Building Urban Resilience

Assessing Urban and Peri-urban Agriculture in Kathmandu, Nepal

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Building Urban Resilience

Assessing Urban and Peri-urban Agriculture in Kathmandu, Nepal

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Preface

Food production in and around cities is an integral part of the urban fabric in much of the developing world. In these regions, urban and peri-urban agriculture (UPA) plays an important role in diversifying urban diets and providing environmental services in urban and peri-urban areas. As such, there is growing interest in UPA as a strategic component of urban resilience and climate change adaptation planning. However, advocacy for UPA in this capacity is outpacing the body of evidence regarding important stressors and drivers that act on UPA. Such knowledge is especially critical in the developing world where urban areas are experiencing rapid growth and transformation. In these regions, UPA is facing intensifying pressures from urban encroachment, waste disposal, pollution, and climate change that may undermine the sector's long-term viability.

The need to better understand these critical sustainability dimensions provided the impetus for city-level knowledge assessments of UPA, whose main findings are contained in nine underlying assessment reports including this one. The assessed cities were Dakar (Senegal), Tamale (Ghana), Ibadan (Nigeria), Dar es Salaam (Tanzania), Kampala (Uganda), Addis Ababa (Ethiopia), Dhaka (Bangladesh), Kathmandu (Nepal) and Chennai (India). All of the reports and the synthesis report can be found at *http://start.org/programs/upa*. The assessments were conducted in 2012, with initial stakeholder engagement beginning in 2011. The assessments were led by city-based teams, the composition of which varied, with some of the teams being comprised predominately of researchers and other teams comprising of a mix of researchers, city officials and urban NGO representatives.

The assessments seek to better understand the changing nature of UPA systems, and the critical interactions at the land-water-climate nexus that influence resilience of UPA in rapidly growing developing-country cities. The audience for these assessments includes national and city-level policymakers, sectoral experts and city planners, the research community, and non-governmental organizations (NGOs) that interface with urban farmers and other actors within the broader UPA sector.

The UPA assessments are part of a larger project on strengthening understanding of critical links between climate change and development planning in West Africa, East Africa and South Asia. The premise for the project is that progress towards undertaking effective action to address climate change risks in these regions is hindered by low levels of awareness of global climate change, lack of understanding of the findings of the Intergovernmental Panel on Climate Change (IPCC) and other sources of scientific information, lack of location and sector specific knowledge, and the need for strengthening capacities to undertake integrated assessments that support decision making. This multi-year project has been a collaborative effort between the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), START, the University of Ghana, the University of Dar es Salaam, and the Bangladesh Centre for Advanced Studies (BCAS).

Jon Padgham
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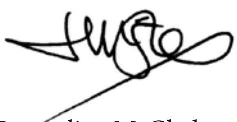

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We would like to thank the different individuals and institutions who in one way or another contributed to the execution of the larger European Commission-led project. In particular, the successful implementation and completion of the project, and the subsequent knowledge assessments were made possible due to the close cooperation and commitment of the International START Secretariat; the United Nations Environment Programme (UNEP) represented by the Division of Early Warning and Assessments and the Office of the Chief Scientist; the World Meteorological Organization (WMO), the University of Ghana, the University of Dar es Salaam, and the Bangladesh Centre for Advanced Studies (BCAS). Several colleagues across these organizations rendered valuable insight, expert advice, guidance and encouragement during this 4-year endeavor. We would especially like to recognize the efforts and support of Ghassem Asrar, Hassan Virji, Katie Dietrich, Clark Seipt, Chris Gordon, Pius Yanda, Atiq Rahman, Chipo Plaxedes Mubaya, Adelina Mensah, Elaine Tweneboah, Abu Syed, Salif Diop, Audrey Ringler, Jennifer Odallo, Peter Gilruth and Joseph Alcamo as well as Jon Padgham and Jason Jabbour, the project managers and editors of this series.

The overall project and the associated UPA assessments were made possible in large part thanks to funding provided by the European Commission (through project ENV/2008/149690 '*Understanding the Findings of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report "Climate Change 2007"—Integrating Climate Change Adaptation and Mitigation in Development Planning*'), as well as by the United Nations Environment Programme (UNEP), and the Global Climate Change Programme at the US Agency for International Development (USAID). The editors of this series wish to thank these organizations for their financial support.

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Acronyms and abbreviations

ADB	Asian Development Bank
CBO	Community-based organization
DADOs	District agriculture development offices
DDC	Dairy Development Corporation
DHM	Department of Hydrology and Meteorology
DUDBC	Department of Urban Development and Building Construction
ESPA	Ecosystem Services for Poverty Alleviation
ESRC	Economic and Social Research Council
FAO	Food and Agriculture Organization of the United Nations
GCM	General circulation models
GDP	Gross domestic product
GLOF	Glacial lake outburst flood
GoN	Government of Nepal
HMG	His Majesty's Government of Nepal
ICIMOD	International Centre for Integrated Mountain Development
IFPRI	International Food Policy Research Institute
IPCC	The Intergovernmental Panel on Climate Change
IPM	Integrated pest management
ISET-Nepal	Institute for Social and Economic Transition-Nepal
KFVWM	Kalimati Fruit and Vegetable Wholesale Market
KUKL	Kathmandu Upattayka Khanepani Limited
KVTDC	Kathmandu Valley Town Development Committee
LPG	Liquefied petroleum gas
LSGA	Local Self-Governance Act
MLD	Million litres per day
MoAC	Ministry of Agriculture and Cooperative
MoEST	Ministry of Environment Science and Technology
MOFALD	Ministry of Federal Affairs and Local Development
MoPE	Ministry of Population and Environment
MT	Million tonnes
NARC	Nepal Agricultural Research Council
NCVST	Nepal Climate Vulnerability Study Team
NDRI	Nepal Development Research Institute
NWCF	Nepal Water Conservation Foundation
PRMD	Pesticide Registration and Management Division
RUAF	Rural Centre of Urban Agriculture and Food Security
SLD	Shared learning dialogue
UNEP	United Nations Environment Programme
UPA	Urban and peri-urban agriculture
VDCs	Village Development Committees
WFP	World Food Programme of the United Nations

Contents

Executive summary

This report presents the findings of a knowledge assessment on peri-urban agriculture in the Kathmandu Valley. This assessment locates peri-urban agriculture within larger, ongoing change occurring in the Kathmandu Valley's food system by identifying and describing the multi-stressor context related to intensifying urban pressures, environmental degradation, and increasing climate risks. The assessments objectives are to:

1. explore links between peri-urban agriculture and Kathmandu Valley's food system and possible future changes in these;
2. estimate the additional challenges that will be incurred in accessing food in the future given the transforming pressures of urbanization in the valley; and
3. examine components of Kathmandu Valley's food system that are vulnerable to disruption from extreme climate events and the implications of this given intensification of climate change risks.

Kathmandu's food and energy security are increasingly subjected to regional and global forces that bring significant risk as well as some measure of opportunity to the city. At the local scale, rapid urban expansion into agricultural areas of the Kathmandu Valley are undermining the viability of local food production and subjecting it to additional vulnerabilities. In the past, agriculture in and around Kathmandu constituted an important source of vegetables and cereals for the city. However, as is the case elsewhere in the country, farmers in peri-urban regions of the Kathmandu Valley are abandoning their traditional occupation due to low financial returns, lack of labour, climatic variability, environmental degradation caused by urbanization and, conversely, attractive job opportunities created by urbanization. These dynamics present a critical challenge to food production, particularly when considering the ever-increasing demand for food from this rapidly growing city.

Beyond concerns around localized food production, the food system of the valley is increasingly interlinked with regional and global food chains, which exposes residents to multiple sources of vulnerability that have the potential to undermine food security. The vulnerability of vital transportation systems to disruption from climate-induced disasters such as floods and landslides is of particular concern in this mountainous region. The valley's increasing dependence on regional food sources requires that systems related to transport, warehousing and cold storage, marketing mechanisms and communications be strengthened in order to make food systems and their links more robust. Thus dependency introduces new sources of vulnerability that must be better understood so that the susceptibility of different components of food systems to climate change and other stresses can be assessed and their cascading effects on the production, supply and distribution of food addressed.

The ability to attribute the ongoing processes of change to global climate change is limited by the uncertainties inherent in modeling exercises, incomplete knowledge of monsoon dynamics and inadequate data sets for the Kathmandu Valley. In particular, there is a lack of data needed to capture the spatial and temporal characteristics of temperature and precipitation. Existing records provide a macro-level picture but do not capture micro-level details. Irrespective of this limitation, existing scenarios for Nepal suggest that climate change will influence the local climate, in most cases adversely, and add a new layer of stress that may generate social, environmental, economic and political challenges that exacerbate food insecurity.

The resilience of Nepal's food systems will depend on overcoming a variety of existing and emerging challenges. One key challenge for Nepal, as elsewhere in South Asia, is its economic and political instability, which influences how well its food systems function. For example, the lack of adequate budgetary resources for agriculture, and poor timeliness in releasing available funds for the sector, stymies the ability of key institutions to promote innovative agricultural practices that would help to advance adaptation to climate change. The late release of budgetary funds, characteristic of Nepal's wrangling administrative system, also has potential to disrupt food systems, especially when it hampers the maintenance of roads, bridges and other infrastructure vulnerable to climate-induced floods and landslides. Moreover, continued power outages, the result of the nation's inadequate electricity supply system, causes multiple problems including fewer hours to pump irrigation water and operate cold-storage facilities. The performance of the industrial and service sectors, which also contribute to building resilience and adaptive capacity, are also affected by the shortage of electricity.

This study shows that in the fluid and transitional social-political context of Nepal, transformative change in the Kathmandu Valley will play a significant role in determining the future of agriculture. Changes in population growth, economic activity and social structure, together with political transitions, will have a significant impact on the allocation of resources as well as governance mechanisms at central, district, and municipal levels. Such trends will help determine government policies on agriculture, the development pathways of the valley and the nation, and strategies for building adaptive capacity. Rather than conventional approaches to diagnose and propose solutions, there is a need for flexible approaches that permit an iterative process of acting, learning and refining

what is to be done. Institutions that address climate change vulnerabilities need to adapt to changing times. Such adaption is the key to maintaining, and even extending, peri-urban agriculture in the Kathmandu Valley.

The following key findings of this assessment provide a basis for action:

- The food system of the Kathmandu Valley experiences vulnerabilities from increasing biotic and abiotic stresses to crop productivity, urban encroachment onto arable land, and diminishing or increasingly unreliable sources of irrigation water coupled with farmer poverty. Climate change, continued urbanization pressures, and other change drivers will likely exacerbate these vulnerabilities.
- Our ability to attribute the ongoing processes of change to global climate change is limited by the uncertainties inherent in modelling exercises, incomplete knowledge of monsoon dynamics and inadequate data sets for Kathmandu Valley. Irrespective of this limitation, existing scenarios for Nepal suggest that climate change will influence the local climate, in most cases adversely, and add a new layer of challenges that exacerbate food insecurity.
- Climate-induced disasters expose residents in Kathmandu Valley to multiple sources of food insecurity. Floods and landslides disrupt vital transportation systems, which create volatile market prices for food.
- By contributing to artificial food shortages, price escalations and general food insecurity, poor governance consolidates existing vulnerabilities and stymies efforts to build resilience in food and other systems. The country faces fundamental challenges due to slow economic growth, deficient physical infrastructures, subsistence-level agriculture systems, limited foreign direct investment, and widespread unemployment and underemployment (GoN, 2012).

1 Introduction

Challenges facing urban food systems

As the next few decades sees *Homo sapiens* become *Homo sapiens urbanus,* the 21st century will be an urban century (UN-Habitat, 2010). According to UN-Habitat (2010), by 2030 there will be more people living in urban than in rural areas across the global south, and the yawning prosperity gap will mean that "*the rich will live in well-serviced neighborhoods, gated communities and well-built formal settlements, whereas the poor will be confined to inner-city or peri-urban informal settlements and slums*" (p. viii). A characteristic feature of this more urbanised world may very well be greater social disparities and inequalities in income, opportunities, health, and education than is currently the case. The extant social divide will widen, and poverty and hunger will be widespread, leaving the 870 million people who are chronically undernourished in a potentially more dire state. The poor lack tangible assets and access to basic needs such as food, education, clean water, health care, secure shelter and food security (UNDP, 2007), and often face political and social discrimination (Fischer *et al.*, 2002).

Climate change represents an additional and potentially quite significant stressor in these low-income and rapidly urbanizing regions. The Intergovernmental Panel on Climate Change (IPCC) states in its fourth assessment that average global temperatures are likely to increase 1.8–4° C by the end of this century (IPCC, 2007), but if the current trend of greenhouse gas emissions continues this may be an overly optimistic estimate. Atmospheric warming is likely to magnify extreme climatic events and increase climatic uncertainty and variability. The knock-on effects of these climatic changes will affect food production, infrastructure and services, and human health. The attendant increase in natural disasters will strain social relationships and put pressure on existing institutions.

Will cities be adequately armed to adapt to the heightened risks associated with climate change? What will happen to the urban poor, who already struggle to feed themselves, as disasters severely impede urban food supply and distribution? History offers little encouragement. Extreme events such as Superstorm Sandy and Hurricane Katrina devastated New York City and New Orleans, respectively, and the oft-unnamed and soon-forgotten tropical cyclones and inland floods that regularly ravage coastal cities in South and Southeast Asia and riparian cities in the Ganga and Indus river basins result in huge losses of life and property and leave urban residents hungry and miserable. What will a future with more events such as these hold for the vulnerable? Even inland cities such as Kathmandu, Addis Ababa and La Paz, none of which are directly impacted by hurricanes or rising sea levels, are likely to be impacted by extreme climate hazards, albeit in different ways.

All cities depend on a wide variety of interconnected systems beyond their physical boundaries in order to meet the food needs of their residents. Key food system processes (transport, processing, storage, consumption and waste) depend on a variety of systems, including transportation, storage, energy, market, banking and communication. Maintaining a food basket sufficient to feed all residents is a challenge of particular concern, especially as climate change introduces new sources of vulnerabilities and urban poverty rises. Building the resilience of increasingly threatened food systems requires an in-depth understanding of the dynamics of interdependence among food systems, climate change, and technological and economic globalisation (DST, 2008). When considering climate change through the lens of a food system, impacts will not only occur at the crop production stage, but will extend to also affect transportation systems and distribution of food, given that climate-induced floods and landslides are expected to occur with higher frequency in the coming decades. Because growing populations stress extant infrastructures of cities, rapid urbanisation is another key source of vulnerability for urban food systems.

Unplanned urbanisation affects more than just food systems: encroaching upon prime agricultural land, forests and wetlands and, interfering with their traditional provision of services to urban residents, disordered urban growth also converts regions surrounding cities or peri-urban regions into haphazard settlements. In fact, the very nature of these regions, which interactively juxtapose urban and rural characteristics, brings about rapid and frequent changes in landscape features (Douglas, 2006). Human activities in peri-urban regions, which are often fuelled by market-related processes, result in the unregulated use of agricultural and natural resource systems (Simon *et al.*, 2006) and thereby increase environmental degradation, social stress, and land, water and air pollution.

Peri-urban regions support crucial economic activities, including beneficial systems of urban and peri-urban agriculture (UPA). In South Asia alone, an estimated 11 million urban residents engage in UPA, thereby contributing to urban food baskets (Van Veenhuizen and Danso, 2007), and bridging the gap between the demand and supply of food (Umoh, 2006). By engaging in UPA, urban dwellers can meet some of their basic food needs and reduce their spending on food. UPA also improves the quality of the diet of the urban poor and increases their incomes (FAO 2012; Gundel, 2006). However, the extent to which UPA contributes to food security of low-income urban households is contested with some regional studies (e.g., Crush *et al.*, 2010) reporting a relatively minor contribution of UPA to household food security, thus pointing to the strong need for much more quantitative studies on UPA's contribution to food security. One such study, a multi-region analysis of UPA by Zezza and Tasciotti (2010) reported strong involvement of the poorest quintile of Nepal's urban residents in UPA.

Additional benefits of UPA include the management of urban waste streams, provisioning of green space and biodiversity and the modulation of a city's microclimate (Cofie *et al.,* 2006; Konijnendijk *et al.*, 2004 Midmore and Jansen, 2003). Finally, the production of fresh food close to the ultimate consumers minimises the energy required to transport and store food and engage in post-harvest activities, thereby mitigating greenhouse gas emissions, reducing a city's carbon footprint, and promoting climate change adaptation. However, these environmental attributes of UPA lack a strongly quantitative foundation, and thus the overall benefits of UPA on resilient urban environments are difficult to fully assess.

The situation in Kathmandu

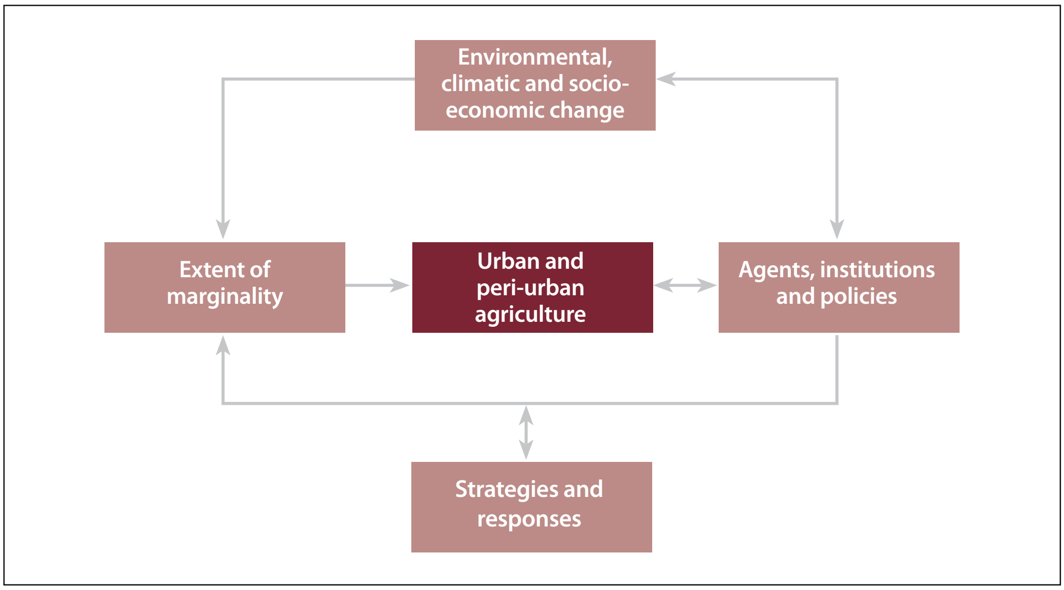
Kathmandu, the capital of Nepal, has witnessed rapid changes in its urban form and character in the last five decades. In the past, agricultural production from urban and peri-urban areas contributed significantly to vegetable and cereal requirements of Kathmandu's people but now production is unable to match demand. Increasing rates of urban expansion, use of fertilisers and pesticides, fragile systems, poor access to land and water, and untreated industrial and domestic wastes undermine the sustainability of UPA. A lack of interest in farming amongst young people, political instability and poor governance and policy vacuum, in addition to erratic rainfall, all contribute to vulnerability. Urban and peri-urban agriculture could contribute to making the city more sustainable, minimise carbon footprints involved in transporting food and offer alternative livelihoods to low-income families. Yet the potential of UPA has remained as a blind spot in Nepal's policy-making.

