$88 million, with damaged irrigation facilities in Kailali and Kanchanpur districts. The estimated cost of damage to irrigation facilities on 11 542 ha was US$12.7 million. Loss of agricultural income caused by lack of irrigation was an estimated US$16.6 million (ADB, 2008)
Far-western Nepal floods (2008)	19–21 September 2008	Heavy monsoon rains and flooding	Affected terai districts were Banke, Baridia, Kailali and Kanchanpur; hill districts were Dang, Dadeldhura, Doti and Salyan (NCVST, 2009). The main cause was believed to be roads and irrigation canals built in an east–west orientation perpendicular to the north–south flow of rivers
Winter drought (2008/2009)	November 2008 to February 2009	Less than 50% of average precipitation	National wheat and barley production decreased by 14.5% and 17.3% respectively. Annual crop production for 2008/2009 recorded a negative production balance of 133 000 tonnes of cereal (-2.5%). This was exacerbated by sustained high food prices, with 66% of rural households hit heavily by food shortages. The worst-hit areas were the far- and mid-western hill and mountain districts (MOAC, WFP and FAO, 2009)
Forest fires (2009)	Winter drought 2008/2009	Low precipitation and dry conditions	Damaged 105 350 ha of forest land, leading to the death of significant numbers of livestock and risk, particularly in the terai and mountains

Wang *et al.* (2013) analysed the meteorological conditions and a historical perspective of winter droughts in western Nepal using instrumental records, satellite observations and climate model simulations. This study revealed that winter drought in western Nepal is linked to the Arctic Oscillation and its decadal variability, and that the persistent warming of the Indian Ocean likely contributes to the suppression of rainfall through enhanced local Hadley circulation. The study concluded that the recent spells of decadal drought in Nepal are the result of both natural variability and anthropogenic influences. Sigdel and Ikeda (2010) studied the connection between Standardized Precipitation Index (SPI) of Nepal and climate indices such as Southern Oscillation Index (SOI) and Indian Ocean Dipole Mode Index (DMI) and suggested that one of the causes for summer drought was El Nino, while the winter drought was related to positive DMI.

The winter drought of 2008/2009 also caused forest fires. The 2009 forest fires may well be indicative of the future impacts of climate change, because an increasing frequency and intensity of drought during dry months and heat waves would greatly increase the risk of fire. In addition to their direct impact, fires also expose soil by destroying the vegetation, thereby increasing rates of erosion and sedimentation. Intense precipitation on areas damaged by fire and drought tends to generate higher sediment loads.

Phenomena such as fog (*pala*) episodes are also frequently reported (Manandhar, 2006) in the *terai*, and reduce the maximum temperature significantly (Baidya *et al.*, 2008). Thick fog in the *terai* plains in 1998 enveloped a very large area of the north Indian Gangetic plains, as well as the southern *terai* plains of Nepal, and the ensuing prolonged cold waves during the winter season had a serious negative impact on winter crops. Thick fog persisted for several days in parts of the *terai* belt in January 1998, causing a drop in day-time temperature (DHM, 1998). *Pala* during the winter cause decreases in the production of winter crops; potatoes and pulses are badly affected by *pala*. Consultations with local communities indicate that winter fog now remains for several days longer than in the past (ActionAid, 2007).

These extreme climate events and their consequences illustrate several key impacts that climate change will probably bring. These impacts may include extremely wet climates during the rainy season with extremely dry conditions during the dry months. Drought-like conditions will damage the vegetative cover, making the hillsides extremely susceptible to landslides and soil erosion. The increase in overall aridity will probably increase sediment loads, as will the extreme rainfall.

CHAPTER 4

INSTITUTIONAL CONTEXT FOR MANAGING CLIMATE RISKS AND ADVANCING ADAPTATION

4.1 INSTITUTIONAL INNOVATIONS TO ADVANCE ADAPTATION

Institutions play a key role in introducing new agricultural technologies to farmers. Changes in resource endowments resulting from climate change can become a trigger for institutional innovation. Institutions can reinforce agricultural adaptation by introducing location-specific technologies in anticipation of future needs (Chhetri and Easterling, 2010), linking local, national and international institutions to transfer technologies, integrating local institutions into markets to enhance economic returns (Agrawal, 2008), and helping farmers to organize and manage local resources through collective action.

Farmers and their support institutions are the key players in technological innovations and have been an integral part of agricultural development (Chhetri *et al.*, 2012). Agrawal (2008) argues that the capacity to respond to changing climate depends on knowledge flow through a broad range of institutions, including farmer-to-farmer interactions. In this context, there is a strong need for participation of institutions to enable improvement of agricultural support services to farmers. These institutions each have their areas of focus, and together they provide farmers with access to services that facilitate improved agricultural practices.

Innovative technologies at the local level are crucial for enhancing the adaptive capacity of farmers (Chhetri *et al.,* 2012). Adaptation practices should be introduced with the full participation of farmers and the community-based organizations, as interactions among local institutions and farmers facilitate knowledge exchange and awareness rising. Nepal's evolving experience in dealing with impacts of climate variability has shown that there is a demand for the participation of farmers and their supporting institutions in advancing adaptation. The development of multi-level institutional partnerships, including collaboration with farmers and NGOs at critical stages of technological development and transfer, is crucial to advancing climate risk management, adaptation and resilience building.

4.2 INSTITUTIONS FOR MANAGING CLIMATE RISKS AND ADAPTATION

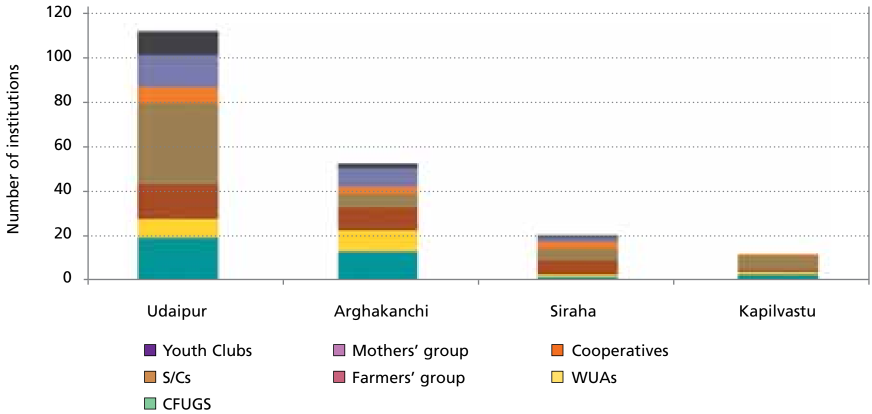
4.2.1 Community-level institutions

Different types of organization work at the community level: community forest user groups (CFUGs), local NGOs, mothers' groups, youth clubs, farmers' groups, CBOs and government organizations (Figure 4.1). However, this broad range of existing institutions suffers from gaps that include the lack of networks among institutions at the local level, inadequate connections to external agencies, ineffective governance, and poor coordination on matters related to climate change. The results of the analysis indicated that less than half of community members are involved in CBOs: about 48 percent of respondents in the mid-hills, and only 37 percent in the *terai* (FAO, 2010a).

CFUGs play a significant role in protecting the forest through community plantations. They promote controlled grazing to reduce soil erosion and riverbank cutting, and participate in the construction of roads, culverts, drinking-water facilities, community sanitation and small temporary crossings in villages. CFUGs provide very sustainable grassroots-level institutions that can take the lead on natural resources management and adaptation. Regmi and Karki (2010) argued that local-level adaptation should be piloted by mobilizing CFUGs and the forestry coordination committees of VDCs.

FIGURE 4.1

Number of active community level institutions (total of 3 VDCs) in selected VDCs in some districts of Nepal



Water user associations (WUAs) are responsible for managing river water for surface irrigation; their main task is water management within their respective command areas. WUAs promote increased productivity and crop yields by managing irrigation in farmers' fields and contribute to reducing the impact of floods and water inundation.

Framers' groups are responsible for sharing knowledge and skills with each other and disseminating new technologies among their members. Some farmers' groups gather funds to supply agricultural inputs and tools such as spare parts and pesticide tanks, and low-interest loans for members. They help to disseminate knowledge and skills in disease and pest management and improved farming, organize training and tours, distribute inputs, and implement awareness raising and riverbank protection work with bioengineering.

Savings and credit groups collect monthly contributions from their members and extend loans to small-scale enterprises at reasonable interest rates. Most loans are used to acquire agricultural inputs for improved farming. Savings and credit groups are effective in building farmers' coping capacities to reduce the impacts of climate risks.

Several other types of institution contribute to climate risk management and increasing the adaptive capacity of local communities:

- **Cooperatives** provide various facilities – marketing of inputs and products from cooperative farming, market regulation of agricultural commodities, and provision of loans to support farmers' on- and off-farm activities.
- **Youth clubs** are involved in social mobilization, community empowerment, advocacy and the enforcement of rights.
- **Mothers' groups** impart knowledge and skills in improved agricultural practices among their members, as well as carrying out regular savings and credit activities.
- **Local NGOs** provide training and implement interventions for reducing the effects of climate-related hazards.
- **Government organizations at the local level** deliver technical training to develop the capacities of farmers' groups.

Regarding climate risk management and adaptation, cooperatives could be instrumental in reducing vulnerability by providing financial support to create off-farm, income-generating activities. In Nepal, about 1.2 million people are involved in cooperatives, which directly employ more than 16 000 people. Women's cooperatives account for 12 percent of the total number of cooperatives. The services offered by cooperatives are instrumental in generating income through the establishment of microenterprises and employment opportunities, but cooperatives need to reach the poorest of the poor, women and other disadvantaged groups.

Women's cooperatives mobilize local resources to create employment opportunities for women. There are many examples of rural women receiving financial support for microenterprises such as goat raising, vegetable cultivation, puffed rice production, snack making, tailoring, tearooms and grocery shops.

Cooperatives' capacity could be further strengthened by building strategic alliances with other service providers at the district and national levels. For example, women's cooperatives can establish links to biogas companies, and cooperatives can operate as marketing agents for the supply of local products through links with larger market actors.

4.2.2 Community participation in local institutions

Community mobilization is a prerequisite to enhancing local communities' participation in climate risk management and adaptation. Supply-based interventions implemented by institutions without proper social mobilization lead to unequal access to resources and institutional services. There is limited provision for needs-based services, so initiatives are not sustained in the long run.

Community participation is critical to understanding location-specific risks and suitable responses, and failure to take into account location-specific characteristics can undermine development activities, especially in risk-prone areas. District-level agriculture and livestock offices should engage local institutions in promoting location-specific practices: for example, in marginal/sloping land, goat raising is a better option than buffalo raising; the high-yielding maize variety Rampur Composite is not necessarily suitable in the mid-hills because of infestations of white grub, borer, northern blight and sheath rot; and the pulpy variety of ginger yields less in areas prone to rhizome rot.

Several factors reduce communities' participation in local institutions. Thomas-Slayter and Bhatt (1994) observed that in rural Nepal, caste and ethnicity constitute the most important variables around which individuals, households and communities aggregate for group action. Although not associated with efforts to address climate adaptation, caste has a deep-rooted role in determining how individuals react to climate stress, variability and change. This has significant implications for people's capacity to adapt, particularly people in lower castes.

4.2.3 District-level institutions

At the district level, the District Disaster Relief Committee (DDRC) is the permanent body for coordinating relief and preparedness activities. Each DDRC is chaired by a Chief District Officer, who is the main administrative functionary for maintaining law and order at the district level. Other DDRC members are representatives of the district-level offices of various public sector agencies, such as those for water supply, education, health, national-level political parties and the Nepal Red Cross Society, the police, housing and urban development, irrigation and forestry, the district agriculture development bank and the District Agriculture Development Office (DADO). The Local Development Officer – the district-level officer of the Ministry of Local Development, who coordinates development work with elected bodies at the district level – is the DDRC Secretary. The roles and responsibilities of the DDRCs are to:

- facilitate, monitor and guide relief and response activities;
- oversee the development, implementation, monitoring and periodic updating of disaster risk reduction strategies, plans and programmes through government and non-governmental entities at the district level;
- formulate and implement response, recovery and rehabilitation plans;
- mobilize resources for response, recovery and rehabilitation after a disaster;
- establish networks and coordinate response activities among international and national NGOs, private sector actors and government stakeholders;
- assess the disaster risks arising from different natural hazards and vulnerabilities, and develop a system for periodically updating these assessments;
- coordinate with the Central Disaster Relief Committee during disasters that affect the district.

The DDRC is familiar with conditions at the district level and is the apex body for coordination and linkages during a disaster. DDRCs have the capacity to mobilize resources for designing and implementing risk management projects, and act as sharing fora for the mainstreaming of climate risk management into district-level programmes and projects. DDRCs could play a major advisory role in climate risk management and climate change adaptation at the district level, but they will require comprehensive capacity development initiatives to do so.

4.2.4 National-level institutions

On 23 July 2009, the Government of Nepal constituted the Climate Change Council chaired by the Prime Minister. This 25-member council provides guidance on policies and programmes. Its major functions are to:

- provide coordination, guidance and direction for the formulation and implementation of climate change-related policies

- provide guidance for the integration of climate change issues into long-term policies, perspective plans and programmes
- take measures to include climate change in the national development agenda
- initiate and coordinate activities for generating additional financial and technical support for climate change-related programme and projects
- initiate and coordinate activities for generating additional benefits from international negotiations and decisions related to climate change.

Understanding the threats and adverse impacts of climate change, the government has constituted the Multi-sectoral Climate Change Initiatives Coordination Committee to serve as the national platform for ensuring regular dialogue and consultations on climate change-related policies, plans, financing, programmes/projects and activities. The committee will:

- establish and/or improve communication mechanisms among the institutions concerned with and involved in climate change;
- coordinate climate change response programmes to foster synergy, avoid duplication of efforts and optimize benefits from existing programmes, and coordinate activities related to policies, plans, strategies, financing programmes and projects;
- provide inputs for developing consensus on climate-related issues under international climate change negotiations;
- provide inputs to ensure financing for the effective implementation, monitoring and evaluation of adaptation actions, including those identified in the NAPA process.

The Ministry of Agricultural Development (MOAD) is the main body responsible for implementing the DRR and CCA programmes and projects in agriculture. The implementing agencies are the two departments, DOA and the Department of Livestock Services, of MOAD. Agricultural development programmes are implemented in all 75 districts of Nepal, with several agricultural service centres and thousands of pocket areas operating at the grassroots level. Supervision and technical backstopping at the regional level are carried out by five regional directorates, each with agriculture and livestock departments.

As actions for climate risk management and adaptation are location-specific, and to cater to the needs of vulnerable districts, there is need to establish a team of regular staff responsible for supervising, coordinating and facilitating the planning and implementation of prioritized activities. Periodic monitoring of activities should be carried out by existing human resources according to the regular procedures of MOAD.

4.3 ENABLING INSTITUTIONS FOR MANAGING CLIMATE RISKS AND ADAPTATION

4.3.1 Strengthening the technical capacity of institutions

The most important issue for initiating climate risk management and adaptation activities at the community level is the lack of awareness on climate change impacts. Institutions at the community level have not yet mobilized resources for adaptation activities. Although some institutions are involved in resource conservation and socio-economic development, the activities of these institutions are not linked directly to climate change adaptation. Table 4.1 shows the capacities that local institutions require for managing climate risks and advancing adaptation. Among the different types of institution, farmers' groups are the best placed to intervene in climate change adaptation as they are closely linked to agricultural activities and

PICTURE 4.1

Agricultural extension staff preparing crop specific climate risk calendars during a district level training programme

work with DADOs. These groups can also mobilize communities, as most households are members of the local farmers' group.

Farmers' groups play a vital role in agricultural activities, but their lack of resources affects their effectiveness. Most VDC revenues are mobilized via CFUGs, WUAs, cooperatives and savings and credit groups, so farmers' groups should be linked to other groups in the village to ensure access to resources and technologies. Farmers' groups could function as the coordinating

TABLE 4.1

Capacity requirements of local institutions for managing climate risks and advancing adaptation

TYPE OF INSTITUTION	CAPACITY REQUIREMENTS
CFUGs	Training on landslide and erosion control, and income-generating activities for community forest areas; promotion of skills in nursery cultivation, forest conservation and management, and afforestation; awareness raising on the impacts of climate hazards on people's lives and livelihoods; financial transparency for governance; fodder and fruit tree plantations in erosion-prone areas; forest resource-based income generation; rotational grazing; integrated approaches to the use of common property resources
WUAs	External resource mobilization for weir construction/rehabilitation and canal lining; equitable water distribution; plantations around springs and in upper catchments; awareness raising on the impacts of climate variability and change
Farmers' groups	Skills training in fertilizer application, pesticide handling, variety selection and soil fertility management; integrated pest management (IPM); management of sprinkle irrigation; easy access to agricultural inputs; awareness raising on the impacts of climate variability and change; organization of Farmer Field Schools (FFS); skills training in improved farming and optimum use of available resources; provision of crop and livestock insurance
Savings and credit groups	Training in group management, credit mobilization and income-generating activities (off-season); mobilization and management of revolving funds; awareness raising on the impacts of climate variability and change; organization of visits to other groups for experience and knowledge sharing
Cooperatives	Market linkages (inside and outside the district); management of agricultural inputs; training in cooperative management; identification of potential areas for investment to enhance people's livelihoods; facilitating investments in off-farm activities; improved marketing linkages; improved farming (vegetable, meat and milk production); small-scale technology transfer
Mothers' groups	Awareness raising on improved farming; training in income generation from goat rearing, vegetable production and small-scale cottage enterprises; training in fertilizer, insecticide and pesticide use
Youth clubs	Campaigns for disaster risk management, ecological conservation, watershed management and biodiversity conservation; community mobilization for the repair and maintenance of basic infrastructure (water resources, roads, schools, irrigation canals, forest conservation); awareness raising on the impacts of climate hazards

bodies for identifying problems and needs across the community, with close linkages to the local DDRC through the DADO enabling them to utilize district-level resources and expertise.

CFUGs create livelihood opportunities for rural communities, particularly poor and marginalized households. Community forestry has brought socio-economic change and contributed significantly to community development, livelihood diversification, biodiversity conservation, improved governance and greater social inclusion.

Infrastructure development by CFUGs includes construction of roads, bridges, irrigation facilities and drinking-water systems. CFUGs carry out projects to reduce the impact of disasters, such as river embankment strengthening, and some CFUGs support informal education, greatly contributing to adult literacy and awareness. CFUG employment creation and fundraising efforts include establishing savings and credit groups, developing forest-based enterprises and establishing markets for forest products.

FAO provided technical assistance to support several capacity development programmes for MOAD between 2008 and 2012 (Table 4.2). Agricultural extension officers from selected districts were trained on climate risk management and community-based adaptation. The Government of Nepal nominated 11 experts from the Department of Agriculture (DOA), the Department of Livestock Services and farmers' organizations to participate in an international field visit to northwest Bangladesh to learn about successful drought management practices. District-level field officers and farmers' groups took part in national-level field trips to share experiences and exchange good practices in disaster risk management (DRM) and climate change adaptation (CCA) interventions.

Several other training programmes were conducted for staff of DOA and the Department of Livestock Services. Topics covered included climate impact and vulnerability patterns; concepts of DRM and CCA; community-based adaptation and DRM tools and methods; adaptation options; early warning systems; and tools for evaluating and prioritizing DRM and CCA practices. A training programme included a hands-on, e-learning tool 'Planning for community based adaptation to climate change' to promote self-learning and practical exercises.

TABLE 4.2

Technical capacity development activities carried out between 2008 and 2012

CAPACITY DEVELOPMENT ACTIVITY	NUMBER OF EVENTS	NUMBER OF DAYS FOR EACH EVENT	NUMBER OF DIRECT BENEFICIARIES
Community-based approaches for climate change adaptation and disaster risk management in agriculture	1	3	34
E-learning training on planning for community-based adaptation	1	2	33
Training on CCA and DRM at district level	6	1	90
Introductory trainings for preparation of DDRMP at district level	4	2	163
Introductory training workshop for preparation of DDRMP at VDC level	12	1	390
Introduction to climate and crop data analysis at district level	4	½	16
DRM/CCA training to farmer groups	5	½ - 1	120
Training on alternate livelihood activities	3	1	230
Training on crop production technologies	3	1	60
Awareness programmes/campaigns and exhibitions for farmers	14	½ - 1	2 600
Field schools, field days and field visits	15	-	423
International training	2	14	2
International study tour	1	4	11
In-country field visit	1	5	48
Local field visits	4	1	30

4.3.2 Strengthening research and development linkages

Agricultural research stations and farms established in the mid-1960s tested technologies from other countries (Yadav, 1987). A more integrated approach to research and development began to emerge in Nepal in the early 1970s (Pokhrel, 1997), and by the mid-1970s, the focus had shifted towards the technological innovations suitable for ecological zones. Table 4.3 outlines how agricultural research has evolved in Nepal to address the problems associated with biotic and abiotic stress. The descriptions are

TABLE 4.3

Evolution of agricultural research relevant to management of biotic and abiotic risks since the 1960s.

PERIOD	RESEARCH OBJECTIVES	APPROACHES	INSTITUTIONAL DEVELOPMENTS
Before 1966	Research to address specific problems in isolation	Top-down approach providing specific interventions	Establishment of the Agriculture Office, experimental farms, and technical sections
1966– 1980	High yields; suitability for irrigated conditions; focus on the terai	Top-down approach to technological innovation; community-specific research	Establishment of agricultural research stations and farms; government institutions involved in research; limited collaboration with other institutions
1980–1996	High yields; disease resistance; rapid maturity; drought tolerance	Farmers' participation limited to adoption of improved varieties	Establishment of farming system research sites; establishment of NARC and focus on training and visit systems
1996–2006	High yields; disease and insect resistance; suitability for irrigated conditions; short duration and drought tolerance; focus on the mid-hills and rainfed areas	Focus on participatory technology development and Participatory Plant Breeding (PPB)	Involvement of NGOs, the private sector and civic groups in developing new technologies; decentralization of research; regular interactions with farmers; expansion of collaboration with international research institutions
2007 onwards	Participatory field demonstrations of climate-resilient technologies	Participatory learning by doing	Strengthening collaboration with district and local institutions for management of climate risks and adaptation to climate change

Note: Compiled based on information from Basnyat (1995), FAO (2010d), NARC (2010a) and Chhetri *et al.* (2012)

indicative, but additional in-depth analysis is needed to elaborate the specific items outlined in the table.

In order to orient its research strategically, NARC (2010a) has organized its research programme into five broad thematic areas of intervention: crops and horticulture; livestock and fisheries; natural resource management and climate change; biotechnology; and technology dissemination, extension, and outreach. These themes are considered dynamic pillars for organizing research outputs to serve Nepal's agriculture. The themes are integrated and research programmes developed in these thematic areas are expected to contribute to the achievement of natural resource management and climate change priorities.

4.3.3 Support systems for service delivery

In Nepal, the agricultural extension system is viewed as an implementation agency for helping to achieve the production targets of the National Development Plan (Basnyat, 1990). The system has a production-oriented focus with a strong technology transfer objective. Extension programmes often appear to be aimed at meeting quantitative targets such as set numbers of trials, demonstrations, tours, trips and training sessions (FAO, 2010d). This has undermined the role of farmers in determining production programmes, and resulted in extension staff spending too much time reporting on progress towards targets.

With a view to improving the functioning of agricultural extension, a number of models and approaches have been tried. These include the block production programme approach, the conventional approach, the training and visit system, the integrated rural development approach, the commodity group approach, and the farming system research and extension approach of Lumle Agricultural Research Centre. These approaches have generally been uncoordinated and differ widely in staffing and resource allocations. They have had varying degrees of success over limited areas and seem to have focused on material resources and structural changes for extension services.

A strong technology transfer bias prevails in Nepal's agricultural development programmes, but insufficient attention has been given to farmers' needs and potential. Efforts to promote farmer-to-farmer transfer of knowledge and skills are lacking, and agricultural extension does not respond to the needs of individual farmers. As climate change impacts increase, local, needs-based services can promote adaptation and resilience.

The Ministry of Agriculture was reorganized in 1992 with a view to overcoming its top-down planning and technology transfer biases and reorienting it to deal with farmers' realities. However, policies reflecting the different needs of the *terai* and hill districts regarding technology generation and information provision from extension programmes and staff are lacking. Future efforts to reorient extension system to match the needs of farmers should consider the impacts of climate variability and change.

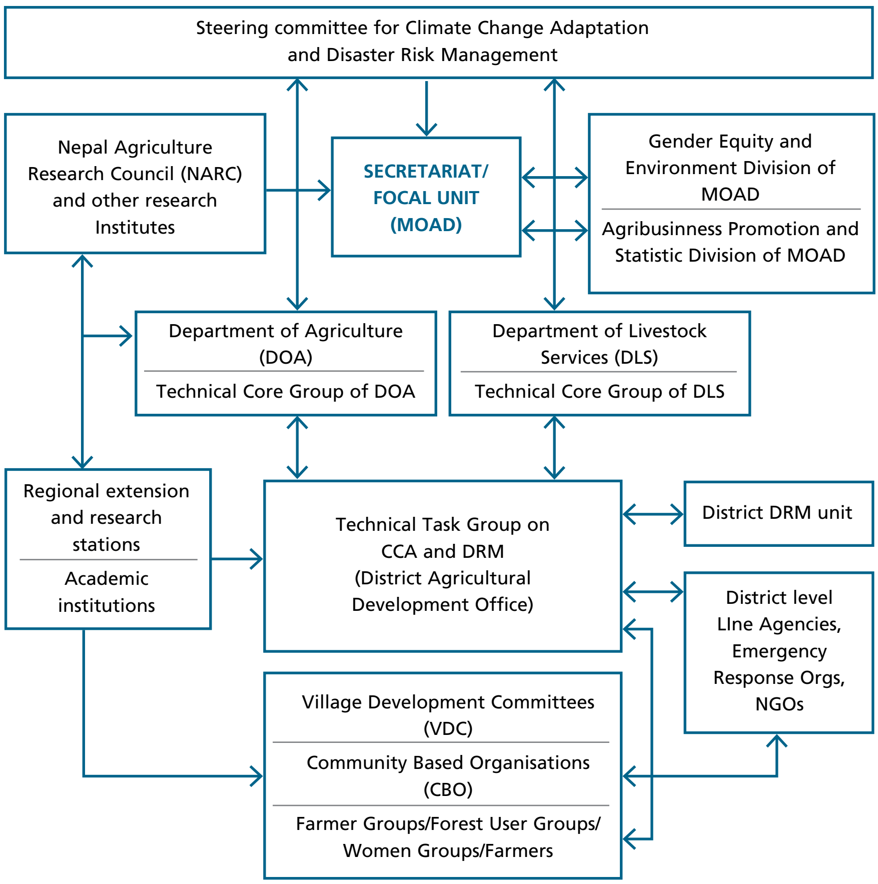
4.4 ARRANGEMENTS FOR THE IMPLEMENTATION OF RELEVANT PROGRAMMES AND PROJECTS

4.4.1 Proposed institutional mechanisms

MOAD has proposed institutional arrangements (Figure 4.2) as part of its Priority Framework for Action (2011–2020) for the implementation of climate risk management and adaptation projects in agriculture (Government of Nepal, 2011a).

FIGURE 4.2

Proposed institutional arrangements for the implementation of activities relevant to managing climate risks and adapting to climate change



Source: Government of Nepal, 2011a

According to this framework, the Gender Equity and Environment Division (GEED), which acted as the coordination unit for the thematic working group on agriculture and food security during NAPA preparation, will act as the focal unit for climate change adaptation, while the Agribusiness Promotion and Statistics Division (ABPSD) continues to serve as the focal point for activities related to disaster risk management. At the department level (DOA and the Department of Livestock Services), however, there is currently no unit established to carry out climate change adaptation- and disaster risk management-related activities. The project offices established for implementing individual projects could be upgraded to lead a technical core group of dedicated staff responsible for coordinating and implementing such activities. In NARC, the Environment Division, which undertakes studies on the impacts of climate change, requires similar strengthening.

The steering committee established as part of the FAO project in 2009 and chaired by the Secretary of MOAD can be made a permanent body responsible for approving work plans related to climate risk management and adaptation to climate change. The current institutional arrangements at the regional, district and local levels could facilitate implementation and monitoring and evaluation.

4.4.2 Improving coordination mechanisms

At present, MOAD oversees disaster risk management and climate change adaptation activities in agriculture at the national level. At the district level, DADO, in collaboration with DLSO, DDC and development agencies and farmers' groups, is responsible for implementing programmes according to MOAD guidelines. Other players from different ministries, international organizations, ministerial divisions and departments are also engaged in climate risk management and climate change adaptation. Coordination mechanisms are essential for enhancing the effectiveness of local actions.

At the national level, the proposed focal unit at MOAD and the focal points in DOA and the Department of Livestock Services may liaise with the Ministry of Environment (MOE), the Ministry of Home Affairs (MOHA), the Ministry of Forest and Soil Conservation (MOFSC), international and UN agencies such as FAO, the United Nations Development Programme (UNDP) and the World Food Programme (WFP), and other relevant international and national NGOs. The secretariat/focal unit needs to liaise with all the members of the steering committee drawn from ministries, organizations and departments at the national level. The proposed focal unit for climate change adaptation and disaster risk management in MOAD could liaise with focal points and technical core group members through the respective heads of departments in DOA and the Department of Livestock Services to channel programmes and projects approved by the steering committee.

CHAPTER 5

DATA AND INFORMATION FOR MANAGING CLIMATE RISKS AND ADAPTATION IN AGRICULTURE

5.1 DATA AND INFORMATION REQUIREMENTS

Efforts to manage climate risks and enhance resilience require data and information on crops and cropping systems, soil, water, livestock, fisheries, socio-economic and geographical features, and the impacts of climate variability and climate change. Government agencies already have systems for collecting and managing data to meet specific needs. For example, MOAD, the Ministry of Home Affairs (MOHA) and the Department of Hydrology and Meteorology (DHM) each has a stand-alone system of data collection and information flow, updated daily, weekly or monthly.

A national disaster database is an organized list of disasters that have affected the country concerned. The database: i) provides sets of records for identifying the most likely risks by geographic or administrative area or livelihood system; and ii) identifies climate risk trends potentially related to climate variability, by category or area. Such a database for Nepal would include several component databases, organized by type of risk – droughts, landslides, floods, fires, high winds, pests, etc. – allowing the user to answer the following key questions:

- What have been the most frequent disasters, by area and/or type?
- What parts of the country have been most prone to droughts, floods, fires, etc.?
- What types of risk management response are required to manage climate risks?

This information is already available in Nepal, partly from MOHA's Disaster Management Section, which has been maintaining a database since 1983. However, information on climate risks more specifically related to agricultural and livestock production needs to be strengthened. Nepal's DesInventar disaster information system represents a good start towards building a database for climate risk management in agriculture. DesInvetar is a software tool for the generation, collection, retrieval, querying and analysis of information about disasters of small, medium and large impact, based on pre-existing official data, academic records, newspaper sources and institutional reports.

Hazard, vulnerability and risk assessments are the cornerstone of preparedness planning and the planning and implementation of risk reduction measures. A comprehensive national- and district-level database on hazards, vulnerabilities and capacities would be an ideal starting point for assessing current risks. In Nepal, such a database is available for some cases, but it is not sufficiently well organized for use in risk management. Vulnerability and risk assessment depends on the amount and quality of the data available and

PICTURE 5.1

District level agriculture experts learn about past climate trends and extreme climate events

the level of sophistication desired. Field surveys to assess communities' coping capacities can be useful in complementing vulnerability and risk analysis.

To assess coping capacities and obtain subjective opinions and perceptions of the hazard, vulnerability and risk situation, questionnaires can be developed and administered at the local level. Household-level questionnaires should cover eight major topics that are relevant to assessing community coping capacities: i) household characteristics; ii) migration; iii) incomes and property; iv) technology availability; v) institutions and infrastructure; vi) losses to insects, diseases and pests; vii) area of irrigated land; and viii) food sufficiency.

5.2 EXISTING DATA AND INFORMATION SYSTEMS

5.2.1 Hazards, vulnerability and risks

Detailed characterization of hazards and identification and mapping of key assets are needed to provide a basis for spatial planning and decision-making (NSET, 2010). To keep track of crop conditions and likely agricultural production, MOAD has set up a weekly reporting system on the crop and livestock situation. Data and information on crops and livestock conditions, agricultural inputs, diseases and the weather situation are collected through the DADO and the DLSO.

The staff of DADO and DLSO service centres and sub-centres are responsible for collecting information in the areas under their command. They collect data and information on the crop/livestock situation and damage due to weather and other episodic events, and forward these data to the Regional Directorate of Agriculture, which synthesizes them with its own observations/findings before passing them on to the DOA/Department of Livestock Services and MOAD. MOAD regularly monitors the situation and validates the DADO/DLSO reports.

MOAD's Agri-business Promotion and Statistical Division is responsible for all agricultural statistics activities except the census. MOAD compiles information on the impacts of natural disasters (floods, droughts, hailstones, cold waves, etc.) in formats prepared by the Food and Agriculture Sectoral Working Group. These formats give priority to collecting victims' profiles for disaster response purposes, to ensure effective rehabilitation and reconstruction activities. Weekly reports are synthesized and published by MOAD in a bi-monthly crop outlook bulletin.

These formats could be made more useful if the weekly data and information were compiled into standard monthly reports in the districts concerned, providing an excellent opportunity for collating agricultural damage and loss data. The DesInventar database does not usually report losses related to agriculture, although such information is essential to understanding the sector's vulnerability and risk. It should therefore be mandatory for the monthly reports following the harvest of a crop to include assessment of production losses due to extreme climate events.

The compilation of district-level data and reports could be streamlined by applying a standard format for monthly reporting, synthesizing weekly reports. A monthly reporting format would: i) assist early warning and crop forecasting; and ii) provide information for the district-level disaster database. By slightly adjusting the monthly reporting format, the subjectivity in reporting can be minimised.

The Global Facility for Disaster Risk Reduction (GFDRR) has provided technical assistance to the Government of Nepal to support efforts in strengthening Nepal's hazard risk assessment. The Asian Disaster Preparedness Center (ADPC), in collaboration with the Ministry of Home Affairs, the Norwegian Geotechnical Institute (NGI) and the Centre for International Studies and Cooperation (CECI), has contributed to a publication for decision-makers and service providers across Nepal, including the necessary tools for building on existing knowledge of disaster risk and vulnerability (Government of Nepal, 2009a). A comprehensive food security and vulnerability analysis (CFSVA) of Nepal was conducted by WFP in 2006 to strengthen capacity for emergency needs assessment. Hazard, vulnerability and risk assessment are helping national and district authorities to conduct their own vulnerability assessments, make better use of existing knowledge on risk, and prioritize their risk reduction plans.

5.2.2 Food security monitoring

The Nepal Food Security Monitoring System (NeKSAP) was initially established by WFP and is currently being institutionalized by the Government of Nepal in collaboration with MOAD and the National Planning Commission. NeKSAP facilitates the collection and analysis of information on household food security, emerging crises, markets and nutrition in Nepal, and provides users with products such as food security bulletins, child nutrition bulletins, crop situation updates, market watch updates and early warning information. These reports are disseminated to the Government of Nepal and the donor and development community to provide critical information on food security and rural livelihood conditions in Nepal. NeKSAP also undertakes emergency needs assessments, produces "Food for Thought" papers and conducts thematic and sector-specific studies. District food security networks in each district validate, exchange and generate up-to-date food security information, prepare quarterly district food security bulletins and food security phase classification maps, and provide food security outlooks based on the latest information locally available.

5.2.3 Weather and climate services

DHM is the Ministry of Environment agency responsible for monitoring all meteorological and hydrological activities in Nepal, including river hydrology, climate, agro-meteorology, sedimentation, air quality, water quality, limnology, snow hydrology, glaciology, and wind and solar energy.

DHM has a network of 282 meteorological stations throughout Nepal, including 68 climate, 22 agro-meteorological, nine synoptic and six aeronautical stations. In addition, five basin offices cover the country. Observers record the daily weather readings, which are sent first to the basin offices and then to the central level for checking and publication. Data is supplied weekly and monthly from selected stations, and annually from the rest.

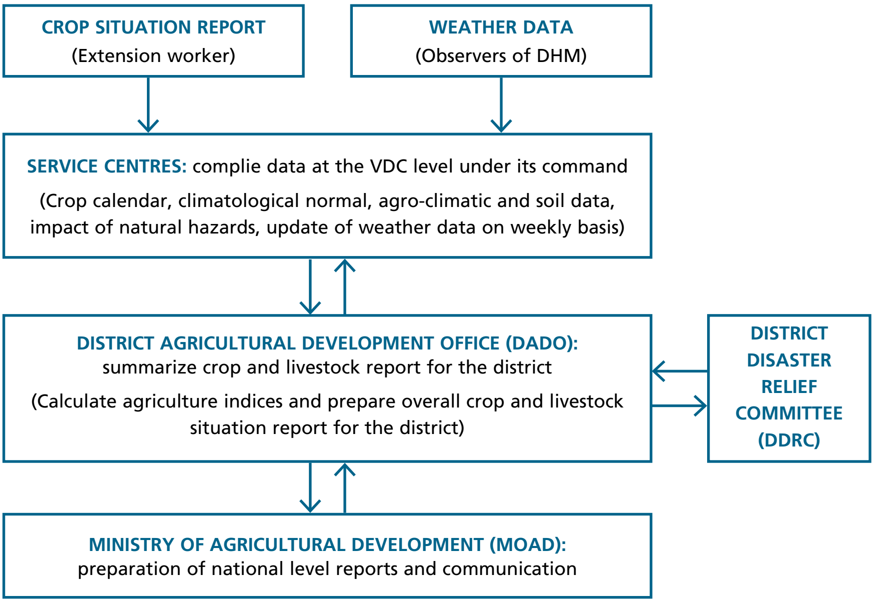
The timely availability of climate data is crucial in providing decision-makers with technical advice on the situation and raising awareness of the issues involved. Under the existing data transmission system, it is not possible to obtain data in time to report climate phenomena and take the necessary measures at the district and VDC levels.

5.3 IMPROVEMENT OF DATA AND INFORMATION FOR CLIMATE RISK MANAGEMENT AND ADAPTATION

Promoting proactive risk management at the local level: So far, DRM initiatives for the agriculture sector have focused mainly on post-disaster activities. To pursue the bottom-up approach to risk management in agriculture, DADO and DLSO service centres should play a leading role in collecting information at the VDC level and supporting district-level agriculture offices (Figure 5.1). Initially, the centres' responsibilities would

FIGURE 5.1

Proposed data flow and responsibilities of activities



Source: FAO, 2009

include inventorying disaster events and impacts; later they would move on to location-specific assessments of vulnerability, risks and the options for managing climate risks.

Standardizing data collection formats: MOAD has developed formats for collecting risk-related information, but a shortage of trained field staff and standardized formats results in inconsistent information collected. The data collected therefore lack uniformity and are difficult to analyse. The methodology currently used by MOAD/DADOs to collect information on agriculture-related climate impacts is based on: i) field supervision and monitoring of affected areas; ii) interviews with farmers from affected areas; and iii) surveillance of crops, weather, and diseases, insects and pests.

For data collection, MOAD relies on agriculture extension workers, who do not have a background in statistics. To enhance their skills, it is therefore very important that extension workers receive training on the collection of crop and climate risk data and on vulnerability analysis, at least once a year. MOAD should coordinate with the Central Bureau of Statistics' Training

Unit to develop curricula and train field staff in data collection, preparedness and impact assessment of damage and loss. MOAD's current weekly and monthly reporting system should incorporate assessment of losses to different factors (natural calamities, disease outbreaks, insect infestations, etc.) in monetary terms, which should be included in the MOAD reports following the harvesting of any crop. Data requirements and current status of data collection are presented in Table 5.1.

TABLE 5.1

Data requirements for managing climate risks and advancing adaptation in agriculture

DATA	DATA COLLECTION/ ANALYSIS METHODS	PRIMARY SOURCE	DESIRED FREQUENCY AND SPATIAL RESOLUTION	CURRENT STATUS
Areas under production of cereals, cash crops, fruits and vegetable	Weekly and monthly field report	MOAD/ DADO/ASC	Weekly/ monthly; VDC/ district	Regular
Livestock population and products	Field reporting of DLSO	MOAD	6-monthly; VDC/district	Annual/ regular
Seed supply	Reports of JTs/ JTAs and Seed Company	MOAD	6-monthly; district-level	Regular
Foodgrain stock	Surveys/NFC/UN partners	MOAD	6-monthly; VDC/district	Regular
Climate-related risks and impacts	DADO and DLSO	MOAD	Seasonal; VDC/ district	Ad hoc
Hazard and vulnerability profile (area, frequency and timing and loss)	DADO and DLSO	MOAD/DHM	Seasonal; VDC/ district	Partial and unsystematic
Identification of high-risk areas (wards/VDC)	Reports of JTs/ JTAs based on local interaction	MOAD	Once every 5–10 years; Ward/VDC	Donor-funded, but unsystematic
Climate change scenarios	Analysis of GCM data and downscaling	DHM, NARC	Spatial resolution suitable for impact assessment	Limited and project-based
Climate change impact assessment	Biophysical and socio-economic impacts	DHM, MOAD (NARC, DOA, DOLS)	All major crops, all regions. Enhanced attention to livestock and fisheries	Very limited

Incentives for data collection and reporting: Extension workers consider data collection as an additional duty over their regular jobs, for which they are given a field allowance of NR 500 per month. No travel and subsistence allowance for statistical work – which requires extensive travelling and stays of several days in different wards and VDCs – is provided. This issue needs to be addressed to improve extension workers' performance.

Identification and characterization of areas prone to climate risks: Information from the DesInventar and MOHA databases could be used to identify and characterize climate hazards, vulnerabilities and risks, facilitating the preparation of vulnerability, coping capacity, socio-economic and demographic profiles of individual areas. The coping capacity of a community is a function of the community's relative level of income, extent of diversification, endowments, food security level, proximity to roads, access to schools and other services, etc. Socio-economic and demographic information can be obtained from previous studies and surveys such as the Nepal Living Standards Survey (NLSS) and the Nepal Labour Force Survey (NLFS).