The extent to which local food production can contribute to the urban food basket is limited, particularly as population growth and market penetration drive Kathmandu's food system towards increasing interlinkages with larger systems of regional food production, markets and transportation. Such interlinked systems offer both opportunities and perils, an important peril being transportation disruptions in mountainous regions. For example, an extreme climatic event in 1993 led to major disruptions in highways connecting Kathmandu with the plains and vulnerabilities cascaded through an interlinked system affecting the food supply. Similar systemic disruption could be the source of major vulnerability in Kathmandu and seriously affect the food and livelihood security of groups at the social and economic margins.

The systemic perspective

Agriculture, including UPA, is embedded in the larger ongoing processes of systemic change, including climate change, urbanization, globalisation and the ever-increasing penetration of transportation and communication systems. Its interdependence is complicated by the fact that in peri-urban regions, relationships among demographic, socio-economic and ecological systems change rapidly, thereby causing the nature and functioning of ecosystems and the services they provide both within those regions themselves and to adjacent cities to also be in constant flux. For these reasons, only an examination from a systemic perspective can provide an understanding of the opportunities and hindrances that face UPA in its efforts to respond effectively to the new vulnerabilities that climate change, as well as other changes, are likely to expose it to (Figure 1.1). Armed with this information, stakeholders can identify areas where production systems, and food systems more broadly, need to be strengthened.

FIGURE 1.1
Conceptual framework



The relative robustness or fragility of systems is one of four key determinants of vulnerability as conceived by this study (Figure 1.2). The other three are social marginality, exposure, and institutional constraints (Moench *et al.*, 2011; Moench and Dixit, forthcoming). If agriculture in the Kathmandu Valley is to be maintained, or even extended, it must address not just climate change but also weak systemic elements. Since natural changes in biophysical systems are broadly linked with human-induced changes such as deforestation, urbanisation and waste production, the impact that climate change will have on any given food system will be mediated by the availability of core, secondary, and tertiary systems (Table 1.1) and the roles that these systems play.

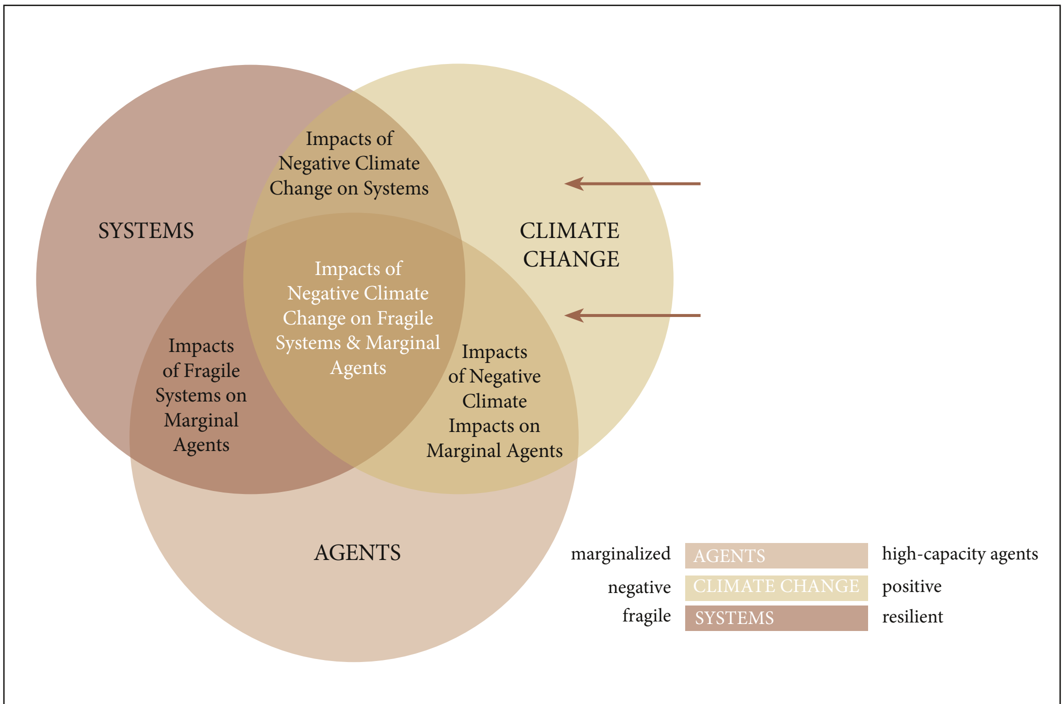


FIGURE 1.2
Interactions and climate change vulnerability
Source: Moench et al., 2012

TABLE 1.1
Core, secondary and tertiary systems

System Scale	Elements
Core	Energy, drinking water, land, forest, food, ecosystem services
Secondary	Transport and mobility, communications, livelihood (agriculture, water, forestry, shelter)
Tertiary	Markets, financial services, health system, education, social networks, non-farm production systems

Source: Dixit *et al.*, 2011

2 Objectives and methods

Objectives

This assessment explores the dynamics of Kathmandu Valley's food system by locating UPA, specifically peri-urban agriculture, within larger, ongoing change processes. Its objectives are to:

1. explore links between peri-urban agriculture and Kathmandu Valley's food system and possible future changes in these;
2. describe the additional challenges that will be incurred in accessing food in the future given the transforming pressures of urbanization in the valley;
3. assess important components of Kathmandu Valley's food system that are vulnerable to extreme climate events.

Description of methods

The assessment comprised of secondary literature review, mostly academic literature and city and national government reports and policy documents, combined with dialogues and interviews with government and local community leaders within peri-urban Kathmandu.

For practical reasons, the study considered the five municipalities of the Kathmandu Valley as the urban core and the Village Development Committees (VDCs) surrounding them as peri-urban, though it is more accurate to describe all as *desakota* (linked village-city). The selection of VDCs for the assessment was an iterative process involving general reconnaissance on the ground, research and interactions with local government officials. Initial scoping suggested that a purposive selection method would suffice and, to that end, four VDCs—Lubhu, Ramkot, Shanku and Tokha—and the two smallest municipalities in the valley—Kirtipur and Madhyapur Thimi—were selected (Figure 2.1). All sites are connected to metropolitan Kathmandu by road and their UPA systems fall within the valley's food system. Using secondary sources of data, the study assessed the status of key elements of core, secondary and tertiary systems (Table 1.1) as gateways to services in the case study VDCs (ISET, 2008; Dixit, 2010; NPC, 2011; Dixit *et al.*, forthcoming).

The VDC case study sites in the Kathmandu Valley (Tables 2.1 and 2.2; Figure 2.1) are experiencing transformative change brought about by urbanisation. Newars constitute the largest section of the population in all the sites except for Ramkot, where Chettris are dominant. Historically, the residents of all six sites were engaged in agriculture and sold their produce, including vegetables, fruits and cereals, in Kathmandu and Lalitpur. These communities also depend on business, service and wage labour, and, in recent times, on remittances from workers abroad. All are served by the national electricity grid and have a road network, telecommunication and other services.

Interactions with local communities were conducted using the shared learning dialogue (SLD) approach (Figure 2.2), which is based on the learning framework proposed by Lewin (1946). In this

TABLE 2.1
Details of case study sites

VDC/ municipality	Distance from Ratnapark Kathmandu (km)	Total area (ha)	Total population			Total HHs	Sources of water	Access to sanitation	Energy		Land			Source of income
			Male	Female	Total				Lighting	Cooking	Culti-vable land (ha)	Irrigated land	Major crop	
Ramkot	13 East	0.5	3 372	3 228	6 650	1 220	Pipe water, wells, springs and others	80	Electricity	Fossil fuel and LPG Gas			Maize, paddy and wheat, fruits and vegetables	Agriculture, remittance, business, service and others
Tokha, Chandeswori	10 North	468	1 768	1 848	3 616	653	Pipe water and wells	93	Electricity	Fossil fuel and LPG Gas	126	Mostly rain-fed with 43 ropani irrigated	Paddy and wheat	Agriculture, remittance, business, service and others
Lubhu	11 East	745	4,654	4 721	9 375	1 870	Pipe water, wells, springs and others	96	Electricity	Kerosene, fossil fuel and LPG Gas	290		Paddy, wheat, maize, mustard, and vegetables	Agriculture, business, service, labour and industry
Kirtipur	7 South	1 787	21 686	19 149	40 835	9 487	Pipe water, wells, stone spouts, springs and ponds		Electricity	Fossil fuel and LPG Gas	798	Completely dependent on the rainwater and well	Wheat, cauliflower, peas, broad beans, paddy and maize	Business, service, agriculture, remittance and others
Sankhu, Pukhulachhi	18 Northeast	286.0	1 112	1 193	2 305	392	Pipe water, tube well, well, spring and others	73	Electricity	Fossil fuel, kerosene, biogas and LPG Gas			Paddy, millet, potato, squash,	Agriculture, business, service, remittance and labour
Madhyapur Thimi	10 East	1 147	23 004	24 747	47 751	9 551	Pipe water, stone spouts and wells		Electricity	Fossil fuel and LPG Gas	178	Completely dependent on rivers and boring wells	Green vegetables, carrot, radish, garlic, cabbage, cauliflower, broccoli and potato	Agriculture, business, service, remittance and labour

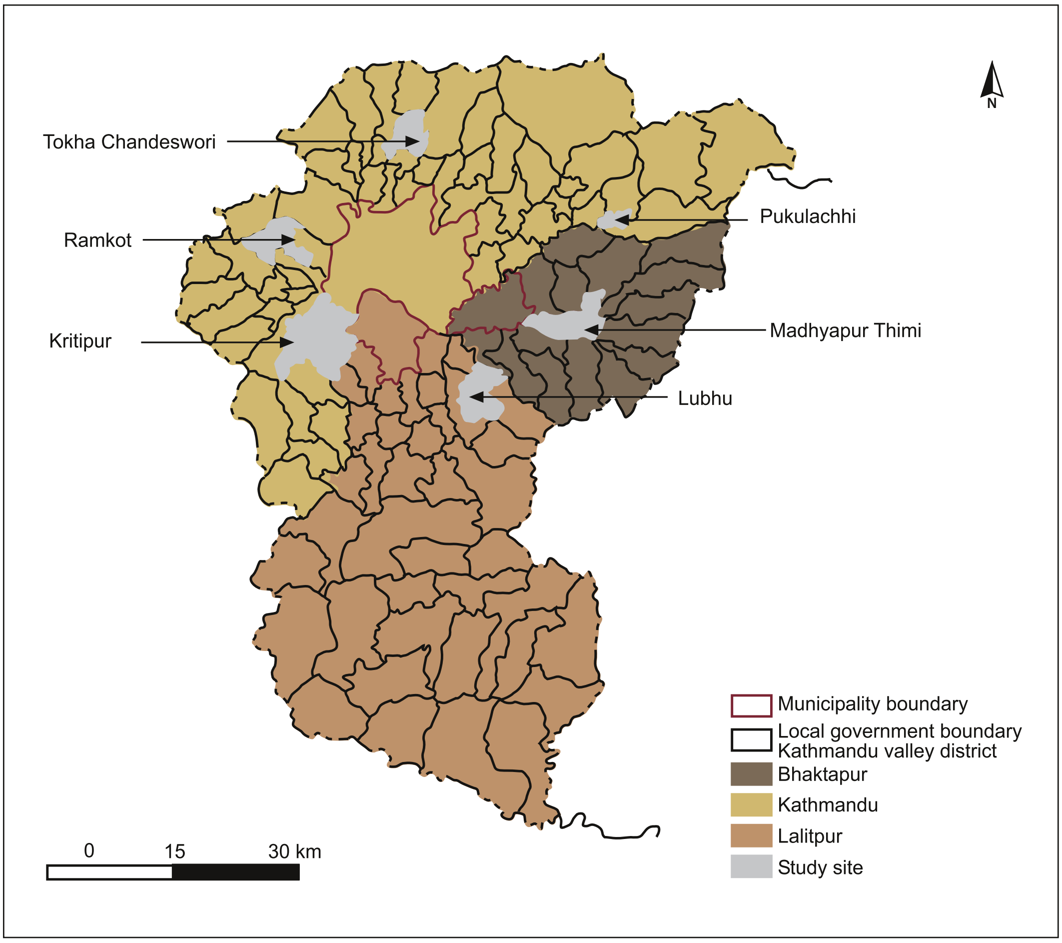


FIGURE 2.1
The case-study sites

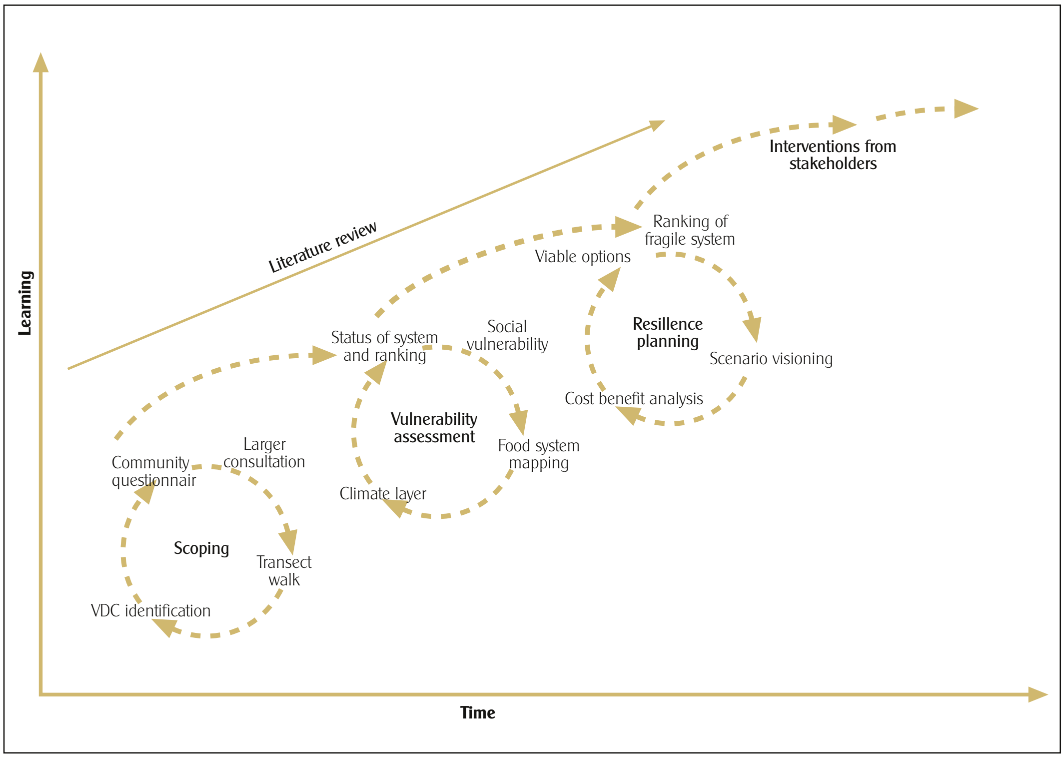
TABLE 2.2
Farmers' groups in the case study VDCs

	Crop	Farmers' group		
		Total no.	Men	Women
1	Vegetables	67	319	1 550
2	Fruits	11	196	112
3	Cereals	38	672	770
4	Beekeeping	4	57	28
5	Mushrooms	1	0	34
6	Seed multiplication	1	0	63
7	Integrated	38	352	966
	Total	160	1 596	3 523

Source: District Agriculture Statistics Data Book, 2011 process, researchers present information to local stakeholders while, at the same time, learning from their experiences. This was conceived as a process of mutual learning in which one set of stakeholders could learn from others' perspectives on the issues under discussion. The underlying assumption of this approach was that while technical and scientific experts know about the function of natural systems such as the climate and hydrological cycle, local people, farmers and vegetable traders, possess deep knowledge about socio-environmental dynamics at local scales. The result is a synthesis of local, experiential and global scientific knowledge.

Municipality and VDC representatives, teachers, farmers, poultry farmers, vegetable sellers, and middlemen participated in these SLDs, as did individuals who work in the vegetable and fruit markets in Kathmandu that function as a meeting place between peri-urban and rural areas. The approach focused on bringing insights from both the social- and natural-science streams to clarify challenges in assessing vulnerability and risks. The discussions also focused on identifying strategies to reduce vulnerability and build adaptive capacity.

FIGURE 2.2
Shared learning dialogue method



3

The Kathmandu Valley

Physical characteristics

The 665 km^2 Kathmandu Valley is situated in the Mahabharat Range at 1 300 m above sea level. The valley's geology is mixed—fluvo-lacustrine deposits of clay and sand filled with alluvium soil dominate the central part, while the southern area is composed of reddish sandstone shale overlain by grey and purple shale. The western and eastern ranges contain a sequence of phyllites, limestones and quartzites (HMG/N, 1969).