To enhance climate risk management and resilience building, it is useful to identify areas, VDCs and districts where the agriculture sector has been very vulnerable to recurrent hydro-meteorological hazards, diseases and pests in the past. This process of identification has to be based on available historical data and information and the perceptions of community members. Government of Nepal (2010a) developed a comprehensive climate change vulnerability mapping for Nepal to supplement the NAPA process in Nepal by supplying the climatic information and identifying different vulnerabilities at the district level. The main constraint is availability of required data for most suitable indicators selected for assessment of sensitivity, exposure, risk and adaptive capacity.

It has become essential to prepare and maintain vulnerability profiles of high-risk areas to enable appropriate response to climate risks. This vulnerability profile should include aspects such as when the climate event occurred, possible threats, assets of households and communities, crop production assets, non-farm incomes, and economic, social and institutional infrastructure. Maintenance of a database of past events and mapping of hazard and vulnerability zones are important aspects of risk information.

A seasonal cropping calendar combined with a hazard threat calendar should be developed for the most vulnerable areas (FAO, 2009).

Technical capacity development: The data collection (for pre-disaster, disaster and post-disaster phases) and climate risk management skills of the staff of DADO and DLSO service centres need to be enhanced through regular training to ensure the production of statistics that conform to set standards and best practices. This aspect needs to be addressed immediately. The cooperation of the Central Bureau of Statistics should be sought in developing curricula on data collection and implementing training programmes.

Systematic updating of existing databases: The information available from the DesInventar database is scanty. MOAD should make arrangements for annual updates of this database by regularly collecting the required information. MOAD's Focal Desk should be strengthened so it can populate the DesInventar format for past years by extracting data from available sources. The bi-monthly bulletins previously brought out by the Department of Food and Agriculture Marketing Services and currently by MOAD include records of droughts, diseases and insect infestations, but the losses caused by these risks are not quantified. Progress in this area would advance risk management.

5.4 CLIMATE AND CROP FORECASTING

5.4.1 Localized weather and climate information services

People-centred services: Localized weather and climate information systems are "people-centred" and empower individuals and communities threatened by climate risks, enabling them to act in a timely and appropriate manner to reduce the possibility of impacts. These systems provide local communities with additional information on risks, which can easily be translated into risk preparedness actions to prevent the loss of agricultural livelihoods. Such interpretation of local information helps reduce economic losses by allowing people to protect their assets and livelihoods. For a localized climate information service to be successful, community-level dialogue must merge technical knowledge with indigenous knowledge in a socio-culturally appropriate manner, to capitalize on existing knowledge and capacities and maximize ownership and sustainability.

BOX 5.1

Strengthening the user interface platform for weather and climate services

Cooperation between MOAD and DHM is critical to strengthening the use of weather and climate services in agriculture. Such collaboration will increase the agricultural perspective of the national weather and climate information currently provided in Nepal. Assessment of the use and functionality of weather and climate information can guide the development of improvements to the current system and the design of information products that extend the warning lead times for farmers' decision-making regarding crop selection and other management practices. Joint capacity development efforts can introduce new weather and climate information products to agriculture extension staff working at the district level.

At the local level, promoting participatory learning through farmer field school is crucial. Farmer field school offer an ideal platform to translate weather and climate information into actions. FFS were implemented in Arghakanchi, Udaipur and Kapilvastu districts to raise farmers' awareness of increasing climate variability and its effects on their livelihoods as part of the FAO project. FFS sessions were organized for 16 – 17 weeks once a week. Farmers' groups spent 3-4 hours and discussed and shared weekly weather and crop situation and interpreted climate data. DADO staff were trained in incorporating climate information into FFS sessions. Farmers' groups visited upgraded weather stations and field demonstrations to improve feedback and mutual learning. In each district 50-60 farmers were directly involved through FFS and more than 50% of them were women (FAO 2010e).

It is essential to involve communities in all stages, from problem identification and project conception and design, to implementation, evaluation and long-term monitoring and management. Genuine grassroots demand is a prerequisite to the success of a location-specific weather and climate information system, which depends on the sustained investment of stakeholders at multiple levels in analysis, participatory dialogue, interpretation, communication, decision-making, and feedback by users to information providers.

Improvement of observation and monitoring networks: Building on ongoing activities of DHM, the FAO TCP project aimed to introduce innovative weather and climate forecasts tailored to the needs of local farmers. This objective was not fully achieved, as efforts are needed to complement the current 24-hour forecasts with medium- and long-term forecasts. Such improvement would help expand the scope of weather and climate information from its current focus on saving lives to incorporate the safeguarding of agricultural livelihoods.

The FAO project supported the improvement of selected meteorological observatories in two districts (Banke and Surkhet). A multidisciplinary team visited nine of the ten stations in these districts to assess their condition. After these visits, four stations were selected based on their closeness to risk-prone areas and on how well they represented the region (DHM, 2010). A plan was developed for upgrading the four stations, all of which are in Banke district (Sikta, Nepalgunj, Naubasta and Khajura). Other stations requiring high investment were not considered for the project, but the regional DHM office committed to upgrading these stations using government funds. Details of the planned upgrade were discussed with the Surkhet regional office and agreed by meteorologists and agriculture experts.

The project's efforts included constructing stone walls with gates around the perimeters of sites, fixing 50-mm angle poles, setting up of nets, installing cup counter anemometers, re-setting Stevenson's screens and rain gauges, and painting the walls and screens. New instruments were installed where required, including thermometers, rain gauges with measuring scales, open pan evaporimeters and cup counter anemometers.

PICTURE 5.2

Rehabilitated weather station in Banke district

5.4.2 Crop yield forecasting

The variability of agricultural production in Nepal is directly related to the inter-annual variability of rainfall in different parts of the country. It has been observed that the distribution of weather parameters generally affects final yields. Mountain ranges, deep valleys, varying slopes and other geophysical aspects of Nepal are the main factors that give rise to a variety of microclimatic regimes within a short distance from south to north. This variability makes the forecasting of crop production extremely difficult, but such forecasts are important for ensuring the sufficiency of foodgrains and their equitable distribution across the country. Assessments based on crop models can help decision-makers develop alternative management strategies to avoid or mitigate economic losses caused by climate impacts.

An early warning and crop forecasting project launched in Nepal in the early 1980s by FAO introduced the water balance model for monitoring the crop situation. Restructuring of the Ministry of Agriculture and the transfer of responsibilities interrupted this work. The water balance model takes into consideration factors such as potential evapotranspiration, crop coefficients, water-holding capacity of soil, rooting depths, and actual soil moisture content at the start of each week. Water balance calculations can highlight periods of water stress or excessive rain, resulting in deductions from the yield index, which is 100 in the case of optimal water supply to the plant. This approach enables the assessment of drought damage week by week, taking into consideration the specific crop stage and the crop's sensitivity to drought.

Assessments from these models could complement other information systems such as field reports or sample surveys. MOAD's existing system of crop forecasting is based on reporting of crop conditions – such as crop damage due to adverse climate conditions and/or severe insect and disease infestation – by field staff stationed at DADO service centres. MOAD's crop forecasts would be substantially enhanced if additional crop-based analysis were incorporated into the system. Advancements in seasonal rainfall prediction can enhance crop yield forecasting capability and has got wide range of application in agriculture and water management. Kadel (2012) reported statistical prediction of seasonal rainfall and showed encouraging results in terms of seasonal prediction that could be applied for agricultural management.

CHAPTER 6

CLIMATE RISK MANAGEMENT AND ADAPTATION PRACTICES

6.1 CURRENT COPING PRACTICES AND ADAPTATION PRIORITIES

Communities adopt different coping mechanisms to deal with the impacts of climate variability. Climate risk management strategies include soil, land and water management, and use of improved crop varieties, early planting and mixed cropping to reduce the risks of crop failure. Careful storage of grains, alternative irrigation methods, gulley control, contouring/terracing, bunding through bioengineering techniques, and community plantations are also practised widely. For effective implementation of these measures, communities need access to information and skills (RCRRP, 2012).

Coping strategies differ among livelihood groups. For example, exchanging food items, borrowing grain from neighbours, engaging in labouring work outside the village, borrowing cash from moneylenders and sharing labour among family members are some of the coping measures followed by wage labourers, especially during abnormal seasons, while village groceries stock more grain during periods of scarcity. People who depend on off-farm employment have invested their incomes in flood control measures such as stone gabions, check dams and plantations, and have established fruit tree plantations to generate income from their limited land.

Migration is a common coping strategy for the most vulnerable livelihood groups. Insufficient production of foodgrains in households has compelled many people to engage in off-farm jobs, going abroad or working in the local labour force. Migration increases significantly in communities hit by drought and floods. The most popular destination for labour migration is India, with 40 percent of migrants, followed by internal migration within Nepal, with 30 percent, and other countries, with 22 percent (WFP, 2008).

Poor, landless and illiterate households have the highest probability of migrating and obtaining remittances. The importance of remittances to Nepal's economy is significant. Remittances have frequently been identified as one of the predominant causes of the fall in poverty from 42 percent in 1995/1996 to 31 percent in 2003/2004. Official figures indicate that migrant remittances make up some 15 percent of GDP and reached US$1.6 billion in 2007 (WFP, 2008).

It has been noted that the most vulnerable population tend to migrate; most migrants are male, with younger and female members of the family migrating subsequently to follow them. Almost 75 percent of men between 19 and 44 years of age migrate. These people form the potential workforce within their villages, so farmers with larger farms face labour shortages. Migration directly affects the timeliness of farming operations. Crop failures due to climate impacts increase the trend for seasonal migration. A comprehensive national-level survey – Nepal Living Standards Survey 2010/11 (CBS, 2011) – indicated that several coping strategies were used in rural areas (Table 6.1), but these are unable to provide the support needed for resilience building.

Moench and Dixit (2004) presented the immediate coping practices applied by communities in the Rohini and the Bagmati river basins during floods. First, families try to save themselves and their valuables; second, they try to save their food supplies; and third, they attempt to save their animals and fodder. In case of severe flooding, families release their livestock and move to safer places. The flood protection measures followed include providing gabion supports to strengthen local stonewalls and bamboo spurs, strengthening local institutions for the control of grazing animals in plantation areas, constructing check dams, and cultivating tall rice varieties that are flood- and lodging-resistant.

TABLE 6.1

Coping strategies followed by local communities to overcome food scarcity

COPING STRATEGY	% OF HOUSEHOLDS
Eat cheaper or less preferred foods	50.4
Borrow food or money	69.6
Buy food on credit	56.5
Eat wild food or unripe crops	6.8
Eat seeds preserved for sowing	14.1
Send household members to eat elsewhere	9.8
Send household members to beg	3.6
Eat less at each meal	41.3
Feed children by reducing adults' share of food	18.3
Feed working members by reducing others' share of food	7.9
Ration available money among household members	2.6
Reduce number of daily meals	33.1
Skip meals on some days	11.7
Sell assets/jewellery to buy food	5.8

Endeavours for reducing the impacts of landslides include promoting slope agriculture land technology (SALT) in the mid-hills, and bioengineering techniques to control soil erosion and landslides. To reduce the impacts of drought, important initiatives include improving irrigation facilities for nursery preparation and seedling raising, preparing dry-bed nurseries for rice where water is very scarce, developing and promoting technologies for early raising of rice seedlings, rehabilitating and conserving traditional water ponds and harvesting and storing rainwater.

To reduce the effects of insects/pests, there is immediate need to increase technical expertise on the use of pesticides, promote local knowledge on biopesticides, identify specific insects/pests for different crops, and develop crop management practices by introducing resistant crops or varieties, new cropping patterns and mixed cropping, or appropriate IPM practices. Existing coping strategies are clearly not sufficient to reduce climate risks and advance adaptation. The NAPA workshop on agriculture and food security prioritized several activities to advance adaptation to climate change (Table 6.2).

TABLE 6.2

Prioritized activities to enhance adaptation in the agriculture sector

AREA	PRIORITY ACTIVITIES
Irrigation and water management	• Increased irrigation facilities through the promotion of shallow tube wells, water collection/recycling and rainwater harvesting • Promotion of low-cost, non-conventional irrigation technology, including drip/sprinkle irrigation and overhead water tank
Resource conservation	• Promotion of resource conservation technologies, including minimum tillage, seed priming, crop mixtures, double transplanting of rice and widely adapted crop species with low nutrient requirements • Promotion of organic agricultural practices, with special focus on biopesticides, organic fertilizers, crop nutrients and pest management • Improved collection and utilization of rainwater in pasture and rangeland areas
Strengthening agriculture service systems	• Introduction of crop seeds, seedlings, saplings and fingerlings adaptable to local conditions • Promotion of a community seed bank for cereal, vegetable, forage, fodder and agroforestry species • Promotion of crop varieties for vulnerable areas, adaptable to climate stresses and suitable for supplying large quantities of food
Infrastructure development for risk reduction and effective response	• Infrastructure (such as plastic or greenhouses for off-season vegetables) and marketing development for agro-based microenterprise development • Stockpiling of agricultural inputs and emergency food supplies through establishment of stores (cold stores and zero energy storage) and decentralized food buffer stocks • Embankments and plantations in riverbank areas • Slope agriculture land technology (SALT) for soil conservation
Policy development, mainstreaming	• Agricultural development policy review in terms of agricultural finance and inputs, small-scale irrigation, seed banks, food storage and buffer stocks • Promotion of resource-efficient technologies (ensuring high income) for vegetable, fruit and flower production • Promotion of pocket area production to back up seed banks and food buffer stocks • Diversification of diets using nutritionally rich cultivated and wild food crop species of local origin • Strengthening of marketing institutions and networks at strategic centres in different ecological regions (Koshi, Gandak and Karnali River basin) • Enacting of pro-farmer land-use policy and programmes • Protection of local community rights to natural resources and indigenous knowledge, practices, skills and innovations
Livestock and animal husbandry	• Improved performance of piggeries with emphasis on housing, mortality and ration management • Promotion of the community approach for innovative pasture and rangeland management using locally adapted fodder and forage species • Improved animal housing, nutrition (based on local feed, fodder and forage supply/ production), disease and parasite management • Improvement of indigenous breeds of pigs, poultry, goats and sheep • Studies of climate change impacts on farm animals • Promotion of poultry, dairy, goat and piggery-based enterprises linked to urban markets

AREA	PRIORITY ACTIVITIES
Fishery and aquaculture	• Conservation of fish species, especially in rivers used for hydropower and irrigation (improved fish migration) • Public–private partnerships in fishery development, especially fingerling supply in pond culture • Improved carrying capacity of natural water bodies (rivers, lakes, reservoirs and other wetlands) for sustainable community fish production and marketing • Promotion of poly-culture and integrated pond culture with low-cost and high-productivity technology • Studies of climate change impacts on fishery • Strengthened livelihoods of ethnic minorities dependent on fishing • Integration of ecotourism and sport fishing into sustainable community development
Awareness raising and local capacity building	• Awareness raising campaign on climate change adaptation • Exposure visits, vocational training and Farmer Field Schools to enhance adaptive capacity of local organizations and communities
Research and Development	• Strengthened climate change adaptation research and education • Promotion of development of new crop varieties and livestock breeds capable of withstanding emerging climate stresses
Impact assessment and early warning systems	• Establishment/strengthening of agro-meteorological stations representing various agricultural systems • Establishment of early warning system based on recent scientific developments and local knowledge and practices
Biodiversity conservation and management	• Improvement of climate-resilient agricultural biodiversity • Indigenous knowledge and innovations • On-farm management of agricultural biodiversity

6.2 CLIMATE RISK MANAGEMENT AND ADAPTATION PRACTICES – SOME EXAMPLES

6.2.1 Proactive and demand-responsive seed systems

Constraints to seed production, storage and supply systems: Seed supply and storage practices, particularly in the pre-monsoon period and in post-emergency situations, are not adequate to meet the needs of farmers. Agricultural service systems are not able to mobilize the seeds required before the start of the rainy season. Challenges in the current seed supply system in Nepal include the dominance of informal seed systems, the lack of well-equipped laboratories and trained personnel, a weak seed certification system, limited involvement of the private sector, the unavailability of proper storage and maintenance structures, and inadequate seed buffer stocks. There are also gaps in the maintenance of seed stocks and their release immediately after climate-related emergencies.

Weather conditions play a major role in the production and supply of quality seeds for farmers. Relative humidity and temperature are the two most important environmental factors affecting the quality of seeds during the monsoon and pre-monsoon seasons and in emergency periods. Climate-related risks in Nepal lead to post-harvest losses of 15–20 percent in cereals and 20–30 percent in perishables. Relative humidity of 70 percent and temperature of 20 °C are considered safe limits, but these limits are often exceeded in many parts of the country. During the monsoon and pre-monsoon seasons, continuous rainfall and high temperatures create problems in the drying and cleaning of seeds to the required moisture level (8–10 percent). Storage of wheat and barley seeds is more challenging than storage of rice and maize, as the storage period of wheat and barley coincides with the monsoon season. The unavailability of quality seeds of stress-tolerant species for normal planting and for re-planting immediately after disasters leaves farmers dependent on external assistance.

Agricultural support services distribute seeds purchased from the domestic market to cope with emergency situations, irrespective of quality and agro-ecological suitability. Major seed suppliers in Nepal are unable to maintain the required quality, as they have to meet huge demand during the monsoon season and emergency periods. The lack of proper transportation and storage facilities affects farmers' access to quality seeds. In some cases, seeds are distributed to farmers without considering the seeds' suitability for different agroclimatic conditions. This situation has affected potential production levels and increases farmers' dependency on external seed sources.

Linking seed production and supply systems to manage climate risks: The seed supply system in Nepal has formal and informal components. The formal, public seed supply component is made up of the National Seeds Company (NSC), DOA and NARC, as well as government farms. The informal component is composed of private companies and local farmers' groups.

NARC is responsible for producing source seeds (breeder seeds and foundation seeds) by developing high-yielding crop varieties, and supplying source seeds for the production of certified seeds by NSC, DOA, private seed companies and farmers' groups. NSC works with contract farmers for certified seed production from foundation seeds received from NARC and produces source seeds for further seed production programmes. The seeds produced by contract seed growers are processed, graded, treated and distributed to farmers by NSC through dealers. NSC is the only government agency that supplies seeds to farmers, but it meets only 10 percent of the total seed requirement (Shrestha and Wulff 2007). District seed self-sufficiency programmes (DISSPROs) are supported by DADOs and support the spread of improved seeds through farmer-to-farmer exchange. The seed production and supply system is currently affected by lack of funds and basic facilities such as storage, quality control and the availability of source seeds of improved varieties.

Efforts are under way to link the production of stress-tolerant crop varieties to supply system at the community level. NARC and the International Maize and Wheat Improvement Center (CIMMYT) support the Hill Maize Research Project (HMRP), which aims to introduce the Community-Based Seed Production and Storage (CBSPS) programme for maize at the district level. The aim is to encourage the participation of resource-poor and disadvantaged farmers in seed production by providing subsidized seeds and fertilizers, storage and technical expertise. Farmers' groups can sell their surplus maize seeds outside their own districts. Some CBSPS groups and cooperatives are running successful seed production and storage businesses. The fourth phase of the project, which is being co-funded by Swiss Agency for Development and Cooperation (SDC) and United States Agency for International Development (USAID), focuses on strengthening seed dissemination channels, developing market links and ensuring the decentralized seed quality assurance system and developing new maize varieties.

The informal supply (from on-farm sources or farmer-to-farmer) accounts for 95 percent of the total seed supply. Most farmers use old, low-quality seeds that have deteriorated over the years and perform very poorly under extreme climatic conditions. The seeds of self-pollinated crops should be replaced at the rate of 25 percent every year, while those of cross-pollinated crops should be replaced at 33 percent a year, but the seed replacement rate in most districts is only 5 percent. Vulnerable farmers in the hills and mountains are constantly affected by floods and droughts and do not have access to certified seeds for replacement. This situation calls for the production of quality seeds at the farm and community levels and for links to seed supply systems through DISSPRO and the NSC.

It is therefore important to link informal and formal seed production and supply so that improved varieties developed for adverse conditions reach farmers in time and in the required quantities. As seed companies/enterprises (including seed-producing farmers' groups and cooperatives) increase their capabilities in terms of quality of seed production, supply and storage, they may be able to produce foundation seeds with high quality standards. Licensing of NGOs, private laboratories and private seed companies/firms for quality seed production and certification involving local farmers' groups is one of the proposed amendments for improving the Seed Act to meet future challenges.

NSC supplies seeds produced through contract growers, while agrovets are private seed suppliers dealing mostly with vegetable seeds of improved hybrids. The seeds supplied through these systems are not sufficient to meet the needs of farmers, especially for varieties tolerant to climate-related risks or emergency conditions. There is need to strengthen public–private partnerships and links with farmers' groups involved in seed production, supply and storage programmes at the community level.

Traditional and improved methods of seed storage: Local CBOs, farmer cooperatives and farmers' groups practise traditional methods of seed storage, which should be identified and implemented at the community level for evaluation and promotion. Traditional practices need locally relevant improvements to meet emerging challenges such as increased fluctuations in weather and climate conditions.