Figure 3.1 (a)
Upper Bagmati River system

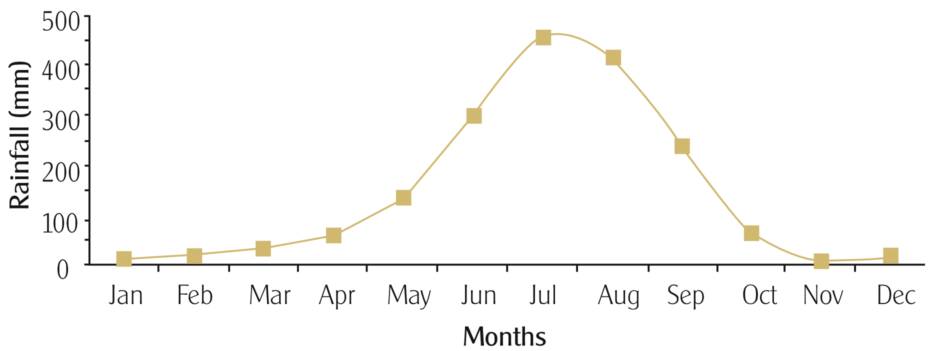


Figure 3.1 (b)
Hydrograph of Bagmati River at Chovar

Monsoon rains supplement the flows of the valley's main river, the Bagmati, which originates in the Shivapuri Mountains north of Kathmandu before being joined by its tributaries, the Nakhu, Kodku, Godavari, Balkhu, Bishnumati, Dhobi, Manohara, Hanumante, and Manamati rivers (Figures 3.1a and b). It then flows out of the valley through the Mahabharat range at Katuwaldaha to the south before joining the Koshi River in Bihar. The Bagmati's upper catchment constitutes 15 per cent of the total area of the Bagmati basin in Nepal (HMG/N, 1994). At Chovar, a few kilometers upstream of Katuwaldaha, the river's minimum flow occurs in April/May; discharge then begins to rise with the arrival of the monsoon rains in mid-June and reaches peak flow in July or August before falling again in the post-monsoon season. The average maximum monthly discharge of 195 m^3/s occurs in July, while the minimum monthly average flow of 0.51 m^3/s occurs in April (HMG/N, 1994).

FIGURE 3.2a
Monthly temperature in the Kathmandu Valley

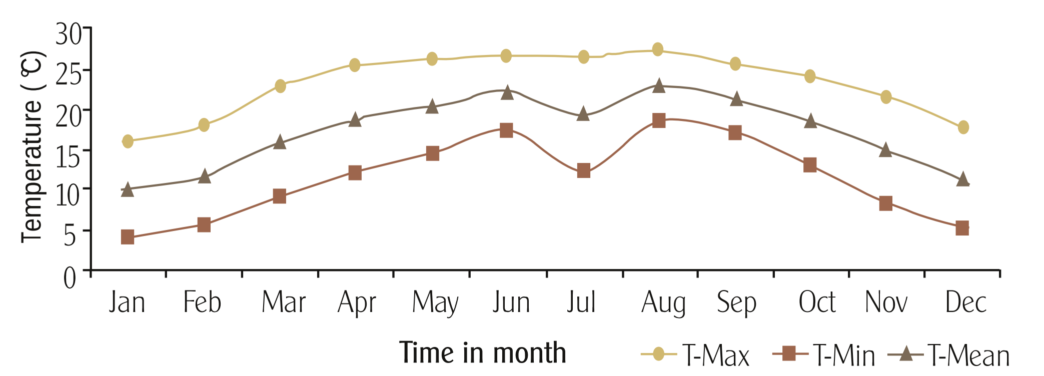


FIGURE 3.2b
Spatial distribution of rainfall in Kathmandu Valley

Climatic characteristics

The valley's sub-tropical, temperate, and cool-temperate climatic zones have four distinct seasons: pre-monsoon, monsoon, post-monsoon and winter. The minimum and maximum temperatures of the valley are -3° C and 35.6° C, respectively (ICIMOD, 2007; UNEP, 2007). More than 90 per cent of the valley's total rainfall occurs during the four months of the monsoon, which begins in mid-June. The amount of rainfall varies, but on average, the valley receives 1 600 mm of rainfall annually. Differences in elevation create orographic effects, which cause spatial variations in rainfall: the valley floor receives about 1 400 mm; the adjoining hills, more than 2 000 mm (Figure 3.2b).

Climate trends and projections

Temperature and rainfall trends

Long-term temperature records in the valley indicate a general warming period from the 1920's through the 1940s, followed by a cooling until the mid-1970s and then by another warming trend (Shrestha, 2001; Shrestha *et al.*, 1999; as cited in Chaulagain, 2006). Recent data indicate that the warming trend is continuing across the country and that the rise in Kathmandu exceeds the national average (Shrestha, 2000) (Figure 3.3). Because of its bowl shape, high levels of pollution and rapid urbanization, the valley can act as a heat island. Farmers in the case-study VDCs report that days and nights are hotter. An analysis of precipitation at Tribhuvan Airport revealed that there have been no changes in the decadal averages of annual or June-to-September (monsoon) rainfall, the number of rainy days or the date of the onset of monsoon (Karmacharya, 2010).

Temperature and rainfall projections

The Department of Hydrology and Meteorology and the Nepal Climate Vulnerability Study Group (NCVST, 2009) used regional and general circulation models (GCMs) to develop climate scenarios for Nepal. The DHM analysed datasets including monthly mean surface air temperatures and precipitation for 1960–1990, while NCVST used 15 different GCMs, divided Nepal into five zones (Figure 3.5) and developed scenarios of changes in temperature and precipitation for 2030, 2060 and 2090.

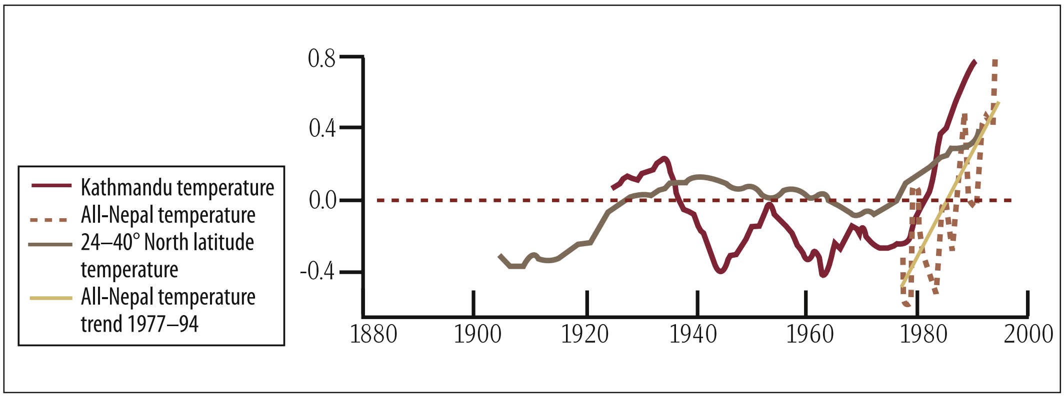


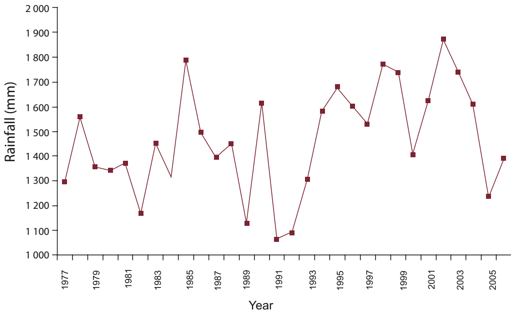
FIGURE 3.3
Comparison between temperature in Kathmandu, all Nepal and globally

Source: Status of climate change in Nepal, GoN, MoE, (2011)

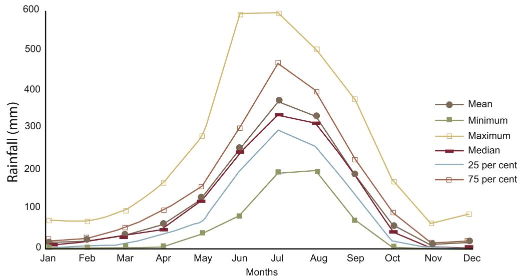
FIGURE 3.4
Precipitation and river flow dynamics

Source: Kamacharya, 2010; Department of Hydrology and Meteorology

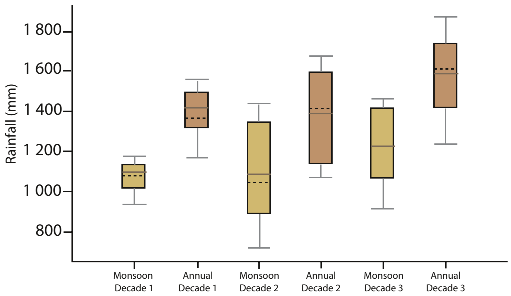
Annual rainfall variability at Kathmandu airport



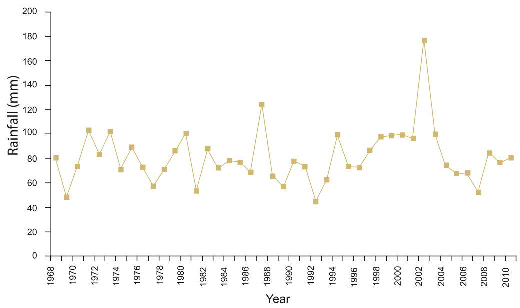
Pattern of monthly rainfall at Kathmandu airport



Annual and monsoon rainfall for 3 decades



Extreme rainfall at Kathmandu airport



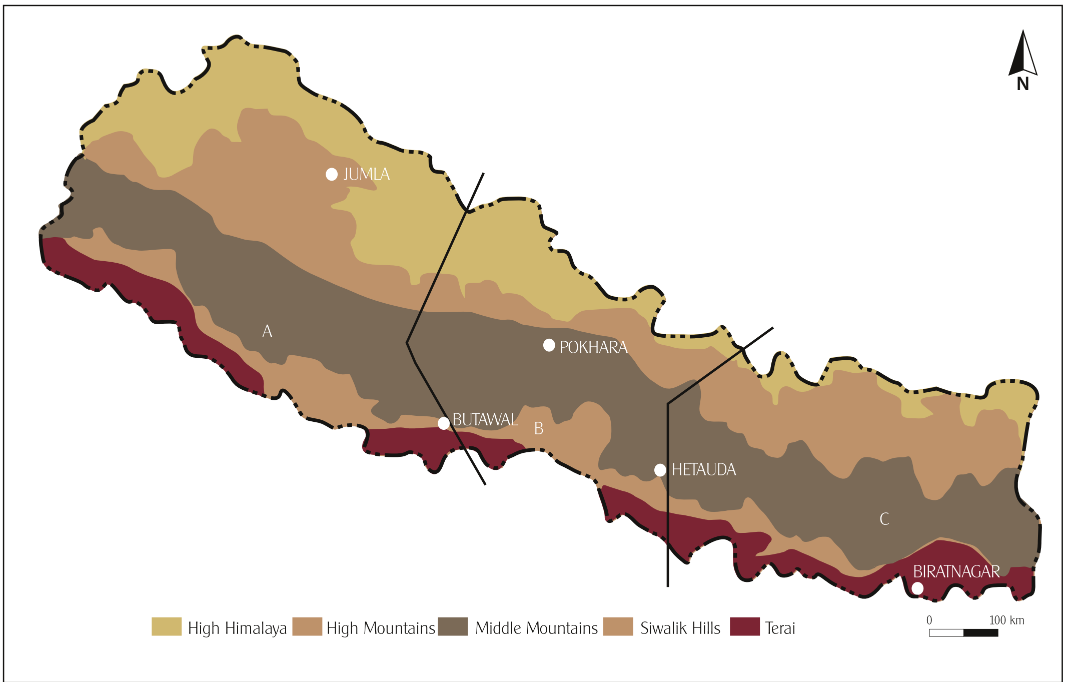


FIGURE 3.5
Division of Nepal for climate change scenarios

Temperature: NCVST (2009) projects that mean temperatures will increase for all seasons (Tables 3.1 to 3.3) and that in all seasons temperatures will be higher in western parts of the country than in the east. Analysis by Karmacharya *et al.*, (2007) also found warming in all seasons by mid-century, with greatest warming in the winter season and least in the pre-monsoon season.

Precipitation: Because there are a limited number of rainfall stations in the valley to capture micro-level variations, future scenarios can claim only that precipitation will be more uncertain and cannot predict future rainfall characteristics with any certainty. Findings of projected precipitation changes in this report should be interpreted with caution as they are based on GCMs and as such are prone to significant error.

TABLE 3.1
GCM projections of changes in mean temperature in Central Nepal (°C relative to 1970–1999 mean)

Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2030s	1.4 (0.9, 2.0)	1.7 (0.8, 2.5)	1.4 (0.5, 2.2)	1.2 (0.7, 2.0)	1.6 (0.9, 2.8)
2060s	3.0 (1.7, 4.1)	3.1 (1.9, 4.7)	2.5 (1.0, 3.4)	2.6 (1.8, 4.1)	3.4 (1.9, 4.6)
2090s	4.9 (3.0, 6.3)	5.4 (3.5, 7.0)	4.5 (1.9, 5.5)	4.6 (3.2, 5.9)	5.4 (3.7, 7.1)

Non-parenthesized numbers in each cell indicate the multi-model mean across 15 GCMs; parenthesized numbers indicate the range across the multi-model ensemble.
Source: NCVST, 2009

TABLE 3.2

Change in frequency of hot days in Central Nepal (%, the hottest 5% of the days in the period 1970–1999) from GCM

Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	18 (10, 41)	25 (17, 52)	25 (14, 75)	26 (9, 49)	37 (18, 65)
2090s	29 (16, 49)	48 (27, 66)	43 (14, 85)	45 (28, 61)	68 (35, 79)

Source: NCVST, 2009

TABLE 3.3

Change in frequency of hot nights in Central Nepal (%, the hottest 5% of the nights in the period 1970–1999) from GCM

Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	23 (13, 26)	26 (3, 34)	55 (25, 71)	23 (16, 36)	28 (10, 40)
2090s	33 (20, 38)	45 (6, 56)	77 (44, 89)	38 (25, 51)	54 (14, 86)

Source: NCVST, 2009

Employing a high-resolution precipitation GCM developed by the Meteorological Research Institute in Japan as well as precipitation data from 1979–2003 at 16 stations inside and around the upper Bagmati River basin, Mishra and Herat (2011) assessed potential future changes in precipitation patterns for that region, which includes Kathmandu Valley. They found that there will be a significant increase in monsoon precipitation and a decrease in rainfall in other months, and that the frequency of extreme precipitation events will increase. Precipitation projections by Jha (2012), based on 21 GCMs, suggests that the amount of precipitation in Kathmandu Valley and the number of rainy days in a month will decrease under a dry scenario, while a wet rainfall scenario found that average annual precipitation would increase slightly. Results such as these point to the need for a more robust and systematized process for generating and interpreting climate model data.

Though acknowledging that modelling is not specific about changes in precipitation, NCVST (2009) suggests that, except in the post- and pre-monsoon seasons, rainfall in Nepal is likely to decrease throughout the country, though more so in the east during the monsoon and winter seasons. NCVST (2009) projects that the frequency of rainfall will increase slightly in the monsoon and post-monsoon seasons but decrease slightly during the winter and pre-monsoon (Table 3.4).

TABLE 3.4

Change in monthly precipitation in Central Nepal (%, relative to mean of 1970-1999)

Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2030s	0 (-34, 22)	- 7 (-32, 11)	5 (-17, 40)	-4 (-26, 86)	-10 (-43, 13)
2060s	0 (-36, 47)	-10 (-45, 19)	10 (-37, 79)	4 (-15, 119)	- 11 (-42, 11)
2090s	7 (-32, 64)	-13 (-54, 36)	19 (-46, 123)	4 (-42, 132)	-19 (-56, 21)

Non-parenthesized numbers in each cell indicate the multi-model mean across 15 GCMs; parenthesized numbers indicate the range across the multi-model ensemble.

Source: NCVST, 2009

4 Sources of vulnerability

This section highlights areas of potential vulnerability to climate change and other drivers of change, which are explored in depth in the remaining sections of this report.

As noted above, Nepal is experiencing temperature increases and extreme weather. As outlined in the conceptual framework of this study (Section 2), systems play a critical role in both determining vulnerability and building resilience. If systems are fragile, exposed to climate hazards and dysfunctional in their operation and management, then general vulnerability to climate change is likely to be high, and the marginal population is likely to become even more vulnerable. Faced with climate and other changes, fragile systems will cease to serve users and the marginalized, because they cannot change their strategies or access these services elsewhere, will suffer.

In the case of the valley's food production systems, change drivers interact in complex and non-linear ways. Increasing biotic and abiotic stresses to crop productivity, urban encroachment onto arable land, and diminishing or increasingly unreliable sources of irrigation water, against a backdrop of persistent farmer poverty, are key vulnerabilities that could be exacerbated by climate change together with continued urbanization pressures as described in Table 4.1. In addition, erratic rainfall elsewhere in Nepal can have a strong bearing on food security within Kathmandu. In 2008/09, for example, when the monsoon arrived late and provided less rainfall than average, the average cereal production in Nepal declined 133 000 MT (MoAC, WFP and FAO, 2009). Since local and regional food systems are interdependent, even extreme climate events on the national and regional levels will cause vulnerabilities to ripple through Kathmandu's food system.

During SLDs, farmers reported that rainfall is becoming increasingly erratic and that its vagaries have affected agriculture, such as through delays in the monsoon rains that shift planting times and reduce maturation periods, and excess rainfall that causes seeds to rot before they germinate. Farmers have experienced a decline in the productivity of paddy rice stemming from several factors, including the sensitivity of the crop to seasonal climate conditions, and difficulties in obtaining fertilisers and insecticides. Such inputs are crucial as the crop is particularly susceptible to pest infestations, which farmers say have increased. Many farmers also identified weed management as a major problem, explaining that low rainfall increases weed populations, reducing production. Inevitably the decline in production affects food prices.

TABLE 4.1
Summary of impacts on agricultural landscapes in the Kathmandu Valley

Activities	Impacts
Expansion of built-up areas	Loss and misuse of prime agricultural land Reduction of natural land and recharge potential
Industrial activities	Conversion of prime agricultural land Disposal of untreated liquid and solid waste
Quarrying	Loss of forest land and forest degradation Increased sedimentation from exposed land Loss of agricultural productivity in downstream plots
Brick manufacture	Loss of prime agriculture land Loss of nutrient-rich topsoil and therefore agricultural productivity
Extraction of sand and gravel from riverbeds	Loss of riverine features such as riverbanks Deepening of river channels and therefore an increased threat to bridges Biological degradation and threat to aquatic life
Groundwater pumping	Lowered water levels and reduced soil moisture

Adapted from Baniya, 2008. Refer to Section 8 for discussion of these activities that impact agriculture.

High rate of urbanization is another factor that compounds vulnerability (Section 5). The continued influx of people into the valley makes it likely that both the number of squatter settlements and the prevalence of urban poverty will increase (Lumanti, 2005). Since most of these informal settlements are located along riverbanks and even in riverbeds, they are very vulnerable to floods (Aryal, 2009). Only a few have access to some basic, low-quality facilities and in most areas, access to both drinking water and sanitation is inadequate. Those living in squatter settlements often resort

to using contaminated river water and 15 per cent of households practice open-defecation (Lumanti, 2009). Low-income families, particularly squatters, are primarily involved in wage-based activities in the informal sector.

The above discussion highlights four key challenges that need to be addressed at both the conceptual and operational levels to build resilience among vulnerable populations:

1. Vulnerable groups face multiple stresses related to inadequate access to food, clean water and sewerage, and safe settlements that expose them to extreme events, which are likely to increase with climate change.
2. Both urbanization and agriculture in rapidly transforming peri-urban areas are embedded within a system that is not conducive to pro-poor development or building adaptive capacity: the systems that serve as gateways to services are inadequate, governance is poor, and institutions are dysfunctional.
3. In peri-urban areas and cities, individuals and households generally make autonomous decisions about the strategies to respond to stress and planned mechanisms on the government's part are often not designed to effectively support these. Though people do, for example, take advantage of such systems as banking, transportation and communication to find jobs in foreign countries, their responses are as yet made informally.
4. Current climate models, while they tell us much about the dynamics of the changing climate, cannot be properly scaled down to levels where decisions are made about risk management and adaptation. At best, the models suggest that precipitation is likely to become more uncertain and temperatures hotter, though without any precision.

5
Kathmandu in transition

Historical perspective

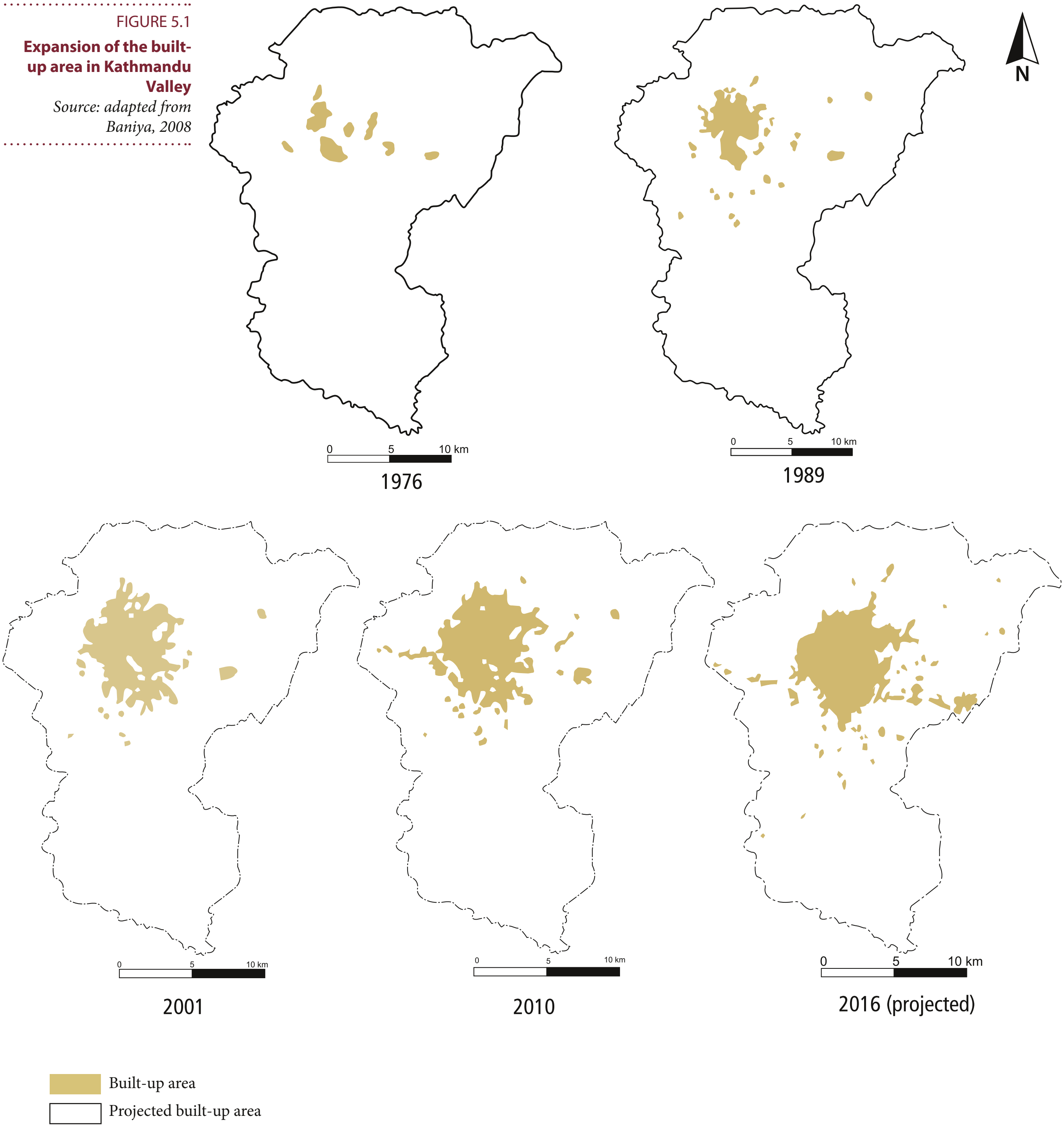
From the early 1500s until quite recently, Kathmandu Valley's fertile soil and monsoon climate favoured the growth of an urban social system with agriculture as its mainstay. For over four centuries, the valley society's close interdependence with the land endured. Then, in 1950, when the Rana oligarchy was abolished and the country embraced democracy, its economy moved toward the industrial and service sectors and its land-use patterns changed in response to both industrialization and steady population growth.

When Nepal was unified in 1734, Kathmandu emerged as the powerful centre of the kingdom (Tiwari, 2001) but because strict migration policies prevented the movement of people to and from the valley (Rademacher, 2008), the population of Kathmandu Valley was stable. However, its growth and the pace of change increased following democratization in 1950, when Kathmandu opened itself not only to the outside world but also to its hinterlands.

FIGURE 5.1

Expansion of the built-up area in Kathmandu Valley

Source: adapted from Baniya, 2008



Immigration and the pace of change within Kathmandu was further boosted in the 1960s by the construction of the Tribhuvan Highway linking the valley to the Tarai and onward to India. Further infrastructure construction increased communication and the availability of goods and services, thereby accelerating urbanization in Kathmandu and other cities and towns in the valley. Growth received yet another impetus in 1990, when multi-party democracy was re-established.

The rate of urban growth in Kathmandu Valley is high –the population in Kathmandu Valley increased 6 per cent annually between 1961 and 1971, then, following a decline in the next decade to 4.2 per cent, surged to 6.4 per cent between 1981 and 1991 (Figure 5.1; ICIMOD, 2007; MoEST and UNEP, 2007). In contrast, Nepal's national urbanization rate is low by regional standards (WFP and NDRI, 2008), especially in the mountains, where no village qualifies as a municipality with a population exceeding 10 000.

Population growth has disproportionately affected the valley relative to the rest of the country. According to Nepal's 2011 population census, the country has a population of 26 494 504. Although Nepal's annual population growth rate averaged 1.35 per cent from 1991 to 2011, growth in Kathmandu District was much higher, 4.76 per cent, and 3.23 per cent and 2.96 per cent respectively in Lalitpur and Bhaktapur Districts. Density in the three districts of Kathmandu Valley is extremely high, with Kathmandu Metropolitan City approaching 20 000 persons/km^2 (Table 5.1). Infrastructure services have not kept pace with population growth, resulting in reduced quality of life for valley residents.

TABLE 5.1
Population and households

Regions	Area (Km^2)	Total Population Census		Number of HHs	Average HH Size	Population density km^2	Decade change in %
		2001	2011				
Nepal	147 181	23 151 423	26 494 504	5 423 297	4.89	180.01	14.44
Kathmandu district	395	1081845	1 744 240	436 344	4.00	4 415.80	61.23
Lalitpur district	385	337785	468 344	109 797	4.27	1 216.48	38.65
Bhaktapur	119	225 461	304 651	68 636	4.44	2 560.09	35.12
Urban Areas							
Kathmandu Metropolitan	49.45	671846	975 453	254 292	3.84	19 726.05	45.19
Lalitpur Sub-Metropolitan	15.15	162991	220 802	54 581	4.05	14 574.39	35.47
Kritipur Municipality	14.76	40835	65 602	19 441	3.37	4 444.58	60.65
Bhaktapur Municipality	6.56	72543	81 748	17 639	4.63	12 461.59	12.69
Madhypur Thimi Municipality	11.11	47751	83 036	20 302	4.09	7 473.99	73.89

Source: Preliminary result of national population census, 2011

TABLE 5.2
Annual percentage growth rate in key sectors

Sectors	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Agriculture and forestry	3.0	3.3	4.7	3.4	1.7	0.9	5.8	2.98
Construction	6.4	2.1	-0.3	2.9	7.7	2.5	5.1	0.99
Real estate, renting and business	-4.9	-4.0	-2.1	10.0	6.3	11.8	10.4	1.93

Source: Economic Survey FY 2011-2012, Ministry of Finance

Drivers of migration

Better education, employment and other opportunities in the Kathmandu Valley have been the main drivers of inward migration. Other factors include the high capital flows in the city; the substantial remittances provided by retired Gorkha soldiers and Nepali youth working in India, the Middle East, Korea, Malaysia, and elsewhere, and the stimulus to the valley's real estate sector provided by easy credit. Accordingly, the real estate sector saw a surge in growth from 2004/05 to 2007/08 (Table 5.2). Immigrants to Kathmandu can be broadly categorized as:

- high-income families that buy land and/or homes;
- those who cannot afford property but are able to rent accommodation; and
- those trying to escape poverty (Lumanti, 2009) who end up in squatter settlements without access to basic housing, drinking water and sanitation, health care, and education.

This third group is highly food insecure and lack health and water service provisioning, which makes them vulnerable to disruptions caused by extreme climatic events.

Besides poverty, other push factors leading to high rates of migration among Nepal's rural residents include low agricultural productivity, lack of local employment, food insecurity, debt and disasters (WFP and NDRI, 2008). The extent to which climate change may also fuel migration is not known, but increasing climate risks along with lack of access to fertilisers, improved seeds and other means of food production, will further strain rural populations. Collectively, these push factors lead to a loss of rural livelihoods; though it is not easy to identify how many people migrate to Kathmandu exclusively because of various pushes. In a recent survey of migrants to the valley, 54 per cent and 18 per cent, respectively, cited family and job opportunities as the reasons they had migrated (NLSS, 2003), both reasons, that are pull, rather than push. More detailed studies are needed to better understand motivations for migration.

Socio-economic characteristics of the Kathmandu Valley

The three districts of the Kathmandu Valley contain 150 Village Development Committees (VDCs) and five municipalities—Kathmandu Metropolitan City, Lalitpur Sub-Metropolitan City, and Bhaktapur, Kirtipur and Madhyapur Thimi municipalities. The Valley contains 85 per cent of Kathmandu District, 50 per cent of Lalitpur District and all of Bhaktapur District (Figures 5.2 and 5.3).

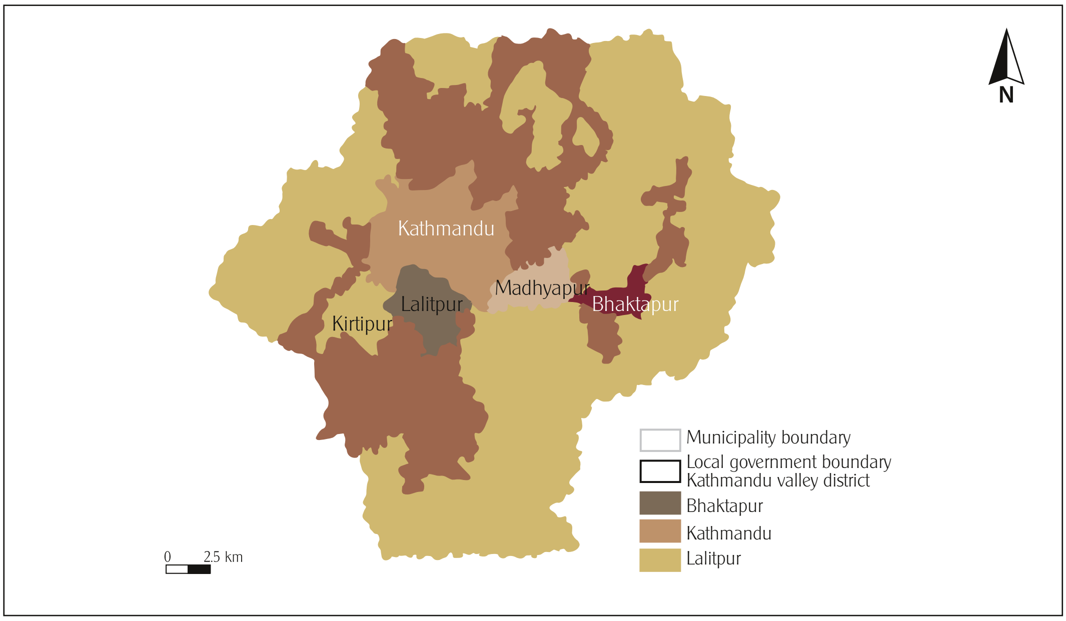


FIGURE 5.2
The five municipalities in Kathmandu Valley

Unit	Area km²	Population
Districts		
Kathmandu (KD)	395	1 744 240
Lalitpur (LD)	385	4 68 132
Bhaktpur (BD)	119	3 04 651
Total	899	2 517 023
Municipalities		
Kathmandu Metropolitan	49.45	9 75 453
Lalitpur Sub-metropolitan	15.50	2 20 802
Bhaktapur municipality	6.56	81 748
Madhyapur municipality	11.11	83 036
Kirtipur municipality	14.76	65 602

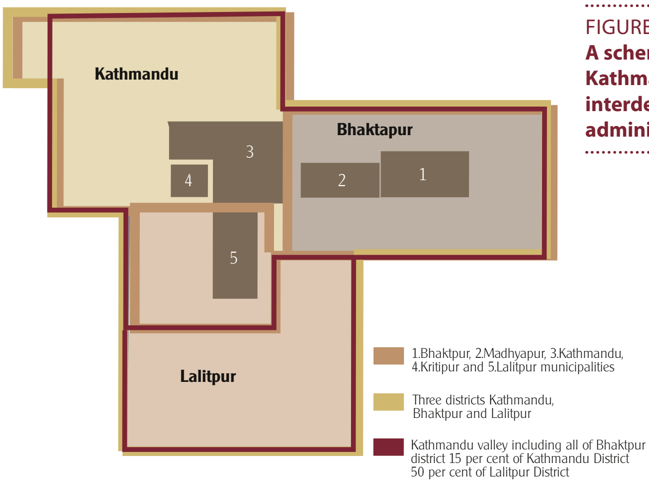


FIGURE 5.3
A schematic of the Kathmandu Valley's interdependent administrative units

The valley's economy is based primarily on trade, industry and the service sectors of education, health, transport and tourism. Kathmandu hosts Nepal's only international airport, which serves as the entry point for the majority of tourists—three-quarters of the total 610 000 tourists who visited Nepal in 2011 (Nepal Beyond, 2011). The valley has better health services than other parts of Nepal and Kathmandu has a greater variety of services than Lalitpur and Bhaktapur.

About 34 per cent of all households, ranging from 50 per cent in Lalitpur to 13 per cent in Kirtipur, engage in small-scale non–farming activities (CBS, 2003). Nearly 50 per cent of households in Kirtipur and Kathmandu municipalities engage in trade and business activities (CBS, 2003), while about

36 per cent engage in agriculture and forestry. Other economic activities see less participation: just 17 per cent of the population engages in manufacturing, 16 per cent in commerce, four per cent in construction, and three per cent in transportation or communication. The most economically active age cohort (15-44 years) constitutes about 56 per cent of the population in Kathmandu Valley (CBS, 2003).

In addition to carpet and garment industries, the valley is home to several smaller, traditional industries, including textiles, bricks, tiles, pottery, handicrafts, carved wooden furniture, bamboo crafts, leatherwork, herbal medicine, sculpture, and painting. Carpet industries are concentrated in Kathmandu while handicrafts, especially metal crafts, in Lalitpur. The valley is also the centre of trade links with foreign countries. In the fiscal year 2007/08, Nepal exported 65 per cent of its goods to India and the remaining 35 per cent to First World countries such as U.S.A., the U.K., Italy, Germany, Canada, and Japan (Economic Survey, 2008/09). Readymade garments and wool carpets, along with iron and steel products, yarns, and lentils, fall among Nepal's top five exports (Khanal, 2011).

In the 1990s, when carpet factories were first opened, the carpet industry saw a boom so great that farmers sold or rented their farmland to factory owners, and constructed houses for labourers. In recent years, however, the number of carpet factories has declined (Department of Industry, 2010) because of their inability to compete in the global market, unscrupulous trading, resource constraints, inefficient management, and environmental problems (Gautam *et al.*, 2008); those that remain, however, consume considerable amounts of water, diverting it from other uses like irrigation, and are major sources of water pollution.