Traditional seed storage equipment includes heap and *kunio* storage of maize inside the upper or loft of houses (heaps of regular shape with no material support), mat bins, mud bins, earthenware pots, metal pots, the *urmi* or *suli* method (for maize), plastic bags/containers and jute bags (FAO, 1992). Majority of rural households in the hills store their maize cobs on vertical wooden or bamboo frames outside the house (thangro practice). Local materials and methods used in storage include neem, *bojo, timur, marich*, titepati leaves/powder for controlling grain pests, sun-drying of seeds, winnowing, rinsing of containers with oil/kerosene, and covering seed containers with ash and chaitaune (e.g., in Kapilvastu). Improved seed storage structures and practices include improved metal bins, split-bamboo bins, improved mud bins, sealed storage containers, super grain bags, ventilated godowns (warehouses), potato seed storage under diffused light, cellar storage of fruits, and zero-energy storage of vegetables and potatoes.

BOX 6.1

Promoting seed storage methods and practices

With the objective of creating a local knowledge base on seed storage, an FAO pilot project facilitated the identification and promotion of traditional outdoor and indoor storage methods. Traditional outdoor storage structures include bery/bhakari (made of split bamboo and timber), muja-ko bhakari (made of straw and reeds), thungki (wooden granaries with roofing), thangro (timber/bamboo drying/storage racks) and dhansar (made of timber and planks and used by only a few large-scale farmers).

Traditional indoor storage structures include kath-ko bhakari (made of wooden planks and platforms), gundari-ko bhakari (made of straw/bamboo mats), chitra/choya-ko bhakari, kotho and doko (made of split bamboo and bamboo strippings), dalo/bamboo baskets (made of bamboo strippings, split bamboo and reeds), dehari and kothi (small and large mud bins), gagro and ghyampo (small and large clay pots), dhukuti (brick-walled structures).

Field demonstrations were carried out on the use of polyethylene-lined bags or polyethylene sacks inside storage bins to reduce the difference between internal and external environments. Traditional seed storage containers such as dehari (made from mud, straw and dung) were lined inside and out with polyethylene sheets and painted with bitumen on their outer sides to mitigate the influence of changes in weather. Rodent problems were reduced by attaching strips of metal about 25 cm long to the bases of these structures. Ghyampo (clay pots) for storing seeds were improved by painting their outer sides with white enamel and using double lids to control moisture content.

Recommendations to farmers included drying seeds to 8–10 percent moisture content to reduce the incidence of storage pests; and placing storage containers in dry, damp-proof areas with proper sanitation, on wooden planks at least 30 cm from house walls and 30 cm above ground level. Field demonstrations were carried out for rice in Kapilbastu and Siraha, potatoes in Arghakhanchi, and wheat in Kapilbastu, Siraha and Udaipur.

Before storage, farmers sun-dry their seeds about four to six times (for three to four hours each time), depending on the moisture content. Some farmers use storage containers cleaned with oil or kerosene, while others treat the seeds with indigenous plant materials such ash, neem, titepati, *marich* and *bojo* powder to protect the seeds from storage pests.

CBOs, cooperatives and farmers' groups often follow traditional methods of seed storage, but face many difficulties: they do not possess warehouses large enough to store seeds on a commercial basis; and seed producing farmers' groups or cooperatives are limited in both number and capacity, so can only serve farmers in accessible districts to a limited extent. Agrovets and some NSC dealers are the only agencies providing seeds in remote districts, but poor roads and transportation problems prevent them from providing timely and adequate supplies of improved seeds to farmers. With improved traditional storage structures and the adoption of improved storage practices, farmers have been able to reduce loss and deterioration during seed storage by about 10–15 percent (FAO, 2010e).

Community-Based Seed Production and Storage: CBSPS is a proactive initiative aimed at meeting needs during the monsoon season and emergency periods. Important features of CBSPS include the provision of adequate storage, cleaning and drying facilities, along with a revolving fund to allow the timely availability of production inputs and credit. CBSPS either provides individual farmers with space for storing their seeds, or collects surplus seeds from participating farmers, for cleaning, grading and careful storage in community seed houses prior to sale at reasonable prices. Participating farmers receive a share of the income from seed sales. During emergencies, poor farmers receive pledging money to buy food so that they can participate in the seed production and supply system by retaining stress-tolerant seeds for the following season.

Successful implementation of CBSPS for the establishment of risk-sensitive and demand-responsive systems requires, among other actions, a feasibility and baseline survey, the selection and mobilization of farmers' groups, the development of business and operational plans for the CBSPS, the provision of a revolving fund and savings and credit schemes, the management and multiplication of source seeds, the creation of processing and storage facilities, maintenance and certification of seed quality standards, the adoption of marketing and promotional activities, the availability of a seed

PICTURE 6.1

Women groups participate in crop observations during farmer field school sessions

and grain exchange and pledging money, the maintenance of a labelling and lot numbering system, and capacity development of farmers, entrepreneurs and agricultural extension staff. The provision of basic equipment for seed testing, related training, and support from the regional seed testing laboratory for the timely field inspection and laboratory examination of seed samples for seed certification are also very useful. The CBSPS group should be able to perform rouging to remove the off-types, and other crop management practices to improve seed quality. High-quality seeds could be produced under farmers' conditions by adopting additional management practices with the treatment and processing of seed (Kshetri, 2010).

A CBSPS group with a centrally located processing and storage facility can manage seed production, supply and storage at the local community level to cope with emergencies and climate risks. Encouraging seed production and facilitating storage capacity through CBSPS can assist local communities in maintaining production cycles after disasters and thus recovering from the adverse impacts of climate extremes.

Maintenance of seed buffer stocks at the community level: NSC maintains buffer stocks of seeds for emergency situations at the national level, in line with government policy. During and after emergencies, seeds are often distributed to vulnerable households affected by climate extremes to help farmers continue their production cycles and to support their coping strategies. These activities should be complemented with community-level interventions that increase farmers' resilience to future climate risks by securing their food and seed production. Community seed banks (CSBs) are established to conserve local varieties through a farmer-led, on-farm conservation approach (Sthapit *et al.*, 2006) and can act as buffer stocks of seed for participating farmers. The CSBs' primary objective is to assist communities in attaining self-sufficiency in local seed production. A CSB gives priority to meeting the seed requirements of its members, ensuring seed security and thereby safeguarding food security during disasters and risk-related situations at the district/local level. CSBs can sell seeds outside their respective districts only when they have a surplus, and must ensure fair

BOX 6.2

Capacity development in seed storage and maintenance

Improvements in production, storage and maintenance practices can help reduce losses of seeds and improve seed quality. An important channel for imparting knowledge and skills on these improved practices is through the training of DADO staff and farmers, combining field demonstrations with awareness programmes.

An important training methodology is the FFS, with meetings every week or two. FFS can be used to share ideas, exchange experiences and expose farmers and DADO staff to demonstrations of techniques and methods for easy replication. As part of the FAO project, farmers undertook exchange visits to Patihani and Pithuwa to learn about successful seed production, supply and storage systems managed by farmers' groups.

Major topics for capacity development include the importance of seeds, seed regulations and policies, seed deterioration and loss under adverse conditions, source seed production, seed certification and quality control, improved methods of seed production, quantification of demand, post-harvest seed management and storage methods, development of CSBs and seed extension, and marketing and enterprise development. Farmers and DADO staff trained on improved seed production and storage technologies have proved more successful in responding to profit sharing among their members. Farmers are therefore able to obtain the seeds of well-adapted and desired varieties – including promising local landraces – that best satisfy their requirements. In this context, the local DADO should encourage interested farmers to maintain nurseries of fruit, fodder/forage and other multipurpose species to meet requirements at the district level.

6.2.2 Management of high-/low-temperature stress

Off-season vegetable cultivation: In the mid-hill regions of Nepal, high temperatures during the summer, foggy weather and prolonged periods of cold during the winter limit farmers' production of seasonal vegetables. Temperature fluctuations between summer and winter make vegetable crops susceptible to insects, pests and diseases.

In this context, vegetable cultivation in semi-controlled tunnels is a suitable low-cost technology for reducing the impacts of temperature fluctuations on crops, as well as increasing vegetable production and the diversification

PICTURE 6.2

Off-season vegetable cultivation in the mid-hills of Nepal

of agriculture. Cultivation of off-season vegetables refers to the production of vegetable crops in unfavourable seasons, using controlled conditions and improved technology to avoid the impacts of weather extremes. Other benefits of partially controlled environments include higher crop yields, better maintenance of land fertility, controlled temperature and humidity, protection from wild animals and insects, and better water conservation.

Tunnels for controlling environmental conditions can be created from locally available materials, making them cost-effective and relatively easy to build. Bamboo canes and wooden poles of about 2.5 cm in diameter are the most suitable material for the tunnel's framework. As single bamboo canes are thin, combining two or three may provide sufficient strength for bow and girder construction, from which strings can be suspended to support the growth of crops such as tomatoes, cucumbers and beans. A transparent plastic sheet placed over this frame allows sunlight to enter during the day, while a black sheet spread over the soil absorbs the sun's heat, raising the internal temperature to desired levels. The plastic sheet on the soil serves three purposes: trapping heat, reducing water loss, and eliminating the growth of weeds, as seeds germinate through holes made in the plastic sheet. Sometimes, if one side of the structure faces strong winds, it is closed by a stone wall, providing stability. During winter, the plastic roof may be covered with leaves or locally available crop wastes for protection from the cold. In autumn and spring, the plastic sheeting is removed to facilitate aeration. The tunnel should be large enough to allow the farmer to plant, monitor and harvest the crop. The need for good cross-ventilation, and the potential stresses caused by heavy wind, hail or rain should be considered when constructing the tunnel.

The growth of off-season vegetables and fruits improves the diets and increases the incomes of farming households. In the absence of storage infrastructure and vegetable processing industries, off-season vegetable farming is the only viable option for increasing farmers' production. Successful implementation of the practice depends on: i) enhancing farmers' capacity to grow and market seasonal and off-season vegetables, ii) providing agricultural inputs and technical support; iii) establishing domestic market linkages for the trade of vegetables; and iv) developing and implementing mechanisms for sustainability. FAO project supported demonstration of several such good practices to farmers in six districts between 2008 and 2012 (Table 6.3)

TABLE 6.3

Number of field demonstrations conducted in six districts (Siraha, Udaipur, Kapilvastu, Arghakanchi, Bankhe and Surkhet) of Nepal between 2008 and 2012

NAME OF DEMONSTRATION		NUMBER OF DEMONSTRATIONS/ SITES	DIRECT BENEFICIARIES*
Climate risk management	Community based seed production	6	60
	Seed storage and maintenance	18	106
	Weather based pest and diseases control	6	75
	Crop diversification, mixed cropping and inter-cropping	9	90
	Vaccination/parasite control for livestock	13	730
	Livestock management (including shed and manure management)	18	380
	Fodder conservation	8	24
	True potato seed (TPS)	3	100
Resource conservation	Water harvesting ponds/community ponds	15	233
	Rehabilitation of irrigation channels, drip irrigation and treadle pumps	18	52
	River bank protection	4	175
	Slope stabilization, soil conservation (bioengineering) and support to Forest User Groups	20	990
	System of Rice Intensification (SRI)	3	60
	Direct sown rice and zero tillage for wheat after rice	12	125
	Bio-gas plants	4	40
Livelihood diversification	Off-season vegetable cultivation	23	178
	Vegetable cultivation in river banks	6	110
	Alternate livelihood activities	7	75
Varietal demonstrations	Rice	32	761
	Wheat	27	397
	Maize	24	309
	Forage crops	14	65

* Includes both individual farmers and households; and in some demonstrations farmer groups are included

Diffused-light storage of potato: Potatoes are the second most important staple food in Nepal after rice, with consumption nearly doubling since 1990. For small-scale farmers, potatoes provide a better diet and higher income, but the storage of quality seed potatoes entails significant costs of nearly 50 percent of total cultivation costs. Temperature fluctuations and light exposure are the main causes of quality deterioration of potatoes in storage. Better seed storage methods can therefore alleviate the problems associated with potato production in the mid-hills. Appropriate storage practices for seed potatoes should not require farmers to make major changes to their existing practices and must be low-cost and easy to adopt.

Diffused-light storage meets the criteria for storing seed potatoes in the mid-hill regions, and can be adapted to any existing on-farm storage practice. Farmers who can store their own seed potatoes in good conditions are more likely to have a good harvest the following season. Light and ventilation are the two elements that are controlled under the diffused-light storage method. Light should be indirect, but of an intensity equivalent to that required for reading. The diffused-light storage method controls the growth of thin, white sprouts, while inducing short, stout and coloured sprouts. Insufficient light intensity is indicated by the development of long, white sprouts, which promote rapid shrinkage of the tubers, implying energy loss. Potato tubers require air to breathe, but their respiration produces heat inside the storage area, which accelerates the growth of sprouts, forcing the tuber to use more energy and to age physiologically. Good management of ventilation helps to remove the heat generated by respiration while providing sufficient air.

The traditional method of storing seed potatoes in bamboo baskets (*perungu*) can be adapted to the diffused-light storage method with minor adjustments. The baskets should be half or two-thirds filled, leaving space for air and light, and hung under the roof, where they have sufficient indirect light and ventilation but are protected from rain and wind. The size and shape of baskets vary according to farmers' needs. Another example of diffused-light stoareg uses wooden trays, usually about 60 cm long, 37 cm wide and 18 cm high and holding about 12 kg of seed potatoes. Rack size too can vary according to farmers' needs. The trays can be stacked to save space and are easy to move. The tray base should be made of slats with gaps between each slat to provide airflow, and trays should be filled with no more than three or four layers of potatoes each. Seed trays can be placed inside the house or on the veranda, wherever there is sufficient light and airflow. If trays are placed on the veranda, they should be protected from rain and wind, and the potatoes should be protected from rats with wire netting.

Simple storage structures built from locally available materials can also be used to store large quantities of seed potatoes (rustic storage). A storage facility about 2 m long, 0.8 m wide and 2.3 m high with five shelves can hold 500 kg of seed potatoes. Shape and size can be altered according to farmers' needs and the quantity of seed potatoes to be stored. The structure's roof must be thatched – and not made of tin, which heats the storage area – and wide enough to cover the storage area while providing adequate ventilation and control of temperature and humidity. Shelves must be at least 30 cm high, with the lowest shelf 30 cm above ground level to prevent rainwater from splashing the tubers. The sides should be of fine wire netting to protect the potatoes from insects and pests.

True Potato Seed for cold tolerance and higher yields: Traditionally, most farmers use small tubers as seed, enabling them to grow potatoes with minimum inputs. Although seed tubers are easy to plant and grow quickly, they are expensive and may account for significant production costs. They are also the main carriers of diseases and pests; are perishable, bulky and difficult to transport; and require costly refrigerated storage facilities to prevent rotting and keep them in adequate physiological condition until the next planting season. Conventional varieties grown by farmers, such as Cardinal, *Kufri jyoti* and *Kufri sindhuri,* are susceptible to diseases and intolerant to low temperatures, leading to poor yields. Farmers are therefore motivated to grow True Potato Seeds (TPS), which are resistant to late blight and tolerant to cold.

True Potato Seeds (TPS) are botanical potato seeds that are genetically identical clones produced in large numbers through fertilization. TPS technology is based on the natural ability of the potato to produce flowers, which are then fertilized and set berries containing potato seeds, which are used as planting material (Mihaela *et al*., 2012). Farmers in Nepal have been producing potatoes from TPS from hybrid potato varieties, such as HPS 7/67 and HPS 1/13.

With TPS technology, farmers can produce first- and second-generation potato seeds on their own farms. Potato production from TPS is more advantageous than using seed potatoes because it maintains genetic diversity, which protects production from new pests or diseases and changes in climate or cultural practices.

6.2.3 Crop diversification based on agro-ecological zones

Nepal is broadly divided from east to west into three agro-ecological zones of approximately equal areas, but with different climate and soil conditions that affect the types of crops grown. Recent trends demonstrate that Nepal is increasingly exposed to extreme climate events, particularly droughts that affect crop yields. Poor irrigation facilities and cold waves (*pala)* have additional impacts on crop production. To respond to these threats, crop diversification is being promoted among farmers, using cropping patterns adapted to the local agro-ecological zone and climate risks.

In the southwest, the *terai* or plains are the northern extension of the Gangetic plains of alluvial soils, with elevations ranging between 100 and 300 m above sea level. The climate is hot and humid with subtropical to tropical conditions. Crop diversification can be achieved for major crops such as rice, wheat, legumes and oilseeds.

In the mid-hills, altitudes range from 250 to 4 000 m above sea level, and the area is characterized by steep valleys that are often terraced for extensive agriculture. Farmers in the mid-hills grow soybeans, beans and ginger, with maize as an intercrop to reduce the risk from drought. Peas and *tori* are intercropped with wheat. Farmers cultivate a wild potato variety that is drought-tolerant and easily adaptable to extreme climatic conditions, with pineapple production as a complementary source of income.

The mountain zone is characterized by varied microclimates is also suitable to diverse crops, but with a number of limitations. To the north, altitudes in the mountain zone reach more than 8 000 m above sea level, with very cold climates, while temperate climates prevail lower down the mountain sides, and subtropical climates in the hills and foothills. Potatoes, barley, buckwheat and amaranthus are the prevailing crops in the mountains. These crops are affected by local dry and cold spells, so intercropping systems are needed to stabilize productivity.

BOX 6.3

Crop diversification with pineapple cultivation on sloping land

In Bengri village in Udaypur District, 44 poor and medium-income Tamang families with small landholdings were selected to study and monitor the impact of pineapple cultivation on sloping lands. Given the income advantage and multiple benefits, farmers showed considerable interest in large-scale pineapple cultivation, and another 82 families in the village adopted the practice voluntarily. The benefits of cultivating pineapple include the generation of additional income and employment that is suitable for women, and the crop's resistance to pests and diseases.

Pineapples are planted on sloping land in shallow 10-cm deep pits, compared with the traditional 60 cm depth required for applying compost manure to the pits. Pineapple sets should be planted between February and March. The costs of cultivating pineapples on 1 kattha (about 67 m^2) of land are estimated at Nr 1 200 (US$15.19), of which Nr 450 (US$5.70) is for land preparation and labour, Nr 150 (US$1.90) for weeding, and Nr 600 (US$7.59) for seedlings. The net income from the same plot of land is Nr 3 500–4 000 (US$44.30¬–50.63), compared with a net income from maize of Nr 600 (US$7.59). The economic advantage and other benefits motivate farmers to practise this form of crop diversification.

6.2.4 Integrated approach to landslide risk reduction

Frequent landslides in mid-hill districts have caused damage to productive land in the lower basin, challenging human settlements and agricultural activities both upstream and downstream. Extensive areas of productive land are left fallow because of their vulnerability to landslides, and many settlements have been displaced, mostly to the *terai* region. Some communities in the mid-hills have adopted an integrated approach to reducing the risks of landslides through a series of conservation practices along the river.

The integrated approach follows a sequential process of:

- community-level meetings to form a landslide treatment committee in charge of coordinating the development and implementation of conservation measures and the monitoring and maintenance of interventions;
- several rounds of consultations with the community to identify the critical areas that are vulnerable to landslides and explore the best possible options before establishing the landslide treatment model;

- development by the committee of a plan for enhancing vegetation barriers and constructing infrastructure – such as check dams and brushwood dams – to reduce runoff speeds in strategic locations along streams and gullies; in some cases, the committee also draws up plans for grazing control and the planting of forage, grasses, fodders and bamboo.

Institutional support is essential to provide communities with technical advice and inputs that ensure adequate implementation of interventions. For example, the local District Soil Conservation Office and DADO provide saplings, grass seeds and jute sacks for the bioengineering work; and the Department of Water Induced Disaster Prevention provides gabion boxes for the construction of spur dykes, which extend from the stream bank to deviate the current away from the bank, protecting it against erosion.

BOX 6.4

Community action planning

Preparation of a community action plan (CAP) is led by a local task group formed through community mobilization processes and mandated by key members of farmers' groups to develop the CAP on behalf of the community, facilitated by experts or agricultural extension officers. Preparation of the plan includes the following steps:

- The local task group organizes information sessions to identify major risks, suggest alternative crops and management practices, and explain the advantages of a CAP.
- The task group meets to discuss these priority risks and the feasibility of adopting the suggested management practices.
- The group meets community members to validate key elements of the CAP.
- A draft CAP is prepared, incorporating the feedback and priorities identified by community members
- The task group presents the draft action plan to the community for approval before the beginning of the season.

The CAP must have clear objectives and expected outcomes. For each objective, key activities should be specified. To ensure local ownership of the CAP, the external facilitators and local task team should mobilize and consolidate local engagement throughout the entire development process: identification of priorities, planning, evaluation and endorsement.

Structural measures, the planting of fast-growing plants and properly implemented conservation rules are all required for effective landslide prevention or reduction. Plantations of non-timber forest products can be included in communities' plans for long-term conservation and landslide risk reduction. These measures lead to increased crop productivity because they remove the need to leave fertile land fallow, and horticulture provides an additional source of income for farmers.