6 Agriculture and food systems in the Kathmandu Valley

Agricultural context

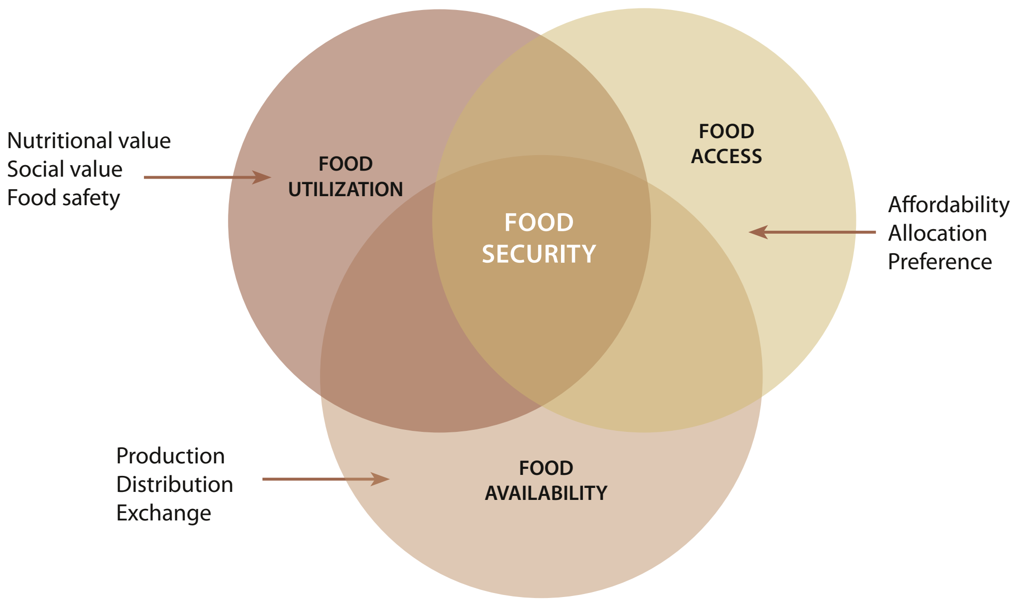
Until the late 1980s, Nepal was a net exporter of food, which helped stabilise the country's macro-level food balance and its economy. Despite sufficient national-level production, however, the storage and distribution of food has long been problematic and many regions in the hills have regularly faced food shortages. Since the 1990s, demand has outstripped cereal production and the country has experienced a macro-level food deficit (Dahal and Khanal, 2010). In 2011, the WFP estimated that about 3.4 million Nepali people were food-insecure due to reduced production, escalating prices and the poor distribution of food. Food security is determined by a range of factors that go beyond simply those of food production and distribution (Figure 6.1).

The valley's main crops are paddy and maize, but millet, wheat, barley, lentils, soybeans, peas, black gram, pulses, potatoes, and oilseeds are also grown (Figure 6.2). Households also raise livestock, whose milk and meat they sell in major urban markets. Similarly, vegetables such as cauliflower, garlic, beans and onion are also grown in the valley. In the past, agriculture within the Kathmandu Valley helped meet the overall food needs of the valley's residents and may have met up to one-quarter of its demand for vegetables (Dixit and Bhandari, 2003; Baniya, 2008). Besides vegetables, peripheral VDCs, locally known as *kaanth,* also supplied the valley with milk (Box 1). Over the years, however, as agricultural land has been built over, agricultural production has declined and the share that local production contributes has decreased. Indeed, it is clear from the shared learning dialogue held in conjunction with this assessment that only about 5 per cent of Kathmandu's demand for vegetables is met by urban and peri-urban areas of the valley.

The Jyapu, a Newar caste whose traditional occupation is farming, once possessed great expertise in the intensive cultivation of vegetables (FAO, 1994). Preserving a variety of good-quality seeds and applying organic fertilisers, compost and human excrement, the Jyapu produced the majority of the fresh vegetables consumed by valley residents. Until the mid-1970s they cultivated land that has long since been converted into built-up areas. The number of Jyapu families currently farming has declined dramatically is not just the result of land-use changes but also because the younger generations have sought new vocations. The nature of land tenure, particularly the fragmentation and small size of landholdings, has also adversely affected these vegetable production systems.

The fact that agricultural inputs, including seed supply, are often not available on time negatively affects production. In addition, dependence on new seed varieties has reduced crop diversity and pushed out traditional seed varieties as well as increased the usage of chemical fertilisers and pesticides. Particularly, widespread use of chemical fertilisers began in the early 1980s as vegetable production began to be commercialized (Pokharel and Panta, 2008) and pesticide usage grew to manage increasing pest and disease pressure. In 2007, almost 348 MT of pesticides were imported

FIGURE 6.1
Food system components
Source: FAO (1996)



to Nepal, 250 per cent more than in 2006 (Pesticide Registration and Management Division, 2009), with the Kathmandu Valley alone using more agrochemicals than in either the hill and mid-hill regions (Bhatta and Werner, 2011).

Even as agronomic and land-use changes have intensified, farmers are simply no longer able to meet the needs of the burgeoning population of the valley. For example, in 2001, 153 356 MT of cereals, 2 279 MT of pulses, 57 350 tonnes of cash crops and 1 488 MT of vegetables were produced in Kathmandu, Bhaktapur and Lalitpur but these levels of production were not enough to meet food needs of the valley's 1 million people (Table 6.1). The shortfall is likely wider because a portion of the cereal is also used to feed livestock in the valley. As Table 6.2 indicates, the majority of highly perishable vegetables consumed in the valley are still produced within Nepal, with less than 10 per cent coming from the Kathmandu Valley, whereas vegetables with a long storage life predominately come from neighbouring countries.

As urbanization progresses, the valley's agricultural production will likely decline still further although if UPA could overcome the policy and governance challenges it faces and be positioned to compete with the real estate sector and overcome other change drivers that challenge it, there is land available for it both to expand and increase production (Baniya, 2008).

Currently, most educated youth eschew manual labour and the illiterate and only slightly schooled are hesitant to risk doing something new. As a result, the average age of farmers is increasing and, as they find themselves increasingly unable to perform all agricultural tasks themselves and cannot find agricultural labourers to hire, they often lease or sell their land to outsiders for non-agricultural and

TABLE 6.1
Availability of and demand for cereal crops in 2009/2010

Region	Edible production (MT)					Total edible production (MT)	Requirement (MT)	Balance
	Rice	Maize	Wheat	Millet	Barley			
Central region	637 393	277 984	412 829	56 949	730	1 385 888	1 862 166	-476 275
Central hills	149 375	189 451	75 593	32 288	422	447 129	873 452	-426 323
Kathmandu District	19 567	8 721	11 667	689	1.9	40 645	284 444	-243 799
Bhaktapur District	10 686	1 392	8 106	81	14	20 279	55 102	-34 823
Lalitpur District	11 545	11 644	6 303	640	68	30 201	82 786	-52 585

Source: www.moad.gov.np

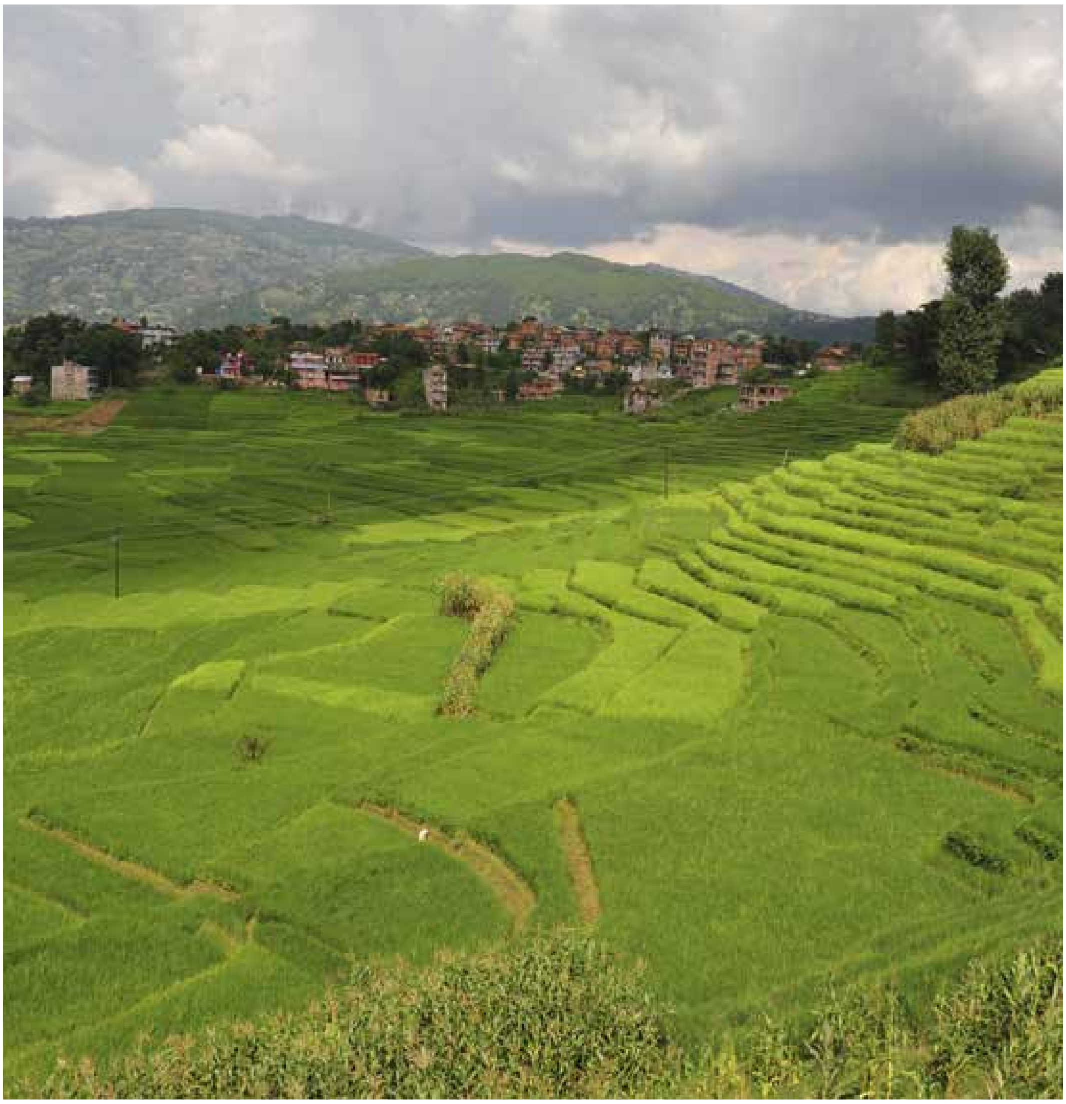


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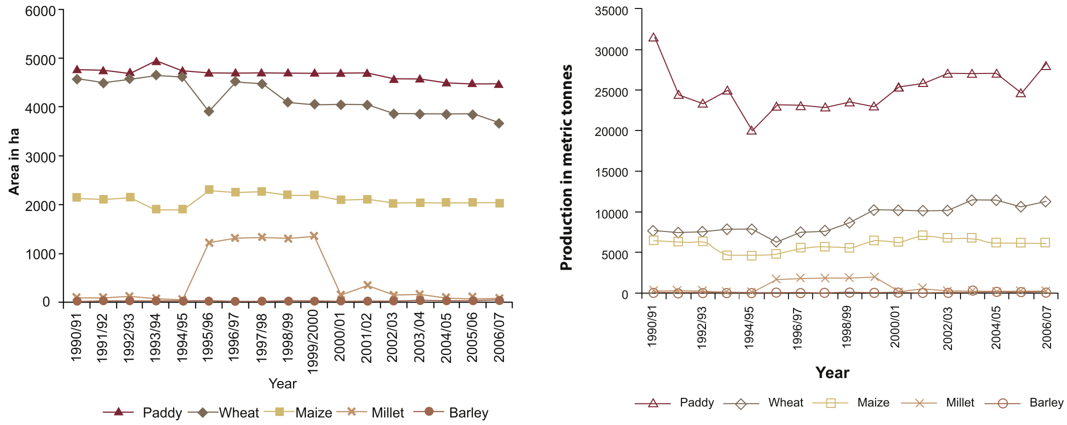
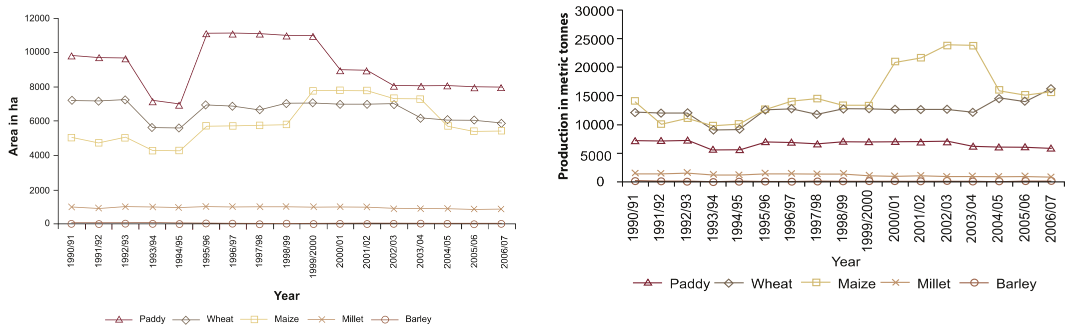
FIGURE 6.2
Cereal production in Kathmandu, Bhaktapur and Lalipur districts

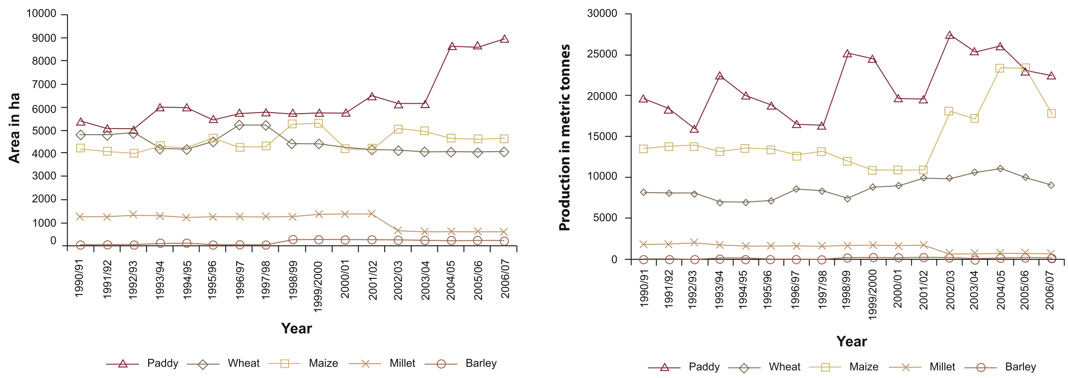
Kathmandu Districts



Bhaktapur Districts



Lalipur Districts



agricultural purposes. One exception to the prevailing trend away from agriculture is the emerging market for organic and other specialty crops that has attracted a small number of enterprising young people, affluent and educated career farmers and cooperatives to cultivate high-return non-seasonal vegetables (Box 2) but these cases are more exceptions than the rule.

Kathmandu Valley's food production is similar to the situation of other districts of Nepal (Figure 6.2). On a national scale, not only is cereal production insufficient but vegetable production is also low despite the fact that between 1999/2000 and 2009/2010 the total area under vegetable cultivation nationally increased almost 60 per cent and average productivity increased by over 25 percent (MoAC, 2010). Data for 2012 from the Kalimati Fruit and Vegetable Wholesale Market (KFVWM) indicates that the shortfall is met by imports (Figure 6.3). According to MoAC, Nepal imported foodstuffs worth USD 621 million and exported agricultural products worth less than half that, USD 248 million (Sapkota, 2011), meaning that trade in agriculture contributes to Nepal's overall trade deficit.

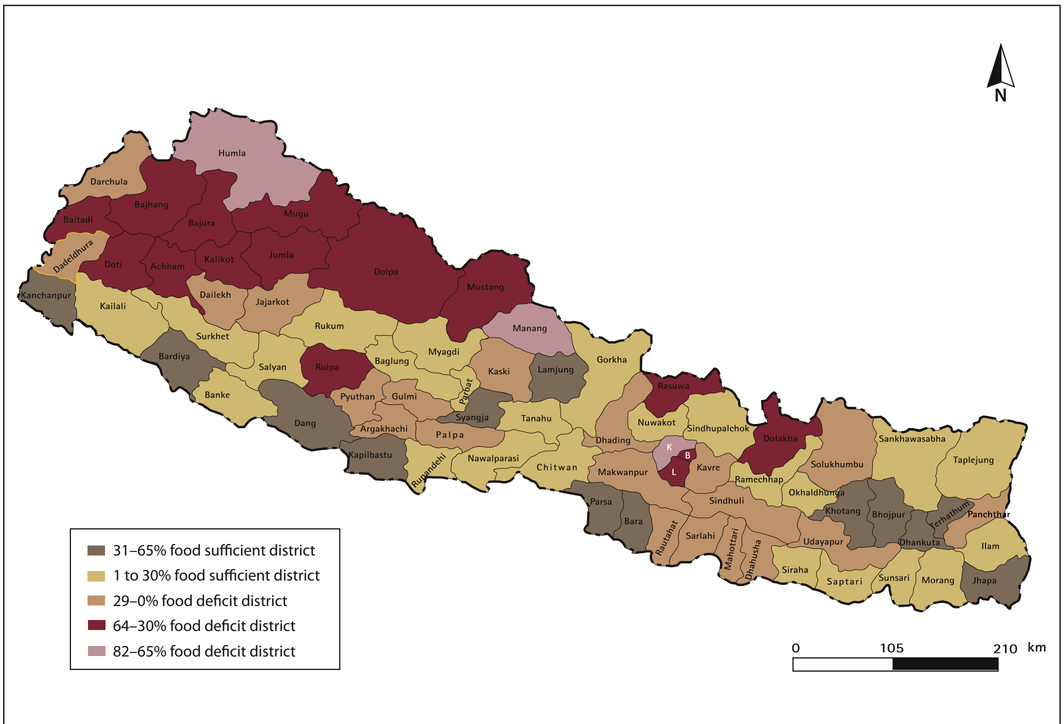


FIGURE 6.3
District level food balance
Source: MOAC (2010)

Box 1. Dairy production

The development of Nepal's dairy sector began in 1953 when FAO helped establish a cheese factory in the central region (Acharya and Basnet, 2009). A few years later, the Department of Agriculture established a small-scale milk processing plant in Nepal's central region; then, in 1969, the Dairy Development Corporation (DDC) was established to meet the increasing demand for milk and milk products (FAO, 2010) from the growing urban population.

The DDC aimed to use its milk supply scheme to bridge the gap between farmers and urban consumers (DDC, 2012). To reduce farmers' transaction costs in reaching end users, the DDC collects milk from centres in 40 districts, many of these are located in seven districts in the central development region around Kathmandu, which supply about 70 per cent of Kathmandu milk (FAO, 2010). Not surprisingly, the Kathmandu Milk Supply Scheme has the most milk-producer cooperatives in the nation. Access to roads plays a major role in the collection and distribution of milk; where there are no roads, ropeways are sometimes used.

Despite the efforts of the DDC, milk supplies have generally diminished resulting in reduced rearing of cattle and buffalo, thus making it difficult for dairies to meet the growing demand. Factors contributing to decreased milk supplies include declines in stores of animal feed, and in the interest of young people in dairy farming, the lack of accessibility of grazing land, reduced government support and increases in the costs of land and labour around highways (Gyawali *et al.*, 2004). Other factors, such as urban encroachment and increased climate extremes, could further impact local milk production to the extent that they impact on forage production; however, studies to assess these factors have not yet been carried out.

Box 2. Reconceptualising incentives in agriculture

Every month large numbers of Nepali youths travel abroad in search of employment. The latest data indicate that in just 11 months, from mid-January to mid-December 2012, more than 500 000 Nepali youths left to work, largely as unskilled labourers, in places like South Korea, Malaysia, and the Middle East (Department of Foreign Employment, 2012). The remittances they send contribute to the incomes of over half of all households and comprises as much as 23 per cent of Nepal's GDP. Some individuals have returned with new skills and ideas and have started new vocations, including the cultivation of organic vegetables and other crops on land they lease in Kathmandu Valley's peri-urban region. However, there are constraints on these efforts, which need deeper study to determine if this autonomously emerging trend can be useful for designing planned governmental strategies for the rejuvenation of agriculture. In addition, technical and other kinds of support for agriculture need to be reconceptualised.

Markets serving agriculture in the Kathmandu Valley

Peri-urban agriculture is dependent on a variety of institutions, including agriculture service centres, farmers' groups, district agriculture development offices (DADOs), and other government offices. Farmers form groups according to the crop they cultivate—vegetable and cereal producing groups are the most prevalent and more than twice as many women as men are group members (Table 2.2; Section 2). In collaboration with DADOs, farmers' groups provide their members with capacity-building training and seeds and identify new markets. Those who are not members are excluded from these and other services.

Besides producer-farmers, peri-urban agriculture involves middlemen, land owners, transporters and vegetable sellers. To facilitate the sale of agricultural produce, in 1986 the Department of Food and Agricultural Marketing Services under the Ministry of Agricultural Development established the Kalimati Food, Vegetable and Fruit Market (KFVWM). At 2.25 ha, it is the biggest fruit and vegetable market in Kathmandu. Potatoes, onions, fresh vegetables, fresh fish, mushrooms, spices, and fruit are the main produce traded through 296 wholesale stalls, 69 retail stalls, 26 fish stalls, 25 cooperatives, 17 fish sheds and 14 shuttered units. According to the KFVWM's annual report, 8.29 per cent of produce comes from within the valley, 63.17 per cent from other areas in Nepal, 26.30 per cent from India, and 2.24 per cent from China (Figure 6.2). Through personal contacts, traders export potatoes, ginger, and garlic to India and capsicum, potatoes, cabbage, and tomatoes to China and supply other markets within the valley. Two other vegetable markets, one in Balaju in the northwest of the valley and the other in Dharke, Dhading District, come under the auspices of KFVWM.

It is difficult to fully assess the actual amount of vegetables produced in the valley and the population served by local production because not all vegetable products sold in Kathmandu Valley get to the market through official channels of KFVWM. In fact, large quantities enter the market informally through middlemen, who collect vegetables directly from production sites for distribution. Also, a large number of women, mostly poor immigrants, collect vegetables from farmers in their fields and sell them at busy road junctions in Kathmandu.

TABLE 6.2
Annual trade in selected vegetables at Kalimati market (2010/2011)

| | | Place of origin | | | | | |
		Volume in MT and percentage					
Commodity	Total	Nepal	%	India	%	China (Tibet)	%
Tomato, big	4 029	1 576	39.1	2 453	60.9	0	0
Tomato, small	20 146	20 060	99.6	86	0.4	0	0
Onion, dry	17 435	76	0.4	15 733	90.2	1 626	9.33
Onion, green	696	673	96.7	23	3.3	0	0
Cabbage	9 162	9 036	98.6	126	1.4	0	0
Cauliflower, local	20 650	20 650	100	0	0	0	0
Cauliflower, Tarai	5 614	5 503	98	111	2	0	0
Chili, green	4 003	1 288	32.2	2 715	67.8	0	0
Capsicum	556	207	37.2	349	62.8	0	0
Cucumber	4 687	4161	88.8	526	11.2	0	0

Source: KFVWM, 2011

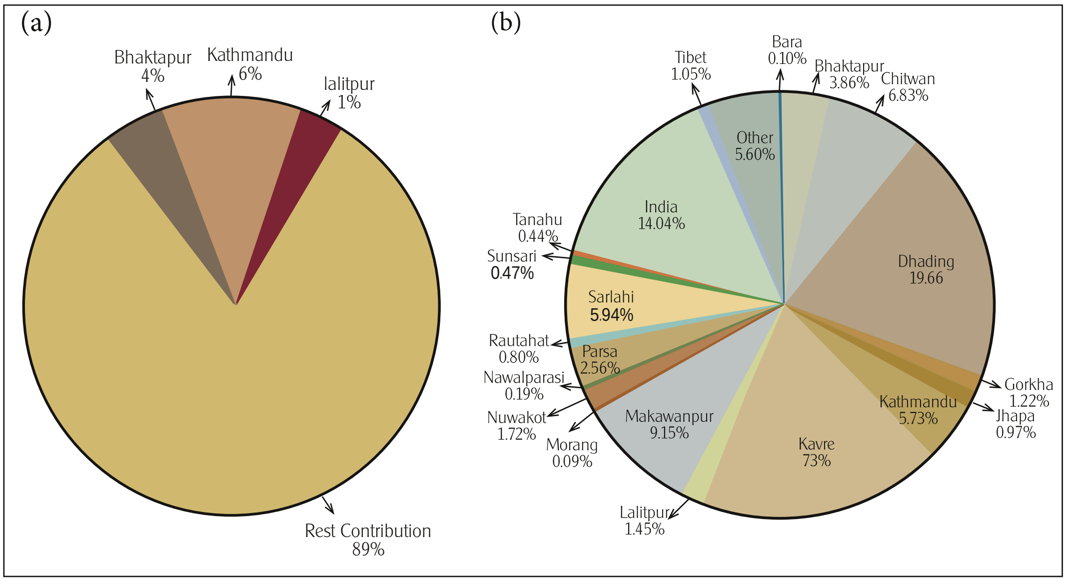


FIGURE 6.4
Percentage of vegetables in the Kalimati market (a) and (b)

Despite the efforts of the KFVWM committee to manage sales, challenges remain. While women constitute 40 per cent of leafy green vegetable wholesalers, just five per cent of onion and potato wholesalers are women, and overall women make up just 15 per cent of registered members of KFVWM. About 16 per cent of traders involved in KFVWM are well-to-do, 64 per cent middle class and 20 per cent relatively poor. Wholesaler farmers are generally better off than retailers.

The committee has allocated nine per cent of the stalls to farmers and cooperatives but there are a limited number of stalls and it is not possible to accommodate everyone. For this reason, the volume of vegetable transactions through informal mechanisms is considerable. Another problem is storage: about 500–600 MT of agricultural commodities enter KFVWM daily, but the storage facilities, including cold storage, are insufficient and what does exist is also poorly managed. Because many vegetables spoil rapidly or are damaged in handling, prices are routinely higher in the morning than in the evening and sellers have been known to dump unsold vegetables because there are no storage facilities.

Institutions and policy frameworks serving agriculture in the Kathmandu Valley

Nepal's Interim Constitution recognises food sovereignty as a fundamental right to all citizens, but urban and peri-urban agriculture is not mentioned nor is such agriculture mentioned in national or municipal plans. An array of instruments exist that can play vital roles in supporting agriculture in and around Kathmandu, though they do not specifically focus on it. For example, the Local Self-Governance Act (LSGA) empowers local bodies for the conservation of soil, forests and other natural resources. Sections 28 and 43 of the Act provide VDCs a legal mandate to formulate and implement programmes related to the protection of the environment and biodiversity. Section 96 of the Act provides municipality committees mandate to frame land-use maps of a municipality by specifying different zones.

The Kathmandu Valley Town Development Committee (KVTDC) was established to regulate residential development at a time when agriculture was the overwhelming economic activity of the valley and to serve as a coordinating body among agencies of national and local government for its

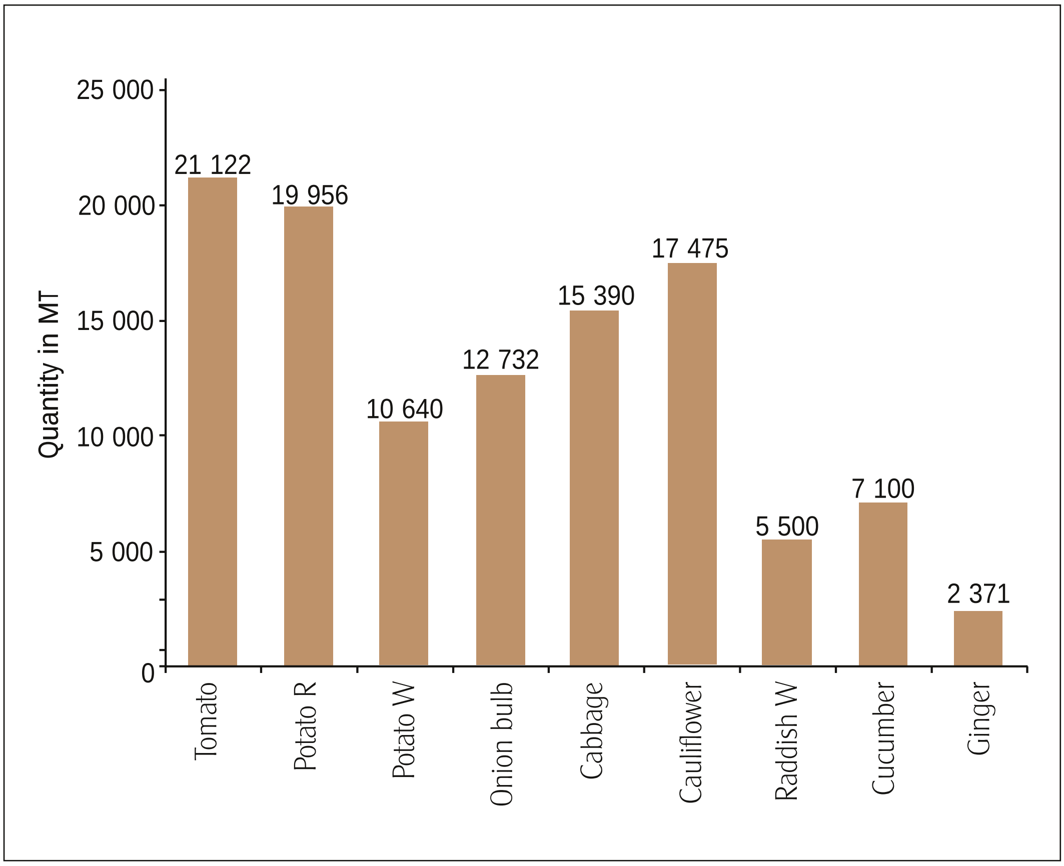


FIGURE 6.5
Type of vegetables coming to Kalimati

TABLE 6.3
Sources of origin of agricultural commodities at Kalimati

Particulars	Types of commodity
Outside valley (Districts) Makawanpur, Dhading, Nuwakot, Nawalparasi, Chitawan, Sarlahi, Sunsari, Morang, Jhapa, Dhanusa, Rautahat, Gorkha, Dolkha, Kavrepalanchowk, Sindhupalchok	Seasonal and off-season vegetables like potatoes, onion, cabbage, cauliflower, radish, tomato, bitter gourd, vegetable gourd, lady's finger, ginger, bottle gourd, spices, cow pea, peas, cucumber, ginger, coco yam, yam, sponge guord.
From Valley Kathmandu, Bhaktapur, Lalitpur	Fresh and leafy vegetables like broad leaf mustard, spinach leaf, cress leaf, mustard leaf, fenugreek leaf, onion green, mushroom, asparagus, broad bean, Yam, Bavelu, balsam apple, cow pea, sweet potato, radish, cristophine, capsicum, spices, soyabean, mint, shallot, turnip, pumpkin, beans, brinjal, fish.
From Other Countries India	Seasonal and off-seasonal vegetables like tomatoes, brinjal, potato, lemon, carrot, cauliflower, bottle gourd, pointed gourd, spices, tamarind, onion, pumpkin, peas, potatoes, shallot, balsam apple, cow pea and fruits like apple, banana, coconut, pomegranate, mango, orange, peach, grapes, pineapple, strawberry, pears, sugarcane, watermelon, tree melon, sweet orange, lichi, fish.
	Fruits and vegetables like apple, tree melon, pears, garlic, ginger, fish.
	Potatoes (In shortage only)

systematic and sustainable development. The five-year national development plans, in place since the 1950s and updated regularly, have moved away from their early emphasis on agriculture.

These policy frameworks exist in addition to many plans and master plans intended to regulate urban growth and keep ecosystems balanced in Kathmandu. Nepal's development plans also incorporate measures to achieve the objectives of regulating urbanization. However, implementation and policy guidelines have been weak (Pradhan and Perera, 2005) and *ad-hocism* pervades (Box 3).

Box 3. Critical policy and investment need: addressing the shortage of agricultural researchers

Policy making in the uncertain realm of future change, including but not limited to climate change, requires robust knowledge systems that are equipped with the scientific capacity and infrastructure to address the climate-related problems that farmers and the country more broadly face. To do so, the agricultural sector needs to generate the sort of evidence that can influence policy processes. While there is no denying that farmers' experiences and knowledge are important, so, too, is scientific analysis. The National Agricultural Research Centre (NARC) play a critical role in agricultural research by conducting experiments on, piloting, and encouraging farmers to adopt new varieties of seed appropriate to their production environments. In a future that climate change is rendering increasingly uncertain, agencies like the NARC must play a pivotal role in generating agricultural knowledge about the impact of change on different crops, regularly piloting, monitoring and evaluating drought- and flood-resistant varieties, and disseminating new seed, as well as good practices and lessons learned among farmers. Strong social science knowledge about climate change, though not the domain of NARC, is also badly needed in Nepal.

Given the potential of NARC's role, it is unfortunate that in recent years the NARC has faced many challenges. Nepali agricultural scientists show little interest in being affiliated with the NARC and the shortage of human resources has hampered its research efforts (pers. comm). Indeed, of NARC's 1 003 positions for scientists, only 676 are currently filled and response to calls for applicants is lukewarm—in 2012, just 70 applications were received for 150 positions. Graduates in agriculture tend to seek employment in developed countries, where research organizations and other opportunities offer better financial incentives.

Because climate change and other change drivers make the future more complex, all forms of knowledge—scientific, social and local—need to be synthesized and assimilated in order to respond to the constraints that these change processes will bring. The challenge faced by NARC is a reflection of a deeper challenge that Nepal faces in its effort to respond to climate change-induced vulnerability. These challenges should encourage government, donors and educators to focus on education and strengthening the capacity across society to generate, share and act on knowledge.

Adapted from Kumar (2012)

7 Critical vulnerabilities

Interconnected food, transport and energy systems

Increasing food prices pose a threat to the valley's food security, particularly for the urban poor and those rural poor who depend significantly on food purchases. Local prices fluctuate given that the valley's food system is heavily dependent on regional/global systems and markets. Other factors, including floods and drought, and local political turmoil, also play a role in food price volatility. In 2011 the prices of vegetables, fruit, sugar, and milk in Nepal increased by 47 per cent, 28 per cent, 23 per cent, and 17 per cent, respectively, compared to 2010, while the prices of cereals and grains each rose by about 10 per cent (World Bank, 2010), increasingly placing dietary basics out of the reach for the poorest and forcing them to turn to cheaper, but less nutritious, foods.

The connection between the valley's food system and fuel prices is also a growing concern. The number of both two and four-wheeled vehicles used within the valley have soared. According to the Department of Transport Management, 1 178 911 vehicles have been registered since 1989/90, and in the five years since 2007 the number of motorcycles has increased by 48 per cent. These vehicles play a pivotal role in transporting food to and from Kathmandu and peri-urban regions as well as further afield but they have also increased Nepal's dependence on imported petroleum products, which now constitute about 11 per cent of the total energy consumed in the country (World Bank, 2011). Current demand for petroleum products is about 1.2 MT per annum and is increasing by 20 per cent annually (NoC, 2012). The cost of meeting that demand is sizable: according to Nepal Rastra Bank, the country spent NPR 76.71 billion on petroleum products in 2010-11, an increase of nearly 44 per cent over the previous year and account for 20 per cent of the country's total imports by value and one-third of its imports from India. The fact that Nepal's export earnings meet only one-third of the cost needed to import petroleum products (World Bank, 2011) is another indication of increasing dependency.

Trucks, pick-ups, vans, mini-trucks, and buses are used to transport food from distant villages while almost all types of vehicles, including bicycles and rickshaws, are used for short-distance transportation. About 20 per cent of farmers transport produce themselves; the rest use middlemen, who are usually local traders. The middlemen fix the prices of fruit and vegetables. Some traders buy produce directly from farmers and pay them 7-8 per cent of their profit.