6.2.5 Alternative management practices

Adopting alternative crops and/or management practices is crucial in the event of water scarcity, drought or flood, when the crops and practices used under normal conditions are no longer appropriate. Measures promoted to reduce the risk of crop failure include adoption of suitable crop varieties, proper spacing, application of plant nutrients based on the number of rainfall events, mid-season correction of management practices, and needs-based pest control. Table 6.4 shows examples of alternative management practices developed by a community in the *terai* region of Nepal, facilitated by the

TABLE 6.4

Alternate crop management practices to reduce the impacts of climate risks

CROP	MEASURES
Rice	Use of dry seedbeds under drought conditions; direct seeding or dapog nursery with early or very late rain; transplanting with normal rain; transplanting of more seedlings (6–8) under rainfed conditions
Maize	Maize–cowpea rotation between rows of Leucaena to reduce soil erosion
Pulses	Mechanical weeding and hoeing for moisture conservation to protect crops during long dry spells, especially in winter; life-saving irrigation to protect black and green gram from drought impacts
Potatoes	Planting in raised beds (24–31 cm) with spacing of 90–100 cm
Vegetables	Drip irrigation during dry spells and water shortage
Lucerne	Crop rotation on sloping land to reduce soil losses
Multipurpose trees	Amla (Emblica officinalis)-based agroforestry systems to reduce drought impacts and increase in-situ moisture conservation.
Multiple crops	Moisture conservation for maize, commercial crops and orchards and green manuring for cowpea, horse gram and sun hemp

district agriculture extension office. This plan considers both indigenous and improved techniques, and provides examples of the contingency measures considered by communities.

6.2.6 Managing climate risks in livestock sector

Vaccination against contagious animal diseases: Incidences of animal diseases are increasing and periodical vaccination against contagious animal diseases is critical. The major diseases for which vaccines are available are haemorrhagic septicaemia, black quarter and foot-and-mouth disease (FMD) in cattle and buffaloes; peste des petits ruminants (PPR) and FMD in goats and sheep; and swine fever and FMD in pigs. The immunity provided by vaccines lasts for six to twelve months. DLSOs, their service centre networks, para-veterinarians, village animal health workers and agrovet stores functioning at the district level generally provide services for vaccination and other treatment. The vaccination cost per animal varies from Nr 3 to Nr 30 (US$0.04–0.4). DLSOs carry out annual PPR vaccination of goats free of charge.

Deworming of animals against internal parasites: The occurrence of internal parasites in animals is increasing. Various studies have indicated huge economic losses due to internal parasite infestations in Nepal, so effective deworming against endo-parasites (liver fluke and nematodes) should be followed to avoid these economic losses and the deterioration of animal health. To control liver fluke infestation, at least two treatments a year are recommended – one in October and one in February. Broad-spectrum drugs to control both nematode and fluke infestations in ruminants include oxyclozanide fortified with levamisole, which is available from veterinary stores. One adult dose (for cattle or buffaloes) costs Nr 95 (US$1.3). Deworming of goats costs Nr 10 (US$0.4) per animal. Deworming should be carried out in both *terai* and mid-hill districts, as parasite problems exist in both.

Establishment of animal relief camps: The establishment of relief camps for cattle and buffaloes, and shelters for other animals, with feeding and watering provision, is an effective risk management strategy during climate extremes. This practice has proved very useful during drought in several parts of India (Ranjhan, 2003). Urea Molasses Mineral Block (UMMB), which contains 40–42 percent molasses, 8–10 percent urea, 38–40 percent rice bran, 8–9 percent cement, 5 percent salt and 0.2 percent trace minerals can be supplied during emergencies. During the recent Koshi floods in Nepal, UMMB and huge quantities of rice straw were supplied from central and western regions of the country. Vaccination against the epidemic diseases haemorrhagic septicaemia and black quarter was also carried out. In such hazardous situations, animals should be moved to safer places and provided with regular feed and water.

6.3 RESOURCE CONSERVATION AND MANAGEMENT TO ADVANCE ADAPTATION

6.3.1 Rainwater harvesting and recycling

Major crops that are grown during the rainy and dry seasons face seasonal droughts. On average, 65 percent of the total cultivated land is rainfed, and yields are low. Livestock rearing as a livelihood activity in the mid-hills and *terai* also requires adequate quantities of water for cultivating fodder

PICTURE 6.3

Water harvesting ponds to support drinking water for livestock and irrigation to kitchen gardens during dry periods

crops (and/or pastures) and for the animals to drink. Water harvesting is essential in supporting livelihood activities throughout the year. As more than 80 percent of Nepal's total annual rainfall falls during the rainy season (June to September), there are opportunities for harvesting rainwater and storing it for agriculture.

Water harvesting ponds: Conservation ponds are a traditional coping strategy for addressing water shortages at the household and community levels. Most rural Nepalese households encounter water shortages during the pre-monsoon season (March to May) and in the post-monsoon, winter months (October to February). These shortages affect crops, livestock rearing and drinking-water availability. Conservation ponds are particularly helpful in supporting livestock and irrigating kitchen gardens during dry periods. Excess water during the rainy season leads to extensive landslides and soil erosion throughout the mid-hill region. Rainwater runoff causes landslides by saturating soils, and can exacerbate existing landslides and gullies by continuing to erode the exposed soils, preventing the regrowth of vegetation. Conservation ponds for collecting rainwater can prevent surface runoff down slopes, allowing the land to stabilize and re-vegetate after a landslide or gullying. Other benefits of conservation ponds include manure generation from dredged silt, replenishing of groundwater and hill springs, fish farming opportunities, and improved water availability for fodder crops, vegetables and fruit trees.

Conservation ponds can be constructed with local tools, materials and labour, facilitating maintenance and reducing costs. The most critical features are size, shape, depth, location and lining material. Size can depend on land availability, household needs and slope considerations (for instance, many small ponds are better than one large pond on land with porous soil and overflow concerns). Location is important because the pond can hold potentially damaging runoff in landslide-prone areas and increase soil moisture in strategic places. The pond's lining material determines the seepage rate and frequency of replacement. Examples include plastic, stones and clay. Most ponds are about 1–1.5 m deep, while length and width depend on land availability. The pond should be connected to a waterway to divert excess water to a safe area; village trenches are often appropriate waterways. Ponds can be constructed for communal or individual use and require annual maintenance prior to the monsoon season. Tasks include dredging of the fine soils from the pond bottom and maintenance of diversion waterways.

The primary beneficiaries of conservation ponds are small farming and rural households, landslide-prone villages and water collectors (mainly women and girls). Institutional support is required to renovate existing ponds, construct new ones and raise the awareness of rural communities regarding the value of ponds in mid-hill regions.

Rooftop rainwater harvesting: Many parts of the country experience water shortages, particularly during the pre-monsoon season (March to May). Sufficient and safe drinking-water supply throughout the year is essential to rural households, but communities located at higher altitudes in the mid-hill region often lack access to water because the necessary systems are expensive or impracticable as there is no reliable electricity supply. Rooftop rainwater harvesting provides a local source of water for drinking or kitchen garden irrigation in many areas where a conventional water supply cannot be provided.

Rooftop rainwater harvesting systems consist of three basic elements: a collection area, a conveyance system, and storage facilities. The collection area is the roof of the house, which must be solid enough to shunt rainwater efficiently and support a gutter system. The conveyance system usually consists of gutters or pipes that deliver the rainwater from the roof and channel it to the storage facility, which is usually a tank. Implementation of a rooftop rainwater harvesting system requires substantial initial investments of the household's time and money for materials, the tank and gutter system, training and labour, and transport and installation of materials.

Rainwater harvesting tanks vary in size and cost, depending on the construction materials and the delivery fees, which vary according to the number of tanks delivered to the same locality and the distance between the construction site and the road network. A 2 000-litre ferro-cement tank and gutter system ranges from Nr 6 000 to Nr 8 500 (US$65–90). A tank of 1 000 litres is the minimum size recommended for a household of two to four members, as rainfall can be sporadic. The water harvested from a roof area of

20 m^2 could meet 100 percent of the drinking-water needs of a family of two to four people from June to September (monsoon), 30 percent of their needs in April, 80 percent in May (pre-monsoon) and 40 percent in October (post-monsoon). Water harvested from the system can also be used for irrigating homestead gardens.

Rooftop rainwater harvesting saves a household an average of 6.4 hours per day for water collection, especially by women and girls. Most women employ the time saved in reproductive activities such as child care, cooking or cleaning, or income-generating activities such as selling livestock and vegetables from the kitchen garden. Women also have more time to participate in social and management activities such as studying, training or accounting. Increased availability of water is directly related to better hygiene practices and improved health conditions in communities.

6.3.2 Improvement of irrigation services

Development of irrigation will benefit the agriculture sector by facilitating adaptation to water scarcity, increasing agricultural productivity and incomes, and improving rural livelihoods. There is tremendous potential for increasing agricultural production through a combination of better water management, improved cultivation technologies and market-oriented production (Pradhan, 2012). To meet the targets for increased agricultural productivity, revitalization of irrigation systems through physical improvement and institutional reform is essential.

Developing existing water structures to improve the reliability of supplies, expand the system of secondary and tertiary canals, and exploit groundwater to augment the lean season water supply are among the hardware solutions for improving irrigation services. Software solutions require the development of more efficient mechanisms for the delivery and management of irrigation systems to the field level, through the clear delineation of responsibilities between the government, which is in charge of major infrastructure, and water user associations (WUAs), which are in charge of delivering irrigation services to farmers. Irrigation systems require multidimensional features to address water resource issues, including physical infrastructure and appropriate irrigation institutions (Ostrom *et al*., 2011).

PICTURE 6.4

Small-scale drip irrigation systems for off-season vegetable cultivation in Surkhet

Greater attention to on-farm water management is essential to enhance the efficiency of water application and use and the use of other agricultural inputs. To ensure effective on-farm water management, it is important to strengthen the institutional and technical capacity of DADOs, WUAs and farmers' groups. The Farmer Field Schools (FFS) already developed by DOA can be used to disseminate knowledge of on-farm water management to WUAs and farmers' groups. This will requires the adjustment of FFS curricula to increase the focus on water management issues.

6.3.3 Improvement of degraded land

Land degradation decreases the quality of land and reduces its potential productivity and resilience. Increasingly frequent natural hazards, such as landslides in the hills, drought in most areas of Nepal, and flooding in the foothills and *terai*, have contributed to increased land degradation, resulting in poor socio-economic conditions and the deterioration of natural ecosystems. Anthropogenic causes such as deforestation, overgrazing and cultivation of steep slopes have resulted in loss of flora and fauna, erosion of topsoil, landslides in the hills, and flooding on the plains.

The repeated pressures of grazing beyond the carrying capacity of grasslands, shifting cultivation in the mountains, and overgrazing on open land lead to land degradation and damage the vegetation and grassland ecosystems. Climate change and associated impacts increase this vulnerability. Improving degraded land contributes to climate change adaptation and mitigation and brings potential benefits for disaster risk reduction.

Bioengineering to control riverbank cutting: Heavy rainfall and landslides in the upstream areas of the Churia range cause the sedimentation of river beds, leading to erosion of the river embankments by fast-flowing water. This has significant effects on the livelihoods of farmers downstream, causing the loss of infrastructure, crops and livestock. The continuous erosion of agricultural land by severe riverbank cutting has also led to floodwater inundation and the deposition of sand, silt and boulders on agricultural land. Organic screens such as fodder/forage grasses and bamboo plantations can mitigate the impacts of extreme climate events such as floods, while inorganic barriers such as rocks and boulders are suitable for stabilizing the points of erosion. Revetments of fast-growing hedges of bamboo, fodder crops, *ipil ipil, sisso, khayar* or *bakaino* along embankments can control riverbank cutting and soil erosion.

Bioengineering is most effective at the community level, so farmers should be encouraged to form groups and local committees to identify riverbank cutting sites for intervention. Committee members provide the labour for development work, while saplings (of bamboo and other species) and gabion wires are provided from external sources, along with technical expertise, training and materials. Farmers are supported in designing and implementing action plans and regulations for riverbank control and plantation activities. This support may include distribution of tree saplings; planting of soil-binding and fast-growing fodders/grasses, bamboo and trees along dikes and embankments; bioengineering techniques such as bamboo spur check dams to protect embankments; removal of sand, silt and boulders from river beds to allow smooth water flow; river flow control to stabilize riverbanks and reduce erosion; construction of gabions from wire and boulders to stabilize points of erosion; community mobilization for improving vegetation and afforestation; construction of proper outlet channels for diverting runoff; and selection of tall varieties of rice suitable for flood-prone areas. In addition, strategies that assist people in developing alternative and less vulnerable livelihoods and reducing their susceptibility to flood hazards may be a more effective response than focusing only on structural measures to control floods (Moench and Dixit, 2007).

Slope stabilization and management: Approximately 86 percent of Nepal's land area is characterized by steep hills and mountains. Intensive use of land resources for agriculture, grazing, fuelwood collection and the development of infrastructure without adequate conservation measures have accelerated surface gullying and soil erosion. The percentage of landslides caused by human activities is significantly higher in the densely populated mid-hills. Major human causes of slope instability include deforestation in the hills and mountains, and slope instability following extreme precipitation.

Slope agriculture land technology (SALT) supports slope stabilization and soil conservation. A FAO project is promoting the management of sloping land using plantations of fodder trees and coffee on terraces to control erosion in the mid-hill region of Arghakanchi. The project is being implemented with the full involvement of farmers' groups. It provides the dual benefits of soil erosion control and fodder for livestock. Another option for stabilizing slopes is hedgerow planting. Rows of perennial crops such as coffee, cocoa, citrus fruits and bananas are planted on every third row created by contoured hedgerows. Rows not occupied by permanent crops are planted with cereals such as maize, upland rice in rotation with sweet potatoes, melons and legumes. Perennial forages and grasses are planted along the ridges. This cyclical cropping provides farmers with several harvests throughout the year. The model is considered very well suited to the mid-hill regions of Nepal.

Under hedgerow contour planting, terraces and contours are gradually improved to reduce soil erosion. The technologies implemented under this system include:

- high or multi-storey cropping with shade-loving crops (e.g., coffee/colocasia) in the lower storey, which is suitable for high-rainfall areas prone to soil erosion and landslides;

- integrated silvipastoral management or agroforestry systems as a drought management and soil erosion control strategy for low-rainfall uplands (e.g., maize under acacia and *Cenchrus* sp., large cardamom under *Alnus* sp.);
- vetiver grass to stabilize farm bunds and road inclines.

Bagar farming along riverbanks: Farmers located along riverbanks in the *terai* (e.g., in Kapilvastu district) face frequent floods and subsequent land degradation that affect their livelihoods, as the sand deposited makes crop cultivation impossible. Bagar farming is particularly suitable for this situation. Watermelon and sweet potato seeds are planted in January and February in the river bed area, in pits of 30 cm depth and 30 cm diameter spaced at 1-m intervals, which have been left to dry out for 10 to 15 days prior to crop planting. The pits are filled with farmyard manure, DAP fertilizer and urea, and three to four seeds are sown in each pit and covered with mulching materials, preferably straw or tree branches, to maintain soil temperature and moisture until the plants have developed four or five leaves. The watermelons need to be watered daily until they have developed two or three leaves. The crop is ready for harvest in May, but farmers usually wait for the monsoon and sometimes extend bagar cultivation until late August before transplanting rice. If the rains are insufficient for rice cultivation, sweet potatoes are cultivated through vegetative propagation with vine cuttings from mature crops, or from tubers. Farmers leave some sweet potato tubers and watermelon vines in the field at harvest, to provide seed for the next year's crops.

This initiative benefits landless households and small farmers dependent on daily wage labour. The costs of producing watermelons on 1 *kattha* (67 m^2) of land are Nr 4 500, of which Nr 1 800 is for DAP fertilizer and urea, Nr 1 500 for improved seeds, Nr 500 for labour, and Nr 700 for harvesting and marketing. The normal watermelon yield is 3 000 kg per *kattha*, generating a total income of Nr 15 000. This favourable cost:benefit ratio – along with the crop's rapid maturation and the low-cost technology and minimum investment required – is attracting increasing interest from farmers, who lack alternative employment opportunities between February and June.

Sweet potatoes can also be grown on the eroded and sandy land along riverbanks. Good yields can be achieved with minimum inputs, as chemical fertilizers are not needed. The costs of cultivating sweet potatoes on 1 *kattha* (67 m^2) of land are Nr 1 700, of which Nr 500 is for seeds, Nr 500 for labour, and Nr 700 for harvesting and marketing. The total income from the same plot of land is Nr 4 500. High productivity can be ensured even with traditional varieties and local tubers. Poor and small-scale farmers can benefit, as sweet potatoes can be consumed by the household, with surpluses sold at local markets.

However, despite the benefits of bagar farming, there are challenges that reduce the scope for scaling up the practice. The poor availability of quality seeds and other inputs at reasonable prices, and the need for irrigation facilities during long dry spells are among the foremost obstacles. In addition, the collective marketing system is still weak, and the involvement of external institutions is required to provide technical support and to disseminate the practice.

6.3.4 On-farm conservation and management of agricultural biodiversity

The variety of ecosystems and the numbers of endemic and globally important threatened and endangered species make Nepal one of the world's prime areas for conservation. In recent decades, however, Nepal has lost more than 0.5 million ha of forest, resulting in loss of biodiversity, increased soil erosion, severe downstream sedimentation, and loss of agricultural productivity. Although several agencies are developing strategies for addressing biodiversity conservation, these strategies have not been comprehensively linked to climate change adaptation and disaster risk management. However, biodiversity conservation can provide win–win solutions for adaptation of agricultural production systems. Innovative practices that conserve biodiversity while achieving other objectives need to be demonstrated, to build farmers' awareness of their value. Local crop varieties tolerant to drought, flood and other extreme events should be demonstrated to alleviate conflicts between the interests of local communities and biodiversity conservation and to reduce the pressure on resources.

6.3.5 Improved crops and varieties for managing climate risks

Stress-tolerant crop varieties: Rice, wheat and maize yields at lower latitudes may decrease because of temperature increase, and be further affected by water scarcity or drought. One approach to dealing with these heat-related constraints is to improve rice, wheat and maize germplasm to provide higher tolerance to such stresses. The new varieties screened by NARC and demonstrated to farmers focus on enhancing crop yield potential and maintaining yields under higher temperatures. These varieties are assisting farmers in building cropping systems that are resilient to climate change and natural hazards.

NARC conducted participatory varietal selection (PVS) trials in six districts (Arghakanchi, Udaipur, Siraha, Kapilvastu, Banke and Surkhet) between November 2008 and October 2011 as part of the FAO-supported project (NARC, 2010; 2011). Based on the results of the PVS trials, it was recommended that the use of drought-tolerant varieties of rice such as Sukkha Dhan 1, 2 and 3 be scaled up. Varieties such as Radha 11, Radha 12, Loktantra and Hardinath 1 are identified as high-yielding and drought-tolerant (Table 6.5).

TABLE 6.5

Stress-tolerant crop varieties identified by NARC through on-farm field trials (2009 – 2011) and their yield advantages over control

CROP	VARIETIES	GRAIN YIELD (KG/HA)		YIELD INCREASE OVER CONTROL/ AVERAGE OF OTHER VARIETIES (%)
		VARIETY	CONTROL/ AVERAGE OF ALL OTHER VARIETIES	
Rice	Radha 11	1 911	1 677	14.0
	Radha 12	3 460	1 593	117.2
	Loktantra	2 494	2 031	22.8
	Hardinath 1	2 525	1 960	28.8
		3 473	1 593	118.0
	Ghaiya-2	2 066	1 699	21.6
Wheat	WK 1204	4 140	3 180	30.2
	NL1073	3 463	3 270	5.9
Maize	Rampur Composite	3 704	2 111	75.5
	Manakamana-4	3 990	2 230	78.9
		4 804	2 200	118.4

PICTURE 6.5

On-farm demonstration of drought tolerant wheat varieties in Udaipur

IR 64 sub 1, Sambha Mahasuri sub 1 and Swarna sub 1 varieties of rice should also be scaled up and evaluated further through the farmers' acceptance test (FAT) or mini-kits in rice growing areas where crops are submerged for several weeks during the tillering stage or in areas where floodwater stagnates for one or two weeks. Rice variety Ghaiya 2 has outperformed other varieties under upland conditions and was recommended for strengthening seed supply systems to facilitate the availability of adequate seeds. NARC also recommended that seed multiplication programmes for rice variety NR 1190 should be started by the Agricultural Development Office, in coordination with the National Commodity Programme, for further dissemination of the variety on a large scale.

Among the wheat varieties demonstrated through PVS trials, NL 1073, BL 3063, BL 3064 and BL 3264 are identified as high-yielding. However, varietal seed multiplication should be carried out at research stations, and further testing through FAT is required. Maize varieties Rampur composite, Manakamana 3 and Manakamana 4 are also considered high-yielding.

Promising grasses and legumes for adaptation: Many grass and legume species that are suitable for *terai* and mid-hill regions are available. These species should be planted on uplands, bunds and community land and forests to produce more green forage for dairy cattle, buffaloes and goats. Most of these forage species are vigorous, have high green matter yields, and are tolerant to droughts and floods. Climate-related hazards have always had severe impacts on the availability of livestock feed, so improving feed and fodder supply for ruminants should be emphasized.