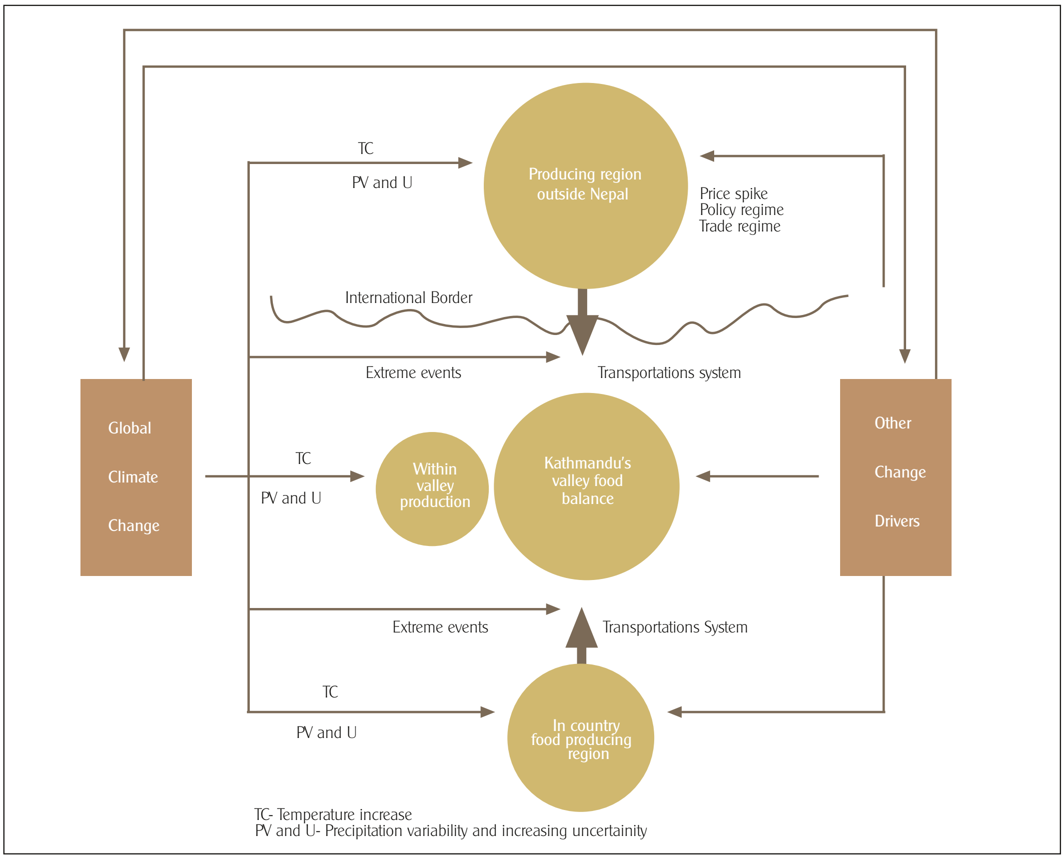
During Nepal's main festival season, Dashain and Tihar, increased demand drives prices up, giving farmers the opportunity to make an extra profit. In contrast, strikes and political actions hinder trade. When farmers cannot get their produce to the market due to general shutdowns, it often rots in the fields. The profits of farmers who themselves transport their vegetables to the market are eaten into by the steady increase in the cost of transportation largely due to increasing petroleum prices.

Lessons from past signature events

The interdependence of regional and local food systems requires taking measures that build resilience across local and regional levels. The impacts of and lessons learnt from past events can shed light on such interdependence and vulnerability, suggest how food systems might be affected, and provide insights into future scenarios under which climate change could make extreme events that trigger disruptions in food and energy supply systems more intense and frequent (IPCC, 2012). In this case, two examples, a disaster triggered by a cloudburst in 1993 that seriously affected Kathmandu and the breaching of a Koshi River embankment in 2008, are insightful. The latter, though not a climate-induced disaster, nonetheless highlights how a systemic failure transmits vulnerability within a system (Dixit, 2009).

These two ‘signature events’ demonstrate unique climate change challenges facing large cities located in mountainous regions. Though more robust place-based climate modelling is needed to determine to what extent extreme climate events will increase with a warming climate, the current perilous state of transportation infrastructure serving the Kathmandu Valley leaves significant space for implementation of no-regrets adaptation measures to bolster the resilience of transport, power and communication infrastructures. Studies are also needed to understand how proximate and distant factors, be they physical disruptions or market forces, influence food prices and subsequent impacts on food security of the poor.

FIGURE 7.1
Systemic interdependence of local and regional food systems



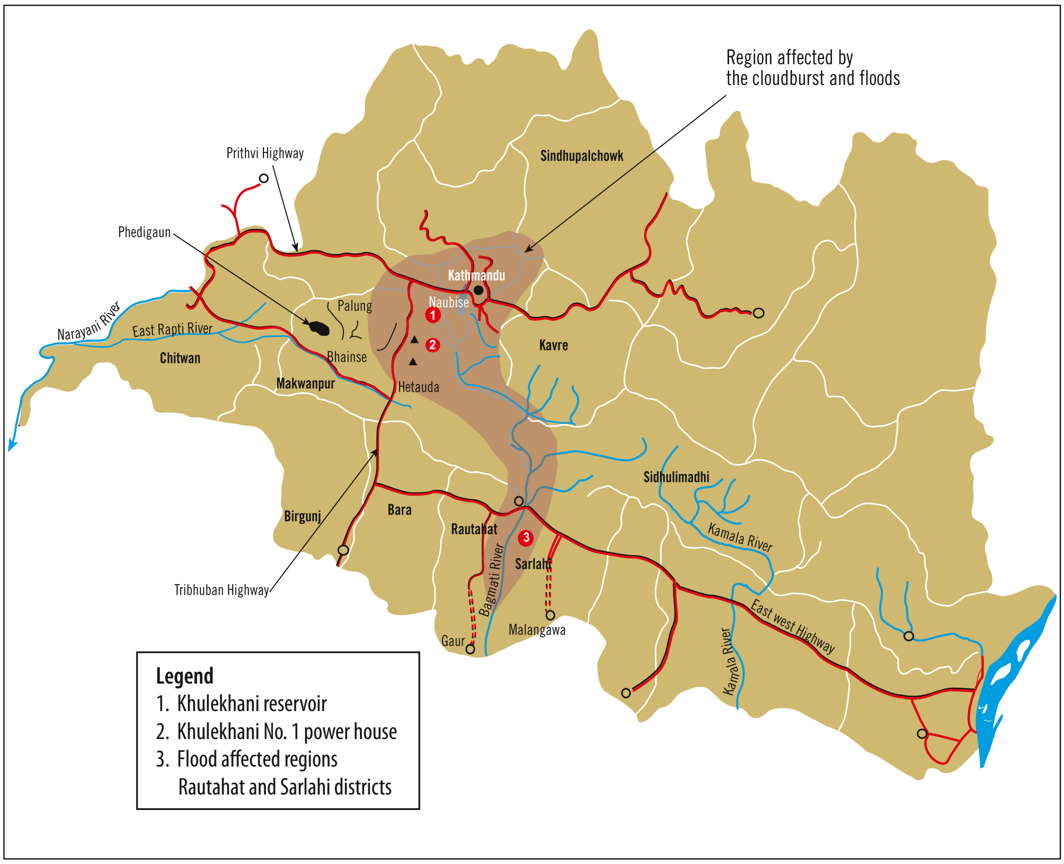
1993 Central Nepal cloudburst: In July 1993, a massive cloudburst in the central mid-hills triggered an unprecedented number of landslides and floods. The swelling of the Bagmati and Narayani rivers and their tributaries beyond capacity caused major flooding both in the mid-hills and the lower Bagmati basin. Besides Kathmandu, seven other districts in the central region were severely affected. The event was a record-breaker, with one station in the Kulekhani watershed recording a 24-hr accumulation of 540 mm, with a maximum of 65 mm of rain recorded in one hour.

The disaster took about 1 158 lives, completely or partially destroyed 32 000 houses, and seriously affected about 65 367 families. About 39 676 ha of cultivated land were affected by landslides, washed away or covered with debris. The disaster damaged 341 km of roads, 169 bridges, 376 irrigation schemes and 401 school buildings, hospitals and government offices (Nepal Disaster Report, 2009). Though the event did not have a direct effect on the residents of the Kathmandu Valley, life there was nonetheless disrupted. The flood destroyed major bridges on the two national highways that connect Kathmandu Valley with the rest of Nepal, and India, thereby disrupting the supply of goods, including vegetables and other foods and petroleum products, for more than a month. The event also severely damaged two major water projects—the 90 MW Kulekhani hydropower plant and a barrage in the Bagmati River. With the plant damaged, electricity production declined and power outages increased, affecting food storage and other service provisioning. In addition, the flooding caused such excessive sedimentation of the Kulekhani reservoir that the World Bank estimated that the economic life of the plant was shortened from 100 to 30 years (Dixit, 2003). This event demonstrated how vulnerabilities cascade through interlinked systems (Figure 7.2).

The 1993 crisis was resolved as the Hetauda-Kathmandu ropeway provided an alternative transport system for foodstuffs and temporary bridges were soon constructed along the highways. A similar event today, however, would have much greater consequences as the ropeway has been dismantled and, with more than 2.5 times more residents in the valley, the demand for food is greater. Additionally, while two new roads now link Kathmandu with Hetauda and the Tarai, they cannot accommodate trucks that ordinarily transport food to Kathmandu, quite apart from the fact that a torrential downpour could very well damage these roads as well as the main highways.

2008 Koshi embankment breach: When the 2008 Koshi embankment breach blocked the movement of agricultural products from eastern Tarai to all areas west of the Koshi River by damaging the East-West Highway, the prices of commodities, particularly onions, potatoes and firewood, increased to the west (IASC, 2008; WFP, 2008), while in the east, the livelihoods of farmers suffered and the prices of perishables such as bananas and vegetables fell sharply. In addition, the inundation caused by the breach damaged underground fibre-optic cables, telephone lines and pylons, disrupting telecommunications (IASC, 2008; Pathak, 2008). The flooding damaged electricity-transmission pylons, disrupting India's supply of electricity to the Integrated Nepal Power System and increasing the duration of power cuts in Nepal. The costs of disruption in communications and power supply were high but they have never been accurately assessed. Following the 2008 Koshi embankment breach and the disruption of transportation and communication connectivity, the government decided to build a new bridge over the Koshi River at Chatara, upstream of the Koshi barrage. Progress in its construction has been slow, however, in part due to budgetary constraints.

FIGURE 7.2
Koshi embankment



Disrupted mobility following embankment breach @ Ajaya Dixit

8 Changing land and water resources: implications for food production

Land-use change

As described in Section 5, peri-urban agricultural land is facing intense development pressures. Over the last few decades, settlement patterns in Kathmandu Valley have resulted in expansion of the built-up area by a factor of four and shrinking the non–urban area proportionately (Table 8.1). In 1967, the built-up area comprised just 3 per cent of the total area; in 2000, it was 14 per cent, a gain of over 5 000 ha. Agricultural land has been seriously impacted: the proportion of farmland declined from 64 per cent in 1984 to less than 42 per cent in 2000. During the same period, the area of non-agricultural land increased from 5.6 per cent to 14.5 per cent (KVTDC, 2002). The expansion of urban areas and the attendant decline in agriculture, forest and shrub areas have adversely affected food production and the ecological services offered by the natural resource base, while at the same time placing stresses on the management of water and waste.

Though the total agricultural area declined slightly in the 1990s, from 13 350 ha in 1989 to 12 944 in 1999, it then increased 9 per cent over the next seven years, perhaps through the conversion of some forest and shrub land, to reach 14 420 ha in 2006. An earlier estimate (MoPE, 1999) suggested that half of the valley's *abbal* (A-grade) land, which in 1999 comprised 43 per cent of the total agricultural land, would be converted to urban sprawl by 2010. This prognosis has, by and large, proved to be accurate and, if this trend continues, very little prime agricultural land will remain in the Kathmandu Valley (Shrestha, 2006). Equally worrying for UPA is the continuing decline in the areas of open land and water bodies (Bhandari, 2010) as well as the fact that farmers are tempted by profit to sell their rice fields, riverbanks and wetlands to developers.

The establishment of numerous kilns in the peri-urban regions as brick factory owners exploit the valley's topsoil to produce bricks and farmers take advantage of the chance to lease their land during the agricultural off-season, has also had negative impacts on peri-urban agriculture. According to data compiled by the Department of Cottage and Small Industries, there are 110 brick kilns in the valley, 64 in Bhaktapur, 28 in Lalitpur, and 18 in Kathmandu (Adhikary, 2012), which together use about 80 000 MT of coal and emit 200 000 MT of carbon dioxide every year (Amatya, 2012). Most kilns operate during the dry season, from December to May, whereas in the rainy season the same land is used as paddy, which is harvested in October/November. The hundreds of kilns deplete the productivity of hundreds of hectares of productive farmland—a single brick kiln, on average, removes 1 500 MT of productive topsoil per *ropani* (0.05 ha) per year. As a result, agricultural yields decrease year-on-year until, ultimately, farming becomes unsustainable. Brick kilns also use large volumes of water: 208 000 m^3 annually in Bhaktapur alone (Sada, 2009). In short, the brick industry poses a considerable threat to the sustainability of UPA—brick is a common and preferred construction material and until affordable and reliable alternatives are available the competition between their manufacture and agriculture will continue.

Kilns mining © Fawaad Khan

Sand mining © Fawaad Khan

Water delivery systems

The Kathmandu Valley's water resources are under intense pressure from increased demand, poor water delivery infrastructures, haphazard land conversion associated with urban expansion and other forms of environmental degradation. The impact of climate change on the valley's water resources is uncertain. Because all of its waters are rainfed and the valley receives no snow, glacier melt and reduced snow cover, which are major climate change-water resource issues elsewhere in Nepal (e.g., McSweeney *et al*., 2008; Eriksson *et al*., 2009 and Bartlett *et al*., 2010), are not of particular concern in the valley. Flood, landslides and debris flow hazards are important risks in some parts of the Kathmandu Valley, particularly for land along the rivers in the core areas (Disaster Risk Management Profile, 2005).

Five drinking water systems – traditional, piped, groundwater, rainwater harvesting system, and water tankers and bottled water – are commonly used in the valley. The traditional system, though considerably less extensive than it once was, consists of a number of stone waterspouts fed by canals, which tap springs in the foothills surrounding the valley. The canals once fed a network of ponds constructed on the outskirts of and within settlements to recharge the underground aquifers that supplied them. In the last decade the number of spouts in use has decreased drastically (Dixit, 2003).

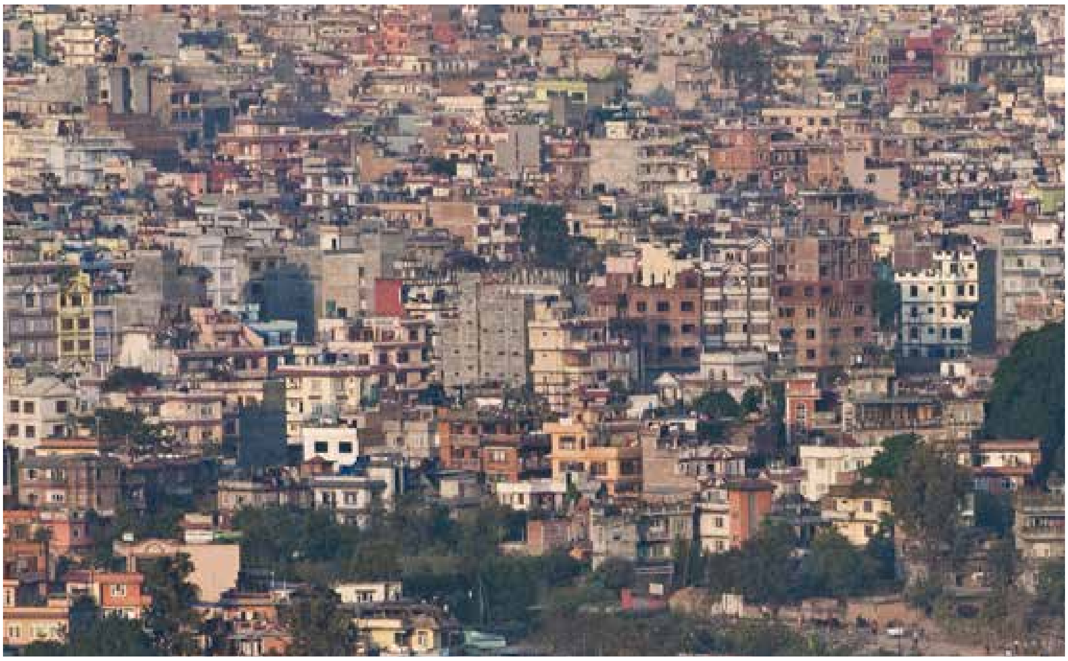
When the ruling class first introduced Western practices to the valley, it built piped drinking water systems with technology imported from the United Kingdom. The first piped drinking water system was built in the 1890s and many others gradually followed but the level of service has been consistently poor. Water demand in Kathmandu Valley is currently about 320 million litres per day (MLD) but supply is just 86 MLD in April/May, and 148 MLD (46 per cent) in July/August (KUKL b, 2009). In the dry season, about 27 per cent of the municipal supply (23 MLD) is met through groundwater extraction (KUKL, 2009b). The Kathmandu Upattayka Khanepani Limited (KUKL) serves about 78 per cent of Kathmandu's population (ADB and GoN, 2010) though, like the rest of the population, it also relies on tankers and other sources because supply is so unreliable.

Irrigation systems

Traditional irrigation canals compensate for inadequate rainfall. Across the nation, thousands of large and small farmer-built and managed irrigation systems provide irrigation – about 70 per cent of land under cultivation has some form of irrigation (Thapa, 2012). In the valley, however, these systems, once common, have become increasingly dysfunctional because of poor maintenance, disuse and general degradation, leading to a drastic reduction in or complete shut-off of water supplies, even in areas where water- user associations exist. Moreover, the ever-increasing demand for water for non-agricultural uses has deprived many downstream irrigation water users, impacting downstream landscapes negatively and raising questions about livelihood equity (Dixit *et al.*, 2005).