The promising perennial grasses include Napier (Mott) (*Pennisetum purpureum* cv Mott), Guinea grass (*Panicum maximum),* Mulato (*Brachieria* hybrids), Molasses grass (*Melinis minutiflora),* Signal grass (*Brachieria decumbens),* Paspalum (*Paspalum atratum),* Guatemala grass (*Tripsacum laxam),* Sumba and Setaria (*Setaria* spp.). The suitable legumes include Stylosanthes (*Stylosanthes* spp.), Forage peanut (*Arachis pintoi),* Wynn cassia (*Chamaecrista rotundifolia),* Desmodium greenleaf (*Desmodium intortum), and* Joint vetch (*Aeschynomene americana).*

Fodder and forage plantations contribute to the control of runoff and soil erosion, and improve the conservation of soil moisture and nutrient availability. Field demonstrations conducted in Udaipur, Arghakanchi, Siraha and Kapilvastu districts by the FAO project established that the cultivation of grass and legume species can supply green forage for livestock during dry season and increase milk production by 40–50 percent (FAO, 2010e).

6.3.6 Multi-storey cropping and agroforestry systems

Agroforestry systems using the best combinations of crops and trees for intercropping or interfacing will help reduce land degradation while meeting local people’s needs for food, fuelwood, fodder and timber. In agroforestry or multi-storey cropping systems, trees or tall crops provide shade and appropriate microclimatic conditions for other crops planted at lower levels.

Crops grown under multi-storey cropping normally include citrus fruits, coffee, bananas, pineapples, turmeric, maize, legumes, vegetables and finger millet for lower-altitude areas; and apples, walnuts, maize, beans and finger millet at higher altitudes. As well as providing ideal microclimatic conditions for the lower crops, these systems also facilitate the use of combinations of crops and trees that help control land degradation, increase productivity and meet rural people's domestic needs for food, fuel, fodder and timber.In multi-storey cropping, coffee, pineapples and turmeric are the main shade-loving crops grown under tall trees in the mid-hills (e.g., Arghakhanchi and Udaipur districts). The multi-storey system reduces the impacts of hazards such as high-intensity rainfall, soil erosion and landslides.

In agroforestry or agro-silvipastoral systems, single, double or multiple crops such as maize or millet and/or grass species are planted between rows of trees such as *Delbergia sissoo*; cardamom is often planted under *Alnus nepalensis* (alder) trees in the hills. The land under forests offers good agro-ecosystems by providing leaf litter and organic matter for agricultural production. Both multi-storey cropping and agroforestry systems lead to efficient use of resources, soil conservation, protection of agricultural and grass/rangeland from flash floods, increased vegetation composition and agro-biodiversity, and reduced risks of crop yield losses, thereby increasing household income and employment opportunities (NARC, 2010b).

6.3.7 Conservation practices in rice–wheat systems

The practice of cultivating rice and wheat together in the same system is unique to the Indo-Gangetic plains, which has suitable thermal conditions for both crops during their annual cycles in warm-temperate and subtropical areas. Since the 1960s, there has been a substantial increase in the area cultivated under the rice–wheat system in *terai* regions of Nepal. The driving force for this expansion is the increasing demand for food, which has to be met by more intensive production systems because there is no land available for the expansion of agriculture.

System of Rice Intensification (SRI): SRI is a resource conservation and agro-ecological rice cultivation method for increasing the productivity of irrigated rice by adapting agronomic management practices. The SRI method facilitates reduced plant populations, improved soil conditions and irrigation methods, leading to better root and plant development. The features of the system include transplanting of young seedlings (11 days), wider spacing (25 x 25 cm) and reduced irrigation following alternate drying and wetting.

The SRI method was demonstrated in two VDCs (Patana and Dhankauli) in Kapilvastu district and compared with farmers' usual practices (NARC, 2010). The results of the field demonstrations indicated that the SRI method produced 21 percent higher rice yields than farmers' usual practices (Figure 6.1a). The higher grain yield under SRI resulted from having more panicles per unit area and 13 percent more grains per panicle. Pilot experiments of the adoption of SRI in Nepal show yields of 6–10 tonnes/ha (Uprety, 2007; Uphoff, 2007).

Direct seeding of rice under rainfed and limited water situations: Direct seeding is a preferred method of rice cultivation in areas where an assured water supply is lacking, as it enables use of the first rain without delay. Direct seeding can reduce labour costs, as locally made seed drills can be used. Weed control is a major problem under direct-seeded conditions, and suitable methods of weed control must be implemented. Field demonstrations carried out through the FAO project have concluded that varieties such as Hardinath 1, Khumal 4, Bindeswori and Gaiya 2 are suitable for such situations (NARC, 2011).

Reduced/zero tillage: Conservation agriculture involves significantly reduced tillage, the surface retention of crop residues, and diversified, economically viable crop rotations. Along with other resource-conserving farming practices, conservation agriculture can improve rural incomes and livelihoods by reducing production costs, managing agro-ecosystem productivity and diversity more sustainably, and minimizing unfavourable environmental impacts, especially in small and medium-scale farms. One of the longer-term productivity benefits of conservation agriculture practices is likely to be reversal of the widespread, chronic soil degradation that threatens yields in intensive wheat cropping systems in *terai* regions of Nepal. Conservation agriculture with minimum tillage, zero tillage, surface seeding of wheat in rice–wheat systems and bed planting produces clear benefits for climate change adaptation and mitigation.

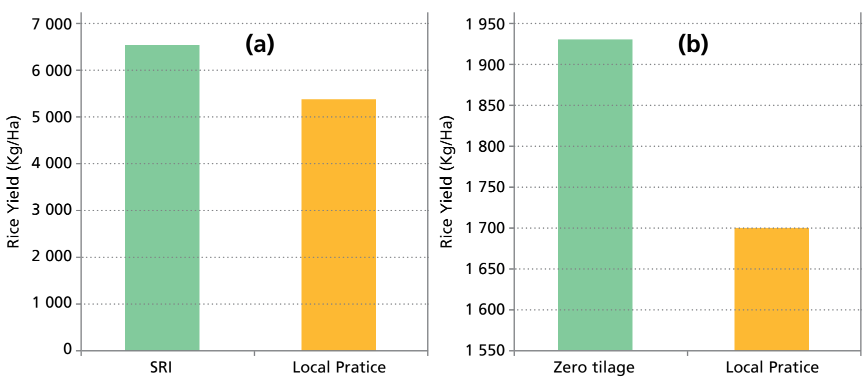
Farmers in the *terai* generally face difficulties in planting wheat on marshy or wet land after rice, as land preparation is very difficult under such conditions. Wet and marshy lands take longer to become ready for tilling, so wheat cannot usually be planted at the right time. Zero or minimum tillage constitutes a suitable alternative for these conditions, while improving the soil's physical properties and utilizing fertilizer more efficiently. Under zero or minimum tillage, soil disturbance is minimal as seeds are placed in the shallow furrows created by the seed drill and covered with the decomposed compost and rice stubble left in the field. This method facilitates the planting of wheat in time, protects the environment, conserves residual soil moisture, reduces production costs, minimizes fuel and energy, and makes cultivation feasible on difficult marshy lands.

Zero-tilled fields need about 30 percent less water than those prepared by conventional tillage, and zero tillage reduces soil erosion because crop residues are left in the soil. Field demonstrations of wheat variety NL 297 sown with a zero-tillage seed drill in Siraha district (2010/2011) achieved yield improvements of 14 percent (Figure 6.1b) compared with conventional practices followed by farmers in the region. The seed-cum-fertilizer drill is attached to a roller and tines and pulled by a power trailer to plant five to six rows of wheat at a time.

Economic analysis of zero tillage in Kapilvastu district (2008/2009 and 2009/2010) indicated that it led to savings of 57 percent in land preparation and seeding costs and 33 percent in irrigation costs compared with farmers' usual practices. These results revealed that a net benefit of approximately 40 percent of total costs can be expected from zero tillage. Results of a trial in Udayapur district concluded that use of this technology can result in not only lower cultivation costs, but also yield increases of 20 percent and irrigation water savings of 40–60 percent (FAO, 2010e). In addition to the

FIGURE 6.1

Yield performance of (a) rice under System of Rice Intensification (SRI) in Patna VDC, Kapilvastu district and (b) wheat under zero till conditions in Sarsawar VDC, Siraha (2010/2011)



good practice examples described in this chapter, Table 6.6 provides a list of adaptation practices prioritized during the transect appraisal for NAPA preparation.

6.4 IMPROVEMENTS IN THE LIVESTOCK SECTOR

Livestock owners already apply several adaptation practices to manage climate risks, including planting fodder trees around farmland; restricting ruminant grazing and managing migratory livestock practices to allow the regrowth of pastures; planting non-timber species to increase food and fodder supplies; using manure to increase crop yields; carrying out

TABLE 6.6

Indicative adaptation practices prioritised during the transect appraisal exercise of NAPA preparation

TERAI	MID-HILLS	MOUNTAINS
• Replace shallow wells with deep tube wells and promote water harvesting and small-scale irrigation • Improve rainwater collection and micro-irrigation • Establish plantations to restore natural water supplies • Introduce rapid-maturing and hardy crops adapted to high temperature • Practise integrated pest management • Reduce inorganic fertilizers and increase use of organic manures • Practise minimum or zero tillage • Address market and production issues through farmers' cooperatives • Breed more adaptable varieties and breeds; and introduce drought-tolerant fruits and vegetables • Introduce insurance schemes for crops and livestock • Conduct capacity building and public awareness • Establish early warning systems • Practise riverbank protection • Introduce alternative energy sources (e.g., biogas)	• Grow vegetable crops, toria, niger instead of potatoes • Select short-duration crop varieties • Practise rainwater harvesting, drip irrigation • Use improved varieties and fertilizers • Establish water conservation ponds • Use groundwater • Increase community awareness on adaptation • Conduct studies on climate change in relation to diseases, pests and parasite incidence • Conduct an epidemiological study of the prevalence of plant and animal diseases and parasites • Increase community awareness on crop and livestock insurance, market outlets and seed banks • Establish decentralized buffer stocks, cold storage etc. • Promote agroforestry • Breed adaptive varieties and breeds • Promote seed banks	• Plant trees around farm land and water sources • Replace present crops with harder varieties • Collect rainwater • Change tree crop types • Tap snow water sources • Introduce small-scale irrigation • Introduce alternative energy sources: improved stoves, solar panels, back boilers, smoke water heaters, micro-hydropower • Establish forest plantations • Introduce micro-irrigation technology • Conduct soil conservation works • Provide training • Establish agro-industries

Source: Government of Nepal, 2010b

reforestation and afforestation activities with tree species that provide fodder; controlling parasitic infestations in domestic animals; cultivating fodder grasses and legumes (summer and winter perennials); and adopting livestock insurance.

Improving livestock infrastructure and services: The livestock sector has been recognized as an important source of income. In areas with potential for green forage production, small-scale production of meat goats and buffaloes should be encouraged, as livestock can compensate households for cereal crop failures. However, frequent climate hazards affect animals severely, so it is important to raise farmers' awareness regarding improved animal management practices. Demonstrations, training, field visits and FFS can play significant roles in this regard.

Appropriate sheds are an important element of livestock management. Animal sheds often lack ventilation, sanitation and the conditions necessary for the animals' comfort. Goat sheds should be improved to provide more floor space and separate enclosures for different age groups and use categories

PICTURE 6.6

Demonstration of improved manure management in Banke

of goats. The roofs of sheds should be raised, to minimize heat stress and provide adequate ventilation. Frequent cleaning of sheds, including beneath the floor slats, can improve goats' health and productivity, and the provision of feeding racks and watering places is also important. Similar changes can be made in pig sheds and chicken pens.

Proper cleaning of shed floors is easier when the floor surface is hard and sloped towards a gutter. Sheds should have adequate floors, roofs, ventilation, and gutters to collect urine and dung. There should also be manure pits, roof-water collection tanks, and shade trees around the shed to improve hygiene and reduce the impacts of extreme weather conditions.

Improved livestock grazing and manure management and utilization: Awareness of the benefits of rotational grazing and stall feeding should be disseminated to communities through training, tours and demonstrations. Stall feeding of ruminants lowers the parasite infestations on animals, protects the environment and provides extra manure for crops and vegetable production. Proper management and utilization of farmyard manure and animal urine reduces nutrient loss and methane emissions, particularly when combined with the use of biogas technology.

Animal breeding strategies: Native breeds have adapted to their harsh environments and are therefore generally more resistant than exotic breeds. However, many Indian buffalo and goat breeds have adapted to conditions in the *terai* and mid-hills. Indian Murrah buffaloes and goat breeds such as Jamnapari and Beetal have survived and reproduced successfully, and also have higher production potential than native breeds. To cope with adverse climate impacts, cross-breeding is recommended. However, in the mid-hills, the native Khari breed has been found superior to cross-breeds with Indian breeds, and Jersey cattle cross-breeds are better adapted to warm climate conditions than Holstein Friesians. Indian cattle breeds are suitable for producing bullocks for draught and land tilling purposes.

6.5 SUSTAINABLE USE OF FOREST RESOURCES: COMMUNITY FORESTRY

Community forestry in Nepal supports the sustainable use of forest resources, ensuring that they are available to benefit local people. Some communities have organized forest user groups (CFUGs) to implement

PICTURE 6.7

Reseeding of fodder crops by the community forestry user groups in Udaipur

community forestry activities for protecting, producing and distributing the benefits of forest resources through sustainable management. Members participate in decision-making processes and implement community forestry activities to fulfil basic needs and generate funds for community development activities.

Nepal's community forestry initiative addresses the two-fold goal of forest conservation and poverty reduction (IFPRI, 2009). The programme has evolved from a protection-oriented, conservation-focused agenda to a more broad-based strategy for forest use, enterprise development and livelihood improvement. The community forestry programme promotes strong collective action through the local community's close involvement in the sustainable management of forest resources. In spite of continuing challenges such as the inequitable distribution of benefits to women and marginalized groups, the approach has proved valuable for the sustainable management of natural resources.

Environmental services are significantly enhanced under the management of CFUGs. Active sustainable management leads to improved forest conditions with enhanced biodiversity, soil conservation and watershed protection. CFUGs contribute to achieving many of the adaptation and mitigation priorities (SDC, 2009). They promote the production of adapted and indigenous natural species such as bamboo and broadleaved trees, which are good soil binders, provide desirable fodder, serve as sources of cash income during scarcity and have other benefits. Many species are promoted on both private and public land to provide shelter, windbreaks and fire barriers.

Community forestry not only protects and manages forest on community land, but also promotes private tree and grass management on farmland bunds, resulting in resilient agroforestry systems. There is evidence that most CFUGs are engaged in plantations of appropriate mixes of multipurpose species that provide fuelwood, fodder, timber, medicinal plants, soil conservation, live fences and nitrogen fixation. Tenure plays a crucial role in these coping strategies, because community and private tenure rights ensure rural people's access to forests and trees and their right to harvest timber and non-timber forest products.

6.6 ALTERNATIVE ENERGY SOURCES FOR HOUSEHOLDS: BIOGAS

Widespread use of traditional energy sources (by 88 percent of the population) has had adverse impacts on Nepal's environment, people's health and the economy (Gautam *et al.*, 2009). Deforestation to provide energy has been linked to many other problems such as soil erosion, loss of cultivable land, fluctuating and unpredictable river flow patterns and flash floods in almost every part of Nepal. In addition, the use of agricultural residues and cattle dung cakes in inefficient cooking stoves causes smoke in indoor environments, provoking respiratory illness in adults, children and infants. The time spent in collecting forest fuelwood accounts for a major share of daily labour and many health-related ailments among women in rural communities (Bajgain *et al.*, 2005). Under these circumstances, biogas provides multiple benefits, especially at the household level.

The major benefits of biogas include its positive impact on gender-differentiated workloads, health, employment and environment. Several studies have documented decreased workloads for rural women, by reducing the time and labour required to gather fuel for cooking. Biogas stoves are also more efficient, shorten cooking times and do not soil pots and pans with soot, as is common with fuelwood stoves. Experiences from the FAO project's demonstration of biogas plants in Siraha district revealed that most women express great satisfaction, particularly with the cooking aspects of biogas, indicating that it is quicker and easier for cooking than fuelwood. Most women also report noticeable improvements in their respiratory health.

From a local perspective, the use of biogas to replace wood stoves has helped significantly to improve the air quality inside homes. In addition, installation of biogas plants has resulted in better management and disposal of animal dung, helping to improve the sanitary conditions around rural homes employing biogas plants. Biogas also helps reduce greenhouse gas emissions by displacing the consumption of fuelwood and kerosene. Biogas plants produce digested dung as slurry. When properly stored, treated and applied to the fields, this has a higher fertilizing value than ordinary farmyard manure and can increase soil fertility. As well as saving nutrients, the biogas slurry also contributes to maintaining the soil's organic matter content. An additional economic benefit from the use of biogas derives from its replacement of the collection and drying of animal dung to produce dung cakes for fuel; these dung-cakes contain valuable soil nutrients that are lost when the dung is collected and burned. When animal dung is processed through a biogas digester, the resulting slurry retains all the nutrients originally in the dung.

6.7 IMPROVING SUPPLY CHAIN LINKAGES

Risk management and climate change adaptation interventions should be broadened to include agricultural commercialization, through processing, trade and other services such as storage, transportation and logistics, finance and marketing. Engaging the private sector and cooperatives and ensuring connectivity to market infrastructure, including agricultural roads, collection/marketing centres, packing houses and information facilities, can provide a basis for profitable commercialization. Without these supply chain linkages, efforts to adapt crops and cropping systems to the changing climate may not be sustainable.

Activities that support agricultural commercialization include improving access to drought-tolerant and high-yielding varieties and input supplies; promoting agro-vets, with regulatory frameworks to ensure quality services;

supporting the establishment of product collection and marketing centres at selected locations; focusing on high-value export crops and the development of innovative local agribusiness enterprises; and facilitating mechanization that is appropriate to the size of landholding and the local situation, especially in the mountains and mid-hills, in terms of fuel availability, skilled workforce, labour availability, cost sharing capacity of farmers, etc.

CHAPTER 7

MAINSTREAMING CLIMATE RISK MANAGEMENT AND ADAPTATION IN POLICIES, PLANS, STRATEGIES AND PROGRAMMES

This chapter presents salient features of existing policies, plans, strategies and programmes that are relevant to agriculture and food security and disaster risk management in the short to medium term and to climate change adaptation in the medium to long-term perspective in agriculture. The chapter also looks at issues in and opportunities for mainstreaming of climate concerns into broader agricultural and food security policies, plans and strategies; and agriculture and food security priorities into disaster risk management and climate change policies, plans, strategies and programmes.

7.1 AGRICULTURE AND FOOD SECURITY PLANS, STRATEGIES AND POLICIES

The 20-year *Agricultural Perspective Plan (APP)* prepared in 1995 and implemented since 1997 emphasizes irrigation, fertilizers, technology, and roads and power as the four priority input areas for sector growth in livestock, high-value crops, agribusiness and forestry. Major thrusts of the APP are accelerated growth of agriculture through increased productivity; poverty alleviation through enhanced employment opportunities; transformation of subsistence agriculture into commercial agriculture through crop diversification; increased opportunities for economic transformation; identification of short- and long-term strategies; and development of standardized guidelines for the preparation of periodic plans and programmes. The plan envisages multiplier effects of agricultural interventions on other non-agriculture sectors. A major objective of the APP is poverty reduction through agricultural and rural development.

The *National Agriculture Policy* (2004) outlines increasing agricultural production and productivity to make Nepalese agriculture competitive on regional and world markets, with the development of commercial agricultural systems and the protection, promotion and sustainable use of natural resources, the environment and biological diversity as objectives for sustainable agriculture and food security (Government of Nepal, 2004b). The policy emphasizes the participation of all kinds of farmers, and indirectly takes into consideration aspects related to DRM and CCA. The priorities are:

- establishment of a survey/surveillance system to assess the impacts of heavy rainfall, droughts, diseases, insects and other natural calamities and to mobilize agriculture relief schemes;
- development of safety nets (food and nutrition) for farmers with less than 0.5 ha of unirrigated land and for landless and marginal farmers with no alternative employment opportunities in periods of climate hazard and natural disasters.

Among recent initiatives, the *Three-Year Interim Plan (TYIP) (2007/2008–2009/2010)* reinforced the APP's objectives (Government of Nepal, 2007). The interim plan was developed as a vision for modernizing and commercializing agriculture as emphasized in the National Agriculture Policy (2004). It focused on broad-based, gender-inclusive and sustainable agricultural growth with priorities in areas such as increased agricultural production and productivity; maintenance of food sovereignty; transformation of subsistence agriculture into commercial agriculture; increased employment opportunities, conservation and promotion; and sustainable use of agricultural biodiversity.

The TYIP followed reforms envisaged for poverty reduction under the *Tenth Five-Year Plan (2002/2003–2006/2007).* The TYIP included climate change issues and highlighted the dangerous consequences related to the outburst of glacier lakes and the need for programmes to mitigate the adverse effects of climate change and reduce the risk of hazards.