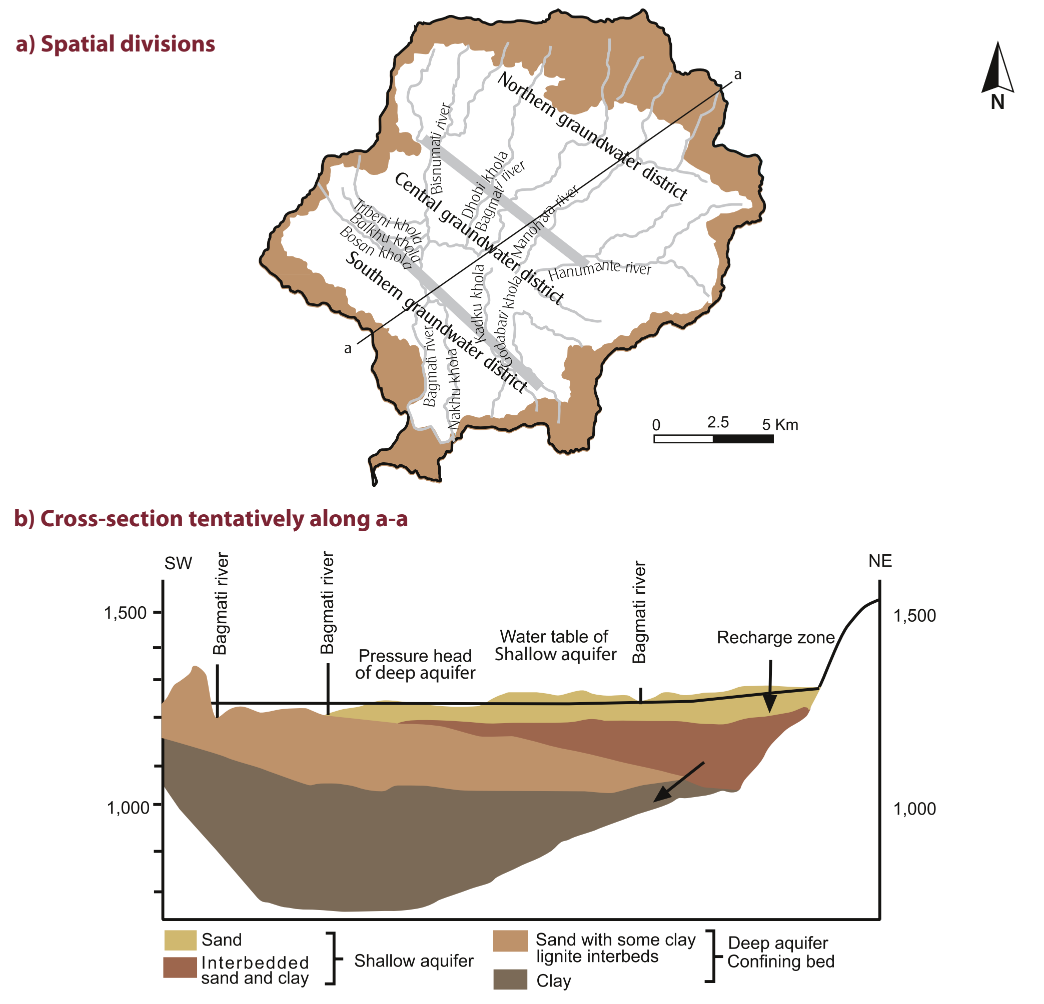
A recent study estimated that the valley has 415 irrigation systems, of which 51 are large, 122 medium and 242 small (Bhattarai, 2011). An earlier estimate was much more conservative: it suggested that 134 irrigation systems served about 7 625 ha in the valley (Dixit *et al.*, 2005). In some places a buffer strip of land is used to capture urban wastewater for use in irrigation, contributing to keeping rivers clean and recharging groundwater (Dixit and Upadhya, 2005).

Use of liquid waste has become more prevalent in the valley as a consequence of diminished supplies of freshwater for agriculture (Shukla *et al.*, 2012). The fact that pollution from untreated waste has rendered stretches of the Bagmati River and adjacent land unusable has placed an additional stress on the physical availability of water (Green *et al.*, 2003). The availability of wastewater has, in some sense, helped farmers because of the high plant-nutrient levels in wastewater irrigation that increases productivity of potatoes, radishes, cauliflower, and cabbage (Ruthkowski, 2004; Shukla *et al.*, 2012). According to Ruthkowski (2007), the farmers living downstream of Kathmandu Valley use wastewater to cultivate cash crops; however, as in other cities in the developing countries, they face risks associated with exposure to untreated wastewater because there are no health and safety measures.



© Foto Voyager

FIGURES 8.1 a,b
Kathmandu's groundwater aquifers



Groundwater resources

The number of tankers that tap surface and underground sources in peri-urban and rural areas, to help cover KUKL's deficit, has increased significantly in recent years – from 80 in 2000 (Moench and Dixit, 2003) to 750 in 2010, and today they meet about 9.1 per cent of the valley's total water need (Shrestha, 2011). The private tanker operators, KUKL and other users extract about 70 million litres of groundwater a day from the valley's aquifers (Figures 8.1a and b) using deep-bore wells, dug wells, rower pumps and tube wells. Disturbingly, the rate of pumping far surpasses that of recharge (Dixit and Upadhya, 2005) and changes in land use have reduced the open area needed for recharge across the valley, including in the north, where most recharging occurs (Dixit and Upadhya, 2005). As a result of reduced recharge and declining water tables, the gap between the supply and demand of water is growing. Poor management has made matters worse, as has the fact that water losses from supply systems approach 38 per cent (KUKL, 2009a). The gap, which is 234 MLD during the dry season and 172 MLD during the wet season (KUKL, 2009c), is expected to decrease when the Melamchi project's 26 km-long tunnel, with the ability to supply 170 MLD, is completed. Implementation of that project, however, has been delayed by contractual disputes and management problems.

In recharge zones and along rivers, the conversion of agricultural into built-up land and the associated excavations to build the foundations of high-rise buildings have disrupted local flows and put stress on groundwater hydrology (Dixit and Upadhya, 2005). Firstly, when new buildings and pavements are built, the area of pervious land decreases, preventing rainwater from infiltrating the ground, thereby lowering recharge rates and limiting groundwater storage. Secondly, when infiltration is limited, any rain that falls results in a rapid increase of surface runoff and high flows to rivers, whose resultant spate scours beds and banks and endangers bridges, piers and other infrastructures. Thirdly, the foundations of buildings block subsurface water flow. These three changes, reduced infiltration, increased runoff, and blockage of subsurface flow, together likely act to lower water flow to rivers, though the nature of these hydrological process needs careful quantitative studies. Specifically, there is a strong need for studies to accurately assess the degree to which unregulated construction is impacting ground- and surface-water hydrology in the valley. Such information would also provide insights into potential additional stresses on hydrologic flows resulting from climate change and increased development pressures.

The reduction of flow, due to upstream diversions and other processes described above, has altered the characteristics of riverbeds. Decreased river flow in the dry season facilitates riverbed sand mining; the Kathmandu Valley saw a surge in this activity in the mid-1980s to meet the demands of the booming construction industry. As a result, the valley's riverbeds were deepened, thereby lowering the river water level and prevented irrigation water from being diverted to higher paddy fields in the banks (Dixit, 1997). Rising land prices, fueled in part by the construction of access roads, encouraged farmers to sell land that could not be irrigated, and the further opportunity to recharge groundwater with water stored in paddy fields was lost. Later, as supplies of sand in riverbeds declined and regulations on its mining began, people turned to haphazard mining from deposits along river terraces. Unfortunately, this technique is no more environmentally friendly as these deposits fall within groundwater recharge zones, and their mining is likely to accelerate landscape degradation, further diminishing groundwater recharge, adversely affecting local agriculture and exacerbating social stress.

Since pits are in groundwater recharge zones, the mining affects the groundwater balance, with serious consequences for agriculture, drinking water supply and environmental integrity. According to Sayami (2007), 3 102 m^3 of sand is extracted daily in Kathmandu, 60 per cent from riverbeds and 40 per cent from pit reserves, many of which are in Rahultar, Jaraku, Paniyatar, Manamaiju, Baluwapati, Baniyatar, Adhikarigau, Aryalgau, Gothatar, Mulpani and other peri-urban regions (Figure 8.2).

FIGURE 8.2
Sand-mining sites in Kathmandu

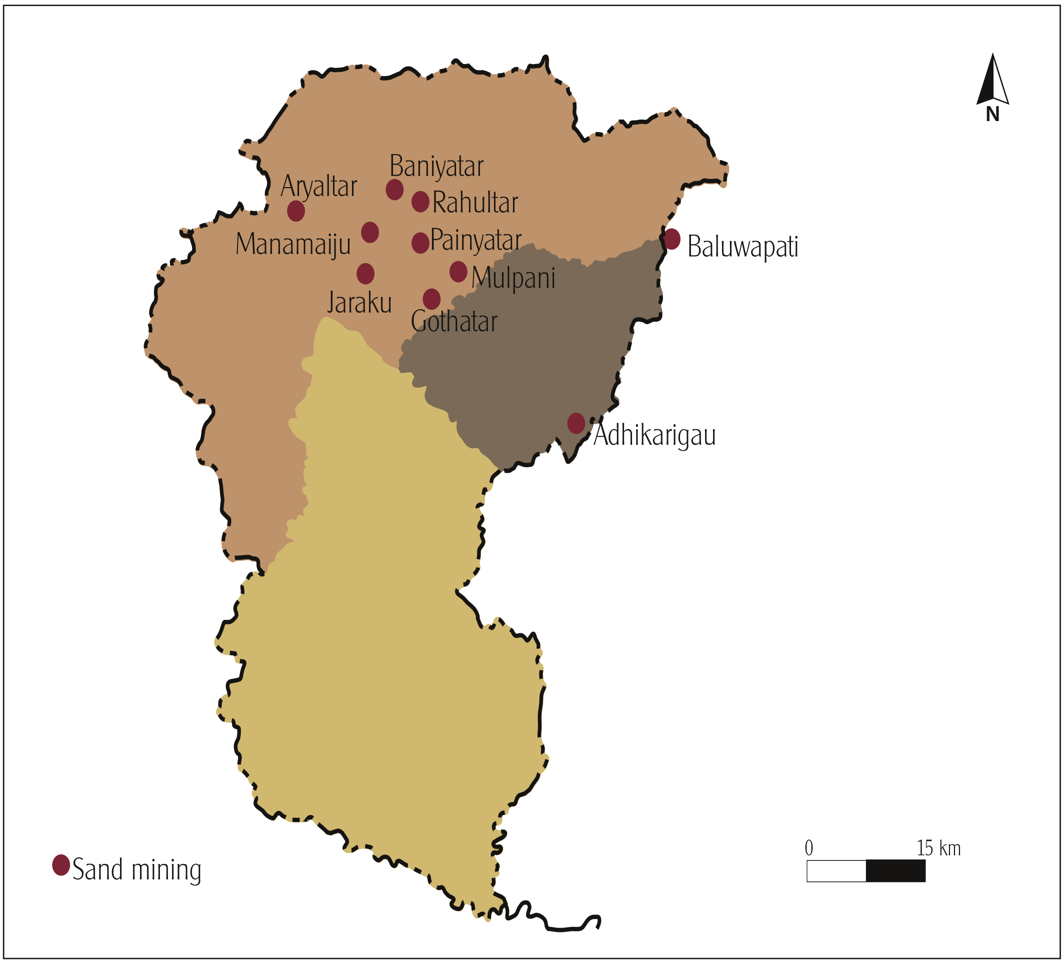


TABLE 8.1
Built-up and non-urban area in Kathmandu Valley (ha)

Type	1967	1978	1991	2000
Built-up	1 855	3 165	5 759	8 379
Non-urban	64 645	63 335	60 741	58 121

Source: Thapa and Murayama, 2008

9 Recommendations

Based on the findings of this assessment, several recommendations are provided for consideration. These recommendations are intended to advance the sustainability of peri-urban agriculture in the Kathmandu Valley and more generally the resilience of Kathmandu's food system given the high exposure to hazards in this region of Nepal.

To ensure that food supplies are less prone to interruption, investments are needed that strengthen transportation and communication systems, and that consider intensifying climate risks to infrastructure. Securing financial resources to undertake the level of investment necessary will be challenging. Besides the Kathmandu Valley (the focus of this report), there are many areas in the nation that are largely inaccessible and need basic transportation systems.

In addition to producing food, agricultural landscapes provide important environmental services for the Kathmandu Valley that need to be considered in long-term planning of this rapidly growing city. More organized spatial planning in the valley that includes agriculture and trees, and that considers the positive role that urban and peri-urban agriculture can play in serving as a sink for biodegradable urban wastes and for dampening runoff that generates flooding, will help to put the valley's development trajectory on a more environmentally sustainable path.

In order to enable a new direction for agriculture in the valley, the many operational challenges that exist, including the low capacity for and lack of incentives to pursue agriculture, the high cost of land and environmental deterioration and the increased uncertainties associated with climate change, need to be addressed. Skills both in agriculture and alternative enterprises need to be developed so that people can turn to alternative methods of farming or broaden livelihoods options outside of agriculture in order to adapt in a resilient fashion.

The transition to a resilient future requires that researchers in a variety of fields, including climate change and agriculture, build partnerships with local authorities in municipalities and Village Development Committees, as well as urban planners and real estate entrepreneurs. Such in-country partnerships will be more effective if similar alliances are established across the region, as well as globally.

Addressing the multitude of challenges facing Kathmandu's food systems and food security could, in part, be achieved by strengthening so-called soft approaches such as promoting institutional reforms and accountable governance, and building social capacity. In particular, Nepal should put in place fundamental reforms in its governance so that it can develop strategies to adapt to emerging stresses. The future requires creative approaches to reforming existing institutions, which rest on a conceptualization of resilient systems within cities.

TABLE 9.1

Suggested arenas for Intervention for UPA

Livelihood and economic diversification	Ecosystem	Organisation	Education and skill development	Financial and risk spreading	Communication for adaptation	Adapted infrastructure	Level of intervention
Risk and Adaptation Specific Intervention							
Livelihood options on non-farm activities such as organic manure production, markets, rental companies	Develop green belt, and promote community farming	Form local farmer welfare groups	Establish forum for dialogue on the role of market, availability of seeds, fertilisers Bring various stakeholders to discussion	Provide insurance and subsidy on fertilizers, seeds	Provide internet access at an affordable rate	Develop plastic ponds. Promote unused vegetables into organic manure	Government, VDC, Municipality, DDC, Private sector, households
Promoting other farming activities like fisheries, sericulture, horticulture	Introduce integrated pest management (IPM)	Information centres for farmers regarding pest, diseases, and prices and availability of agricultural goods such as fertilizers, seeds, and medicines	Practical education for the students regarding agriculture	Invest in seed storage and seed banks	Increase number of communication towers	Promote decentralised wastewater treatment plants, eco-sanitation, and drip irrigation and other technologies	Government, Private sector
Underlying systems for risk reduction and adaptation							
Augment commercial farming	Encourage agro-forestry rainwater harvesting and organic farming	Nurture new business organisations that can manage seeds and fertilisers	Awareness raising and training on IPM, use and impact of fertilisers, pesticides, and drip irrigation	Strengthen institution capacity and provide good government practices	Promote mobile phones and other devices	Promote rainwater harvesting, cold storage, milk chilling centers, fresh house, plastic tunnel system (green houses).	Agriculture service centers, government, private sector, CBOs
Enhancing livestock farming, poultry and floriculture	Preservation of local seeds to conserve biodiversity	Strengthen community based organisations	Provide quality training by agriculture service centers	Rehabilitation and management of irrigation systems	Improve accessibility to communication outlets like radio and newspapers	Help promote reliable transport systems with low carbon footprint	Government, Agriculture service centre, private sector, VDC, municipality

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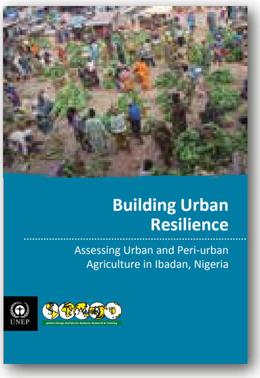
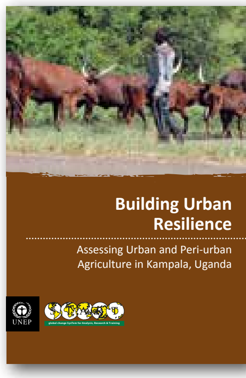
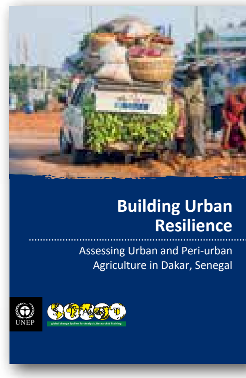
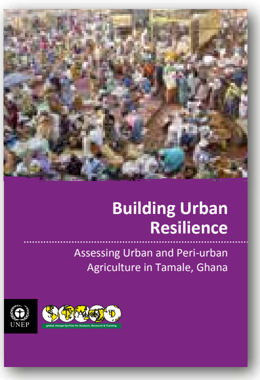
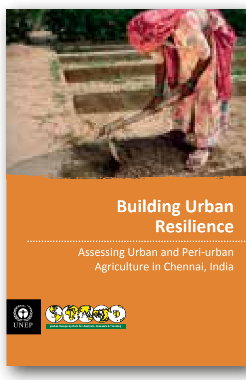
This report represents one from a series of nine city-level reports on urban and peri-urban agriculture (UPA), which together form a larger knowledge assessment. The knowledge assessment was carried out in Dakar (Senegal), Tamale (Ghana), Ibadan (Nigeria), Dar es Salaam (Tanzania), Kampala (Uganda), Addis Ababa (Ethiopia), Dhaka (Bangladesh), Kathmandu (Nepal) and Chennai (India). The nine reports and a synthesis report can be downloaded at: http://start.org/programs/upa

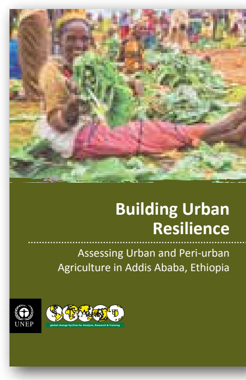


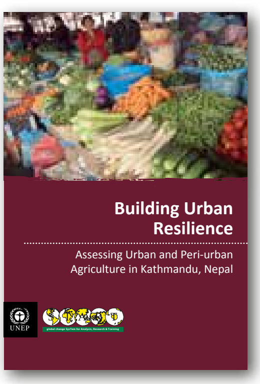


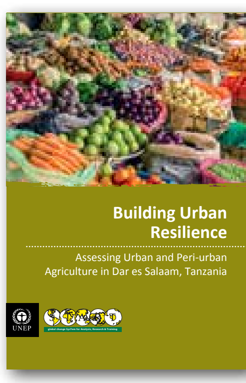


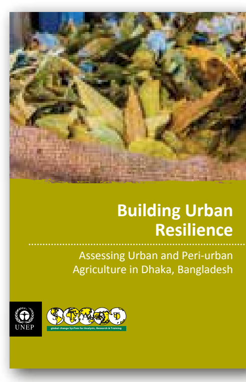












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This assessment report presents the findings of a knowledge assessment on urban and peri-urban agriculture (UPA) for the city of Kathmandu, Nepal, that was conducted in 2012. The assessment examines the state of UPA in the city through the lens of intensifying urban pressures and increasing climate risks with the objective of identifying how these and other drivers potentially interact to affect the long-term sustainability of UPA, and what response options are needed to address existing and emerging challenges.

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