MOAD's later TYIP (2010/2011–2012/2013) emphasizes the transformation of subsistence into competitive agriculture. Major objectives are ensuring food and nutrition security; making the agriculture sector competitive and business-oriented with increased production and productivity; reducing poverty by increasing employment and income-generating opportunities; minimizing the adverse effects of environment and climate change on the agriculture sector; developing cooperatives to support agricultural development; and enhancing human resources for the sustainable agricultural development process. The TYIP emphasizes the need to carry out climate change impact assessment, awareness raising, dissemination of climate friendly technologies, and promote the conservation, promotion and sustainable utilization of agricultural biodiversity.

The *Master Plan for the Forestry Sector (MPFS),* developed in 1989, focuses on meeting people's basic needs from forest products sustainably, conserving ecosystems and genetic resources and protecting land against degradation and the effects of ecological imbalance. It emphasizes implementation of programmes in such areas as community and private forestry development, national and leasehold forestry, development of medicinal and aromatic plants, soil conversion and watershed management, conservation of ecosystems and genetic resources, policy and legal reforms, and institutional reforms. The *Forest Act (1993)* makes provisions for granting leasehold forest areas for agroforestry activities to stimulate income generation and poverty reduction. The *National Water Plan (2005)* emphasizes the conservation and management of water resources for livelihoods development, focusing on hazard mitigation, environmental protection and resolving water-use conflicts.

The *National Agriculture Sector Development Priority (NASDP) for the Medium-Term* (2010/11–2014/15) (Government of Nepal, 2010c) highlights the limited capacity for adaptation to climate change effects. Awareness raising at different levels and the need for location-specific adaptation strategies to manage risks are clear priorities. The document identifies the role of FAO pilot project in demonstrating good practices that have replication potential. Priority 5 on sustaining natural resources conservation and utilization is one of the outputs directly related to climate risk management and adaptation.

The *Nepal Agriculture and Food Security Country Investment Plan (2010)* aims to reduce poverty and household food insecurity sustainably, while strengthening the national economy (Government of Nepal, 2010d). The plan includes programmes in enhancing agricultural production and productivity, supplying quality agricultural inputs and services, developing and strengthening agricultural and marketing infrastructure, increasing agriculture's competitiveness and commercialization, agricultural research and development, promoting and conserving agricultural biodiversity, ensuring food safety and consumer protection, facilitating inclusive agricultural development, developing human resources in the agrifood sector, and strengthening policy research, planning and evaluation.

NARC's *Strategic Vision for Agricultural Research (2011–2030),* developed in 2010, aims to integrate climate change issues into the research agenda by prioritizing research areas that focus on crops and horticulture, livestock and fisheries, natural resources management and biotechnology and outreach, and technology dissemination and extension (NARC, 2010a). The Government of Nepal formulated the *Food and Nutrition Security Plan of Action (FNSP)* with support from FAO. The FNSP complies with the National Planning Commission's TYIP (2007–2010) and Three-Year Plan (2010–2013), and with the National Nutrition Policy and Strategy (2004). The FNSP is intended to serve as the government's standard document for food security interventions for vulnerable populations during the 2013–2022 period.

The plan identifies adverse weather conditions and natural disasters as pressures that reduce the resilience of Nepal's agriculture, resulting in national food production being insufficient to meet the needs of the population. The plan sees the presence of Central Disaster Relief Committee and district disaster relief committees (DDRCs) as providing opportunities to address food emergencies.

The FNSP examines climate change in the context of seasonality and identifies tasks, including the development of agricultural crop, livestock and aquaculture calendars that take climate change effects into account to ensure stable supplies of foods in all months; investment in public research institutions to explore ways of mitigating climate change effects and conserving environments and biodiversity; and promotion of crops with features such as drought tolerance and resilience to flooding or water-logged conditions.

The draft *Agricultural Development Strategy (ADS)* was formulated in 2013 to guide Nepal's agriculture sector over the next 20 years (Government of Nepal, 2013). The ADS considers the agriculture sector in all its complexity, encompassing not only production sectors (crops, livestock, fisheries, forestry) but also processing, trade and other services (storage, transportation and logistics, finance, marketing, research, extension). An ADS action plan and roadmap have been formulated to guide implementation.

The ADS identifies increased resilience to climate change and disasters as one of the five main measures for increasing agricultural productivity. The strategy highlights temperature increases, changing patterns of monsoon precipitation and the need for appropriate adaptation mechanisms to increase farmers' resilience to climate change. It also emphasizes the importance of DRR and the challenges of ensuring sustainable modernization and commercialization of agriculture while strengthening resilience to climate change.

The strategy states that farmers' resilience to climate change and disasters should be increased through a combination of measures such as adoption of stress-tolerant crop and animal species, access to the Farmers' Welfare Fund, establishment of food and seed reserves, and good agricultural practices. The strategy proposes the establishment and adoption of an early warning system for managing climate risks in agriculture and food and nutrition security, and the establishment of climate information and weather indexing systems for farmers. Activities include building the capacity of the DHM to provide weather risk indexing at the local level (as described for agricultural insurance), and building of capacity in the forecasting of crop yields.

7.2 DISASTER RISK MANAGEMENT POLICIES, PLANS AND STRATEGIES

Nepal developed a policy and legal framework for disaster management through the *Natural Calamity (Relief) Act* of 1982. This act constituted the Central Disaster Relief Committee, chaired by the Minister of Home

Affairs, and – for the first time – allocated the district-level management of rescue and relief activities to the Chief District Officer, who also serves as chairperson of the District Disaster Relief Committee (DDRC). Although the act has been amended twice, it has failed to integrate actions in line with the paradigm shift from reactive emergency response through relief to more proactive disaster risk reduction. Emphasis was given to preparedness activities during the International Decade for Natural Disaster Reduction in 1991. The 1996 *National Action Plan* initiated the adoption of measures for addressing different types of disasters.

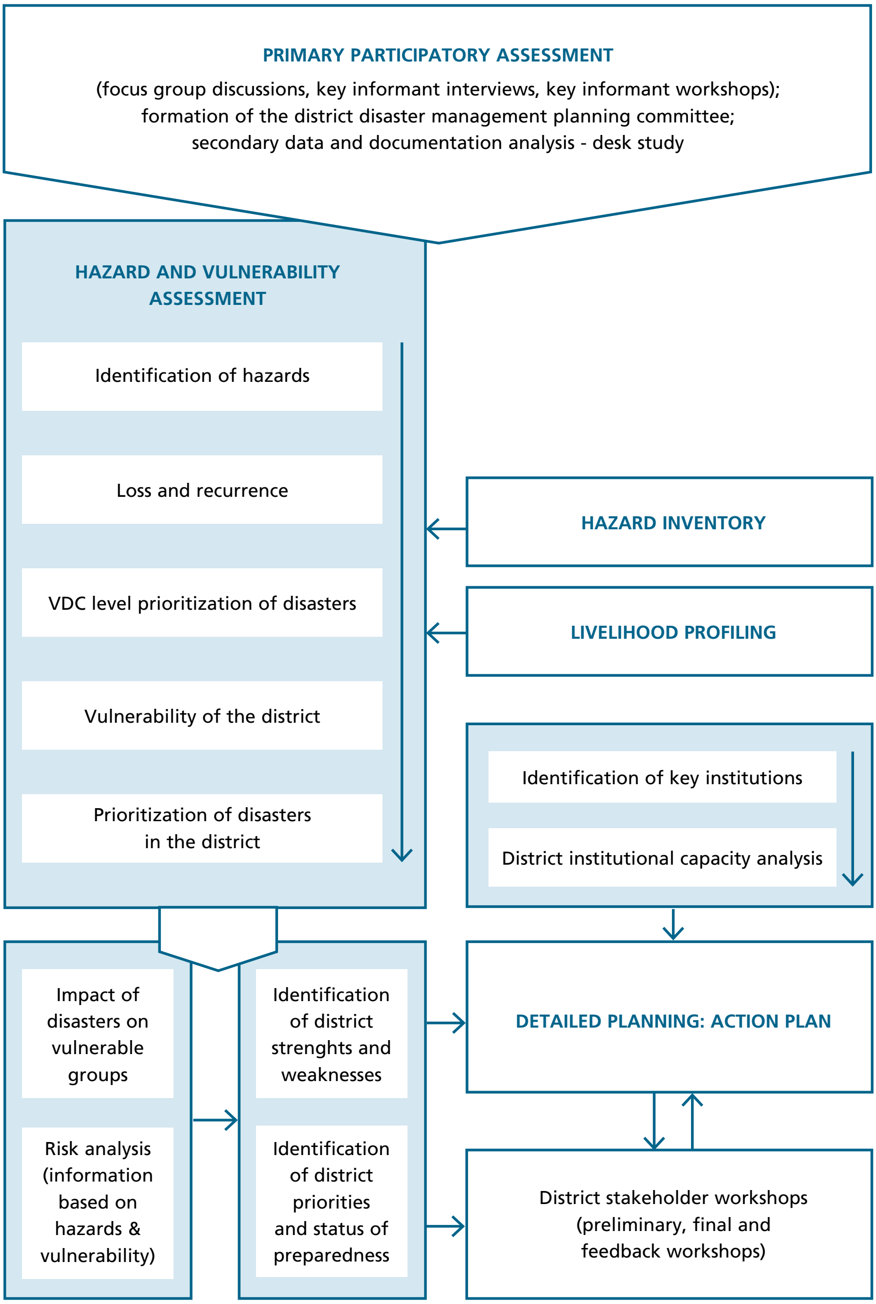
The *National Strategy for Disaster Risk Management (NSDRM)* approved in 2009 (Government of Nepal, 2009b) reflects the spirit and aspirations of the government and people of Nepal as embodied in the tenth Five-Year Development Plan (2002–2007) and the Interim National Development Plan (2008–2010). The strategy aims to facilitate fulfilment of Nepal's commitments to DRR under various international conventions and fora, particularly the *Hyogo Framework of Action (HFA) 2005–2015*, a consensus document adopted at the UN World Conference on Disaster Reduction held in Kobe, Japan in 2005.

The NSDRM implies the necessary changes in government policies to support this paradigm shift, by putting equal emphasis on prevention, mitigation and preparedness, and highlighting the links between disaster management and development, the cross-sectoral nature of DRM and the responsibilities of different actors in DRM. The strategy identifies five priority areas, and sector-specific strategies focus on addressing the identified gaps in each sector.

Following the NSDRM, *district DRM plans (DDRMPs)* were developed for the most vulnerable districts of Nepal. DDRMPs support and extend the national-level needs assessment carried out under the NSDRM by assessing the hazard risk context, analysing the impacts of hazards and the vulnerabilities faced within districts, and identifying key institutions and critical capacity gaps at the district and local levels (Figure 7.1). DDRMPs prioritize hazards and activities to address prevention, mitigation and preparedness efforts during normal times; as response and relief efforts during emergencies; or to strengthen rehabilitation and recovery after emergencies.

FIGURE 7.1

Processes for preparation of district disaster risk management plans



BOX 7.1

Linking national and local disaster risk management planning

The District Disaster Relief Committee (DDRC) becomes active when a district is hit by disaster; local planning for disaster preparedness has often not been considered. To enhance proactive planning for DRR, four districts of Nepal have formulated DDRMPs: Arghakhanchi, Kapilvastu, Udaipur and Siraha. Preparation of the DDRMPs was facilitated jointly by FAO and Practical Action Consulting, Asia in 2009–2010.

District development committees have taken a leading role in the coordination and monitoring of plan preparation; district agricultural development offices (DADOs) have also played an important role because of the heavy impacts of disasters on the agriculture sector. During the planning process, government line agencies and local stakeholders are trained to shift from a reactive disaster management approach to one that is more proactive, with greater involvment in prevention and mitigation actions.

To ensure the linking of national to local disaster risk management planning, the DDRMP planning process uses the framework of sectors and priority areas outlined by NSDRM. This planning document aims to ensure that disaster risks are addressed in a coordinated way by engaging government line agencies, development partners, local institutions and local communities. With periodic reviews and updates, DDRMPs can provide a cornerstone for reducing duplication of efforts, increasing efficiency and – ultimately – helping to empower communities at large.

The *Nepal Risk Reduction Consortium (NRRC)*, launched in 2011, is a government-led entity that unites humanitarian, development and financial partners in efforts to reduce Nepal's vulnerability to natural disasters. NRRC has identified five priorities (flagships): i) school and hospital safety; ii) emergency preparedness and response; iii) flood management in the Kosi River basin; iv) community-based DRR; and v) policy and institutional support for DRM.

7.3 CLIMATE CHANGE POLICIES, PLANS AND STRATEGIES

Nepal became a signatory to the United Nation Framework Convention on Climate Change (UNFCCC) in June 1992 (ratified in May 1994) and to the Kyoto Protocol in September 2005. It prepared its first national communication in 2004 and has developed many environmental and climate change-related programmes and policies, including the Nepal Environmental Policy and Action Plan (2003), the Environmental Protection Act (1996), the Pilot Programme on Climate Resilience (PPCR 2010) and the Climate Change Policy (2011).

Nepal's first National Communication (2004) to UNFCCC integrates priorities relevant to climate change and agriculture, particularly those related to understanding the impacts of climate change on agriculture and evaluating responses to climate change impacts, such as developing drought-tolerant crop varieties and studying the use of traditional varieties; estimating the changes in production rates of rice, field crops and vegetables brought about by carbon dioxide fertilization and temperature increase on different crops. Proposed areas of study include:

- the role of agro-silviculture systems, which are regarded as carbon dioxide sinks;
- economic models that compare the results of mitigating climate change effects through emission reduction with those of adapting to climate change by adjusting production practices;
- soil organic matter and nutrient cycling (accumulation and decomposition rates, etc.) in relation to climate change and agricultural sustainability;
- the effects of traditional practices such as green manuring, continuous cropping with fertilizer, multiple cropping and modified alley farming on reducing climate change impacts;
- the effect of climate change impacts on the occurrence of weed, pest and disease of cultivated crops, and the development of forecasting systems;
- agro-ecological zones, particularly those sensitive to climate change impacts, and potential vulnerable areas;
- the probability of drought in different agricultural seasons and areas;
- the impact of climate change on water availability and crop water requirements, and the promotion of rainfed farming and efficient utilization/ conservation of water.

The *NAPA 2010* was prepared through a consultative process as a strategic tool for assessing climate vulnerability and systematically responding to climate change issues by developing appropriate adaptation measures. Prioritized adaptation options include both urgent/immediate and long-term strategies in key vulnerable sectors. Strategies have been targeted to increase communities' adaptive capacity through livelihood support, improved governance, collective responses, improved service delivery mechanisms, and access to technology and finance (Government of Nepal, 2010b).

The six major sectors identified in the NAPA include agriculture and food security, which is led by MOAD. The NAPA prioritization process identified nine priority profiles of which eight are closely related to agriculture and food security. Based on the FAO/TCP workshop (23 February 2010) findings, five main projects with 40 corresponding activities in agriculture have been prepared:

- on-farm soil and water conservation initiatives for supporting communities that are vulnerable to climate change impacts;
- improving local access to agricultural services for climate-vulnerable communities;
- strengthening highland–lowland linkages to improve community access to agricultural services;
- linking local dairy and meat production to urban markets to enable communities to combat climate change impacts;
- building adaptive capacity to enhance community resilience to climatic hazards.

Following NAPA preparation, development partners initiated several climate change programmes: recognizing the high levels of exposure to climate change risks, in 2009, the Climate Investment Funds (CIF) selected Nepal as one of the countries for the *Pilot Programme for Climate Resilience (PPCR)*; Nepal's *Strategic Programme for Climate Resilience (SPCR)* was developed by the Government of Nepal (2010e) in partnership with ADB, IFC and the World Bank; and the Government of Nepal has started implementation of the Building Resilience to Climate-Related Hazards (BRCH) project, one of five projects identified in Nepal's SPCR to be implemented over a five-year period through collaboration between MOEST's DHM and MOAD. The project aims to transition Nepal's hydro-meteorological services into a modern service-oriented system that builds resilience today and adaptive capacity for the future. It is intended to enhance the government's capacity to mitigate climate-related hazards by improving the accuracy and timeliness of weather and flood forecasts and warnings for climate-vulnerable communities. The project will also support agricultural management information services to help farmers manage climate-related production risks.

The Government of Nepal (2011b) has prepared and promulgated a *Climate Change Policy* centred on local communities whose livelihoods depend on natural resources and conditions. The policy reiterates the need to ensure that local communities receive up to 80 percent of the total funds allocated to climate change activities, and provides guidance on channelling funds through activities at the grassroots level (Tiwari *et al.*, 2012). The most relevant priorities for managing climate risks and advancing adaptation are initiation of community-based adaptation actions; assessment of the losses and benefits resulting from climate change; promotion of climate change adaptation through technology development and transfer, public awareness raising, capacity building and access to financial resources; and development of a reliable system for forecasting impacts to reduce the adverse impacts of climate change.

The importance of *local adaptation plans of action (LAPAs* 2011) is also widely recognized. LAPAs focus on specific local-level adaptation activities and aim to build an integrated framework for using a bottom-up approach to identify adaptation needs, options and priorities (Government of Nepal, 2011c). The LAPA framework ensures that the process of integrating climate change resilience into local and national planning is bottom-up, inclusive, responsive and flexible. The framework supports decision-makers from the local to the national level in identifying the most vulnerable communities, wards and people, and their adaptation needs and options.

The LAPA process supports both the preparation of adaptation plans and their integration into local and national planning, in accordance with the Local Self-Governance Act, and identifies service delivery agents and funding channels for implementation, ensuring that the most appropriate service providers carry out the best sequence of adaptation actions in a timely and resource-efficient manner. The process follows a step-wise procedure that includes climate change sensitization, climate variability and adaptation assessment, prioritization of adaptation options, integration of adaptation priorities into wider planning processes, implementation of local adaptation plans and assessment of their progress.

7.4 KEY ISSUES AND OPPORTUNITIES FOR MAINSTREAMING

Although several planning exercises have been undertaken, there is a clear lack of comprehensive action plans that support local actions related to the management of climate risks and adaptation in agriculture. The government has only recently started to consider DRM and CCA priorities in its agriculture and food security plans, strategies and policies. This change in focus is clearly visible by comparing the APP's objectives with those of more recent agricultural plans and strategies. Although priorities before 2010 include climate risk management and/or adaptation interventions, the location-specific impacts of climate-related risks were not recognized. In some policies, acts and regulations, disaster risks and climate change are considered only in few of the technical areas related to agriculture development (Table 7.1).

Some of the plans in Table 7.1 have identified impacts such as irregular rainfall, frequent floods and droughts, cold waves and increased landslides, and articulated the need for disaster risk reduction and climate change adaptation. For example, climate change adaptation is mentioned in the investment plan, which states that the institutional and technical capacity of MOAD at the national and district levels needs to be increased to address climate risk management, disaster prevention and preparedness issues from agricultural perspectives. The capacity of bureaucrats and elected leaders is critical for the successful integration of climate change adaptation policies into national planning frameworks (Sova and Chaudhury 2013).

Future attempts to mainstream climate risk management and adaptation priorities into agricultural policies, plans and strategies need to consider such issues as strengthening the institutional and technical capacity at all levels of MOAD, the assessment and monitoring of climate risks and forecasting, the sustainable management of natural resources with due consideration of climate impacts, and the strengthening of capacity for disaster risk reduction.

However, no disaster risk management strategy or plan integrated agriculture sector priorities until the National Strategy for Disaster Risk Management (NSDRM) was prepared in 2009 (Table 7.2). The National Action Plan for Managing Disasters (1996) identified a hazard-specific

TABLE 7.1

Integration of climate-related concerns into policies, plans and strategies for agriculture and food security

POLICY/PLAN/STRATEGY	SUMMARY OF REFERENCE AND LEVEL OF INTEGRATION
Agricultural Perspective Plan (APP) 1995	No specific references to climate (disaster) risk management and climate change adaptation
National Agriculture Policy (2004)	Mention of surveillance system for assessing the impacts of extreme weather events and the development of safety nets. Climate risks are considered important, but the key areas of support and activities are not defined.
Three-Year Interim Plan (2007/08 – 2009/10)	Mention of international commitments, programmes on mitigation of the adverse effects of climate change, efforts to exploit opportunities for payments for environmental services, and the danger of glacial lake outbursts in Nepal.
Three Year Plan (2010/11 – 2012/13)	Mention of climate change and dangerous consequences of glacier lake outburst floods; emphasis of the need for a programme on mitigating the adverse effects of climate change and reducing hazard risk
Nepal Agriculture and Food Security Country Investment Plan (2010)	Mention of the problems of irregular rainfall, frequent floods and droughts, cold waves, increased landslides; emphasis of the need for promotion and conservation of agricultural biodiversity
Nepal Agriculture Sector Development Priority for the Medium-Term (NASDP) 2010	Climate change as a main focus area under priority 5 on sustaining natural resources conservation and utilization; emphasis of the limited capacity for adapting to climate change. Key areas of support and activities relevant to climate change adaptation and disaster risk management are defined.
Strategic Vision for Agricultural Research (2011 – 2030)	Climate change as a central and cross-cutting thematic area of research; emphasis of climate change as the most prominent emerging trend and of the impacts of climate change already experienced by the country; promoting adaptation to climate change as a guiding principle of NARC's agricultural research
Food and Nutrition Security Plan of Action (FNSP)	Adverse weather conditions and natural disasters as main causes of reducing resilience; emphasis of need for climate change adaptation to take seasonality into account, the importance of food supply throughout, and the need for promoting stress-tolerant crop varieties
Draft Agricultural Development Strategy (ADS 2013)	Increased resilience to climate change and disasters as a major measure for increasing agricultural productivity; emphasis of need to establish early warning systems and adopt stress-tolerant crops and varieties. Key areas of support and activities relevant to climate change adaptation are defined.

approach, but focused mainly on emergency management; only NSDRM considers sectoral strategies for agriculture and food security, in line with the Hyogo Framework for Action (HFA), provides clear roles and responsibilities, and proposes institutional arrangements. The Nepal Risk Reduction Consortium (NRRC) launched in 2011 does not prioritize agriculture and food security as one of its flagships.

The first national communication on climate change proposed several studies to enhance the understanding of climate change impacts and possible response measures. A comprehensive review conducted as part of the preparation of this report showed clearly that such studies were not yet systematically conducted. A first attempt to integrate agriculture and food security perspective into the National Adaptation Programme of Action (NAPA) was made by the thematic working group (TWG) on agriculture and food security, by grouping the priority adaptation options identified into thematic projects and then systematically integrating them into nine profiles, of which seven could clearly contribute to agriculture and food security. There are opportunities for implementing targeted programmes in accordance with NAPA priorities, as is already the case of projects funded by donors and the Least-Developed Country Fund (LDCF).

The NAPA preparation process included transects and community-level dialogue, but community representatives were not included in the prioritization process and there are no mechanisms for channelling community actions. However, community-level actions are feasible through LAPAs, which apply a bottom-up, inclusive, responsive and flexible approach to integrate climate change adaptation into local and national planning. LAPAs are expected to facilitate identification of the most climate-vulnerable VDCs and communities and their needs related to adaptation. There are opportunities for strengthening LAPAs by facilitating the scale-up of successful interventions. Recently, the Pilot Programme on Climate Resilience (PPCR) identified location-specific weather forecasts and agricultural management information systems as the main areas of investment, and focused on enhancing adaptive capacity within the agriculture sector. It is important that these activities build on NAPA, to ensure that interventions are coordinated and in recognition of NAPA's high degree of national ownership (Ayers *et al*., 2011).

The Climate Change Policy (2011) identifies local communities as key stakeholders, but local communities are generally regarded as passive beneficiaries rather than active partners in development (HELVETAS, 2011).

TABLE 7.2

Integration of agriculture and food security priorities into disaster risk management and climate change policies, plans and strategies

POLICY/PLAN/STRATEGY	SUMMARY OF REFERENCE AND LEVEL OF INTEGRATION
National Action Plan for managing disasters (1996)	Hazard-specific mitigation measures considered, but not specific to the agriculture and food security sector.
National Strategy for Disaster Risk Management (NSDRM 2009)	Sector-specific strategies and activities defined for addressing identified gaps in agriculture and food security. Key areas of support and activities are defined.
District DRM plans (DDRMPs)	Plans developed before 2010 do not explicitly address agriculture sector-specific activities; later plans consider agriculture and food security an integral part of planning. Agriculture and food security are prioritized as an element and/or integrated into results framework.
Nepal Risk Reduction Consortium (NRRC) 2011	Agriculture and food security considered, but not one of the 5 priorities identified.
Nepal's first National Communication (2004)	Climate risks considered as major threats; studies to enhance understanding proposed. Key areas of support and activities are defined. Agriculture and food security are considered important.
Nepal's National Adaptation Programme of Action (NAPA 2010)	Agriculture and food security emphasized; priorities identified through processes including transects, consultations and workshops. Key areas of support and activities are defined.
Pilot Programme for Climate Resilience (PPCR)	Transition of hydrometeorological services into a modern service-oriented system included; opportunities for developing needs-based information products for agriculture identified; support for an agricultural management information system emphasized
Climate Change Policy (2011)	Consequences and need for local interventions at the community level emphasized. Agriculture and food security are prioritized as an element and/or integrated into results framework.
Local adaptation plans of action (LAPAs 2011)	Integrated frameworks for advancing bottom-up approach to identify adaptation needs considered a mechanism for implementing NAPA priorities. Key areas of support and activities are defined.

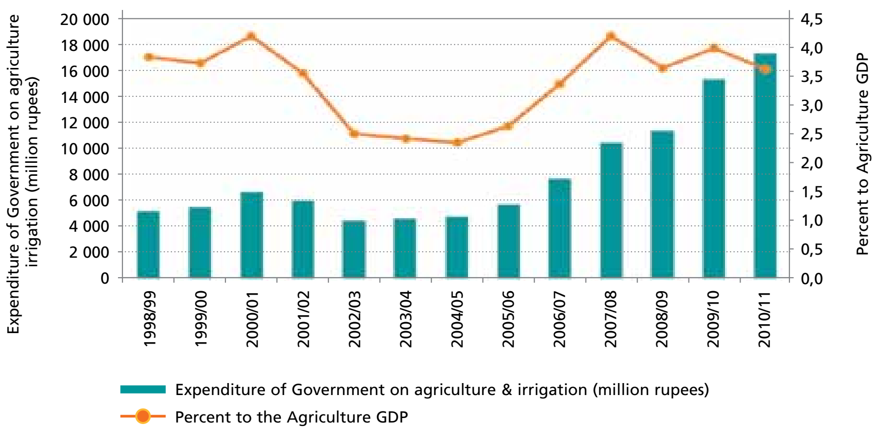
There will be opportunities to clarify the roles, rights and responsibilities of local communities in the guidelines being prepared for implementation of the policy, which currently lacks a concrete plan of action and identification of the main implementation mechanisms on the ground. Reviews of the policy note that it does not mention the priorities of local communities, institutional arrangements and responsibilities at the local level (HELVETAS, 2011; Tiwari *et al.*, 2012; Sova and Chaudhury, 2013). However, there are opportunities for local communities – particularly in the agriculture sector – through creating awareness, enhancing livelihood options and building capacity at the local level. Preparation of guidelines for systematic implementation of the policy will help to identify the most vulnerable communities and gender-sensitive responses to climate change impacts.

7.5 PROGRAMMES AND PROJECTS RELEVANT TO MANAGING CLIMATE RISKS AND ADAPTATION

MOAD is the main government authority for agriculture-related development programmes and projects. Government bodies such as DOA, the Department of Livestock Services and NARC are the implementing arms of MOAD, delivering services to farmers. Several of the projects and programmes already being implemented are directly or indirectly aimed at reducing climate risks and enhancing adaptation. Government expenditure on agriculture and irrigation has been increasing recently, but remains very low compared with agricultural GDP (Figure 7.2). There are opportunities to allocate additional funds to implement some of the priorities relevant to climate change adaptation. Most donor-funded programmes are

FIGURE 7.2

Government expenditure on agriculture and irrigation, and as a percentage of agricultural GDP



Note: Analysis based on data from MOAD (2012) channelled through government or civil society organizations involved in the implementation of pilot projects for improved livelihoods, market systems, productivity enhancement, high-value commodities, risk and vulnerability assessments, and adaptation practices for the most vulnerable communities. These pilot projects are scattered and there is no mechanisms for sharing experiences and lessons to facilitate systematic upscaling and replication.

Much work in the livestock sector focuses on productivity enhancement and links to market systems, to enhance livelihoods in poor communities. Government institutions have initiated a national project for community livestock development, focusing on intensive production, processing, marketing and commercialization. Other projects aim to strengthen surveillance, laboratory testing, preparedness and responses to avian influenza. Most civil society organizations include livestock as an important component of livelihood diversification. Efforts to integrate improved varieties of domesticated animal breeds at the household level include programmes for goat, poultry and rabbit farming, but there are few programmes for the development of new breeds that are resistant to climate risks.

Programmes related to forestry are covered by the Ministry of Forests and Soil Conservation (MOFSC). Community forestry initiatives have been successful in Nepal, with communities obtaining resource use rights for the conservation and use of their forest resources. However, few of these efforts have integrated climate risk-related issues. Other programmes focus on leasehold forest, livestock production and forest development. In the area of forest conservation and community benefits of forest carbon storage, the Reducing Emissions from Deforestation and Forest Degradation (REDD) Cell of MOFSC is responsible for coordinating the REDD process. Some projects, such as Hariyo Ban led by the World Wide Fund for Nature and CARE, focus on adaptation and mitigation aspects by managing the landscape through REDD principles.

Although the fisheries sector contributes only a small share of total agricultural GDP, it is growing rapidly and has high potential. Fisheries occupy only 2 percent of the total water surface area, and their growth is mostly the result of improvements in aquaculture. Few projects focus on the vertical and horizontal integration of vegetable, fruit, seasonal fodder and livestock production with fisheries, and few fishery projects focus on climate change adaptation, but there are opportunities for concrete interventions in the sector.

7.6 DEVELOPMENT OF A PRIORITY FRAMEWORK FOR ACTION (PFA)

Increasing resilience to climate change and disasters (including climate related) is one of the five main measures identified under the draft agriculture development strategy to increase agricultural productivity. The NAPA and NSDRM priorities have already created a strong momentum for integration of climate risk concerns into agricultural priorities, and call for on the ground action to address the immediate issues and also to contribute to the future anticipated impacts. The Priority Framework for Action (PFA) supported by FAO is a response to this call (Government of Nepal, 2011a). Such prioritization will enable donor agencies and development partners to assist the country in agriculture and natural resource management, by building the institutional capacities and technical skills needed for integrated and cross-sectoral implementation of the NSDRM strategies and NAPA priorities. Within the framework of the NSDRM and NAPA, the overall aim of the PFA is to assist MOAD in operationalizing the shift from a reactive emergency response-focused approach towards proactive risk prevention and preparedness in the short term, and climate change adaptation in the long term.

The specific objectives of the PFA are to facilitate: i) strengthening of technical activities for CCA, disaster prevention, impact mitigation, preparedness and response, and rehabilitation in the agriculture sector; ii) integration of NAPA and NSDRM priorities into the regular activities of MOAD and its operational departments; iii) development of institutional and technical capacities to provide farmers with climate change adaptation and disaster risk management services; and iv) better coordination among key stakeholders in climate change adaptation and disaster risk management at the national, district and local levels in the agriculture sector. The key components and priorities are presented in Table 7.3.

The ten-year (2011–2020) PFA proposes ways and means for managing the impacts of climate-related extremes and climate change in agriculture.

TABLE 7.3

Key components and activities of the Priority Framework for Action (PFA) 2011 – 2020

PRIORITY FRAMEWORK FOR ACTION (PFA) 2011 – 2020
COMPONENT 1: STRENGTHEN INSTITUTIONAL AND TECHNICAL CAPACITY
• Strengthen institutional mechanisms within MOAD for effective coordination • Mainstream CCA and DRM policies and strategies into agricultural policies and plans • Strengthen the technical units in DOA and Department of Livestock Services • Strengthen research and development linkages and promote applied research on climate change impacts and adaptation/mitigation
COMPONENT 2: ASSESS AND MONITOR CLIMATE RISKS (CURRENT AND FUTURE) AND VULNERABILITIES AND ENHANCE EARLY WARNING SYSTEMS
• Improve climate impact, risk and vulnerability assessment methodologies • Strengthen climate monitoring infrastructure, needs-based weather and climate information products and services, and early warning systems for agriculture • Develop livelihood-based damage and loss assessment procedures and baseline database
COMPONENT 3: IMPROVE KNOWLEDGE MANAGEMENT, DATABASES AND AWARENESS RAISING
• Design and apply an awareness creation strategy • Enhance knowledge, innovations and good practices and disseminate them to wider adoption • Mobilize local communities and local institutions to benefit from improved knowledge
COMPONENT 4: REDUCE CLIMATE-RELATED RISKS AND UNDERLYING VULNERABILITIES
• Promote integrated production systems, economic diversification and post-harvest practices to manage climate-related risks proactively • Promote risk sharing and transfer mechanisms • Promote sustainable land and soil management practices • Demonstrate water management and conservation practices • Improve the construction of animal shelters and promote proactive animal/livestock management
COMPONENT 5: STRENGTHEN CAPACITIES AND PROCEDURES FOR EFFECTIVE DISASTER PREPAREDNESS, RESPONSE AND REHABILITATION
• Promote regular contingency planning from agriculture perspectives • Enhance response measures to improve the effectiveness of emergency response • Standardize the content and format of the information collected on disaster impacts • Strengthen capacities for integrating CCA and DRM into response and rehabilitation projects

Its preparation was based on a brain-storming session and stakeholder workshops led by MOAD. The PFA provides a roadmap for addressing the impacts of risks associated with extreme climate events and climate change, covering all the hazard-prone districts of Nepal. It seeks to ensure that risk management and climate change adaptation are national and local priorities with a strong institutional basis for implementation. The PFA provides guidelines for institutional arrangements (in its chapter 4), coordination, monitoring and evaluation, and also considers cross-cutting elements such as capacity development, knowledge and communication, partnerships and gender equity.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

Nepal is vulnerable to climate risks, and the impacts of climate change on agriculture and food security are increasingly evident. Growing vulnerability to floods, droughts, landslides, heat waves and animal/plant pests and diseases are the main threats to agriculture and food security in Nepal. Agriculture is the principal economic sector, on which over 65 percent of the population depend, but it is poorly diversified and largely dependent on variable monsoons. Most farms are small, and there has been little adoption of modern technology because of under resourced agricultural support services and weak supply of agricultural inputs.

Institutional support has focused on responses to climate risks, and lacks initiatives on proactive risk management and resilience. Within the agriculture sector there are limited structures and resources for proactive climate risk management and adaptation to climate change. Strengthening of these areas will require coordinated efforts at the national and local levels. Initiatives by MOAD, especially DOA, the Department of Livestock Services, NARC, and regional and district agriculture development offices are critical to the mainstreaming of risk management and climate change adaptation into agriculture. Broader collaboration with other ministries and departments is also fundamental. Interministerial mechanisms established during the project period (e.g., the steering committee) were effective, but efforts are needed to sustain these mechanisms to enhance future collaboration and coordination.

Institutional and technical capacity development is the key priority for improving MOAD's position as a key actor in climate risk management and adaptation. Capacity development at all levels of MOAD is required to implement the climate risk management activities of the NSDRM and to mainstream adaptation into the ministry's sustainable agricultural and rural development planning. Institutional and technical capacity needs to be enhanced at the national and district levels, particularly in DOA and the Department of Livestock Services, to ensure that climate risk management and climate change adaptation are addressed proactively and from an agricultural perspective. The institutional framework of the NSDRM recognizes the importance of agriculture, and the NAPA identifies several priority action areas related to the agriculture sector. Building institutional and technical capacity will also provide MOAD with a comparative advantage in representing the agriculture sector in national-level adaptation initiatives facilitated by the Ministry of Environment.

Additional efforts are needed to mainstream institutional and technical capacity development activities within MOAD. At present, capacity building activities are fragmented and insufficient to meet the needs of the large DOA and Department of Livestock Services staff at the national and district levels. Currently, capacity development activities are mainly at the national level, with selected participants from the districts; capacity development at the district level is usually related to the preparation of DDRMPs. Farmers receive specific training programmes on improved agricultural practices as part of field demonstrations. The sustainability of MOAD capacity development activities at the national and district levels is limited due to the frequent transfer of staff members, and there are very limited efforts to strengthen the capacity of agricultural service centres. Further efforts in this regard should ensure sustainability by mainstreaming capacity building activities into the institutional system.

Data and information about climate change impacts and vulnerabilities must be systematically assessed and managed to help develop adaptation strategies for agriculture. Existing assessments focus on current risks and employ a livelihood perspective to assess location-specific risks and vulnerabilities. As climate change scenarios become increasingly available, model-based impact assessments in line with the NAPA priorities will provide objective vulnerability, risk and impact assessments to facilitate implementation of the adaptation practices identified through the NAPA process.

Currently available weather and climate information and early warning systems offer some opportunities, but are insufficient for managing climate risks proactively. The risk management approach focusing on farm management strategies can enhance the adaptive capacity and resilience of farmers to the anticipated future impacts of climate change. Building on existing weather and climate information, innovative information products tailored to the needs of local farmers can increase lead times for flood and drought warnings, facilitating farmers' decision-making and improving their choice of crops and other management practices. Ongoing efforts seek to enhance the capacity of agricultural support services and local organizations to understand climate change impacts, vulnerabilities and adaptation. However, further efforts are needed to develop the current 24-hour forecasts into longer-term forecasts, which would help to expand the scope of weather and climate information from its current focus on life saving to include better safeguarding of people's livelihoods.

Climate risk management and climate change adaptation interventions must focus on community needs. As climate change impacts and adaptation are location-specific, interventions for the local level require the introduction and demonstration of innovative adaptation options through a guided learning-by-doing process at the district and community levels. The community-based adaptation approach has been tested through the FAO Technical Cooperation Programme project, and efforts are now needed in all risk-prone districts to disseminate locally adapted, innovative and gender-sensitive technologies for climate change adaptation in the agriculture sector. This process will enhance local awareness of adaptation to climate variability and change and resilience to the impacts and unpredictability of current climatic extremes. As MOAD is participating in ongoing community-based adaptation initiatives, its agencies are well placed to scale up climate change adaptation and climate risk management and adaptation initiatives in all risk-prone districts. Climate change policy (2011) and local adaptation plan of action (LAPA) provides a basis to focus on community-level actions.

Local inclusion can help communities gain access to livelihood assets, articulate their needs, and enhance adaptive capacity. Institutions support farmers' groups in improving farming practices, but poor and vulnerable people are often excluded from these groups. Participants in focus group discussions reported that the leaders of farmers' groups are in the front line for receiving benefits, and resources are not distributed equitably to the most vulnerable communities. Experiences suggest that social inclusion and gender considerations are crucial to achieve desired impacts from climate risk management and adaptation interventions.

Enhanced policy advocacy is needed to ensure the scale-up and sustainability of locally tested risk management and adaptation practices: The technologies demonstrated by the pilot projects were either developed by or familiar to the government institutions but not to farmers. Although these practices have a climate risk management and an adaptation focus, they are not much different from business-as-usual agricultural technologies. There are many practices proven to reduce the climate risks significantly and enhance the opportunities for yield increase. Some practices were adopted through observation by farmers, but interventions have not yet been scaled up. The resources are not enough for immediate replication by district authorities, which lack both institutional and technical capacity. Future interventions can make use of tested practices for replication with additional resources from donor agencies and the government.

There are many donor- and government-funded programmes and projects in agriculture and food security, but few include climate change concerns. Very few projects have major objectives and activities related to climate risk management and adaptation. Government budget allocations to the agriculture sector have remained stagnant for years, dropping from about 4 percent in 2001/2002 to 2.41 percent in 2003/2004, before rising again to 3.1 percent in 2009/2010. This budget is marginal compared with agriculture's share of total GDP.

Poor coordination and linkages among CBOs, NGOs and government organizations are a major impediment to advance risk management and adaptation. Institutions and development partners at the local level work in isolation although there are ample opportunities for working with other institutions to share lessons and use resources for synergy. For example, improved coordination and collaboration between the District Forestry Office and the District Livestock Service Office (DLSO) can enhance outcomes of the grazing land and pasture improvement programmes in forests. Similarly, at the village level, coordination between CFUGs and WUAs can improve efficient use of forest resources and enhance the potential for improving the livelihoods of both women and men in risk-prone areas.

Better coordination at the district level is necessary to ensure effective implementation of risk management and adaptation measures. Support is needed to ensure the integration of agriculture issues into district-level risk reduction actions. FAO has supported the integration of agriculture sector perspectives into the DDRMPs in four districts, but many of the most vulnerable districts do not have overall risk management and adaptation plans in place. As responsibility for broader risk management at the district level rests with the district disaster management committee, further efforts are needed to integrate climate risk management and climate change adaptation into these plans. DDRMPs have not been fully implemented as there are insufficient resources for the numerous priority activities, each of which requires significant inputs to achieve any meaningful results. Many NGOs working at the district level are contributing to these priority activities and have been involved in the planning process, but enhanced coordination is needed.

Increased commitment to climate risk management and adaptation at the national level will offer opportunities for building resilience in the agriculture sector. Climate variability and climate change concerns have not yet been fully integrated into Nepal's agriculture policy and planning processes. Despite activities implemented by the government and NGOs, dedicated and predictable budget allocations for climate risk management and adaptation to climate change in the agriculture sector are lacking. FAO's technical assistance has promoted opportunities for aligning agriculture sector plans with the NSDRM and the NAPA, including by facilitating national consultations and providing technical support for preparation of the ten-year PFA. The government is committed to implement the PFA, but continuing efforts are needed for systematically addressing all the priorities through government funding and donor support.

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Printed on ecological paper - February 2014 - Layout: studio@bartoleschi.com

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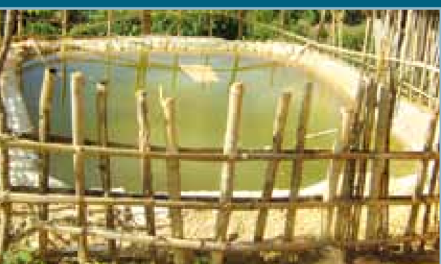

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ISBN 978-92-5-108133-4 ISSN 2071-0992

I3577E/1/12.13