Building Urban Resilience

Assessing Urban and Peri-urban Agriculture in Dhaka, Bangladesh

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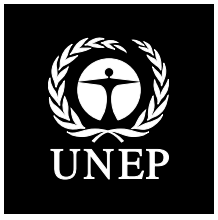

Preface

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).

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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.

In addition to the numerous authors listed in each of the separate reports, we are grateful to the following people for providing useful insights and feedback during the early conception of the knowledge assessment, and helpful review comments on the various manuscripts: Rafael Tuts, Anna Skibevaag, Stephen Twomlow, Elizabeth Migongo-Bake, Trang Nguyen, Volodymyr Demkine, Jane Battersby, Marielle Dubbeling, Anna Kontorov, Richard Munang, Jesica Andrews, Fatoumata Keita-Ouane, Jacqueline McGlade, Keith Alverson, Stuart Crane, Martina Otto, Robert Yennah, Beverly McIntyre, and Tom Downing. We would also like to express our sincere appreciation for the generous support of colleagues at the University of Cape Town's Climate Systems Analysis Group who with the climate projections for six African cities.

Acronyms and Abbreviations

BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agriculture Research Council
BBS	Bangladesh Bureau of Statistics
BMD	Bangladesh Meteorological Department
BNBC	Bangladesh National Building Code
CCCSN	Canadian Climate Change and the Scenarios Network
DAE	Department of Agricultural Extension
DAP	Detail Area Plan
DESA	Dhaka Electric Supply Authority
DMP	Dhaka Metropolitan Police
DNCC	Dhaka North City Corporation
DoE	Department of Environment
DPHE	Department of Public Health Engineering
DSCC	Dhaka South City Corporation
DWASA	Dhaka Water Supply and Sewerage Authority
FAO	Food and Agriculture Organization of the United Nations
GCC	Gazipur City Corporation
GCCP	Global Climate Change Partnership of the United Nations
GIS	Geographic Information Systems
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
LGED	Local Government Engineering Department
MLD	million liter per day
NCC	Narayanganj City Corporation
NHA	National Housing Authority
PDB	Power Development Board
PLDCs	Private Land Development Companies
PWD	Public Works Department
RAJUK	Rajdhani Unnayan Kartipakkha
RHD	Roads and Highways Department
RUAF	Resource Centres on Urban Agriculture and Food security
SMA	Statistical Metropolitan Areas
SRES	Special Report on Emission Scenarios
START	global change SysTem for Analysis, Research, and Training
UA	Urban Agriculture
UDD	Urban Development Directorate
UNEP	United Nations Environment Programme
UNISDR	United Nations Office of Disaster Risk Reduction
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UPA	Urban and Peri-Urban Agriculture
USAID	US Agency for International Development
WARPO	Water Resources Planning Organization
WHO	World Health Organization of the United Nations
WMO	World Meteorological Organization

Contents

Executive summary

This report presents the findings of a knowledge assessment on urban and peri-urban agriculture (UPA) for the city of Dhaka, Bangladesh that was conducted in 2012. It 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. The assessment is intended to:

1) describe the dominant characteristics of UPA, and identify key knowledge gaps in these UPA systems;
2) explore the array of stressors that contribute to vulnerability of UPA systems to climatic and other environmental changes; and
3) identify critical areas for strengthening policies and institutional capacities that contribute to sustaining the UPA sector within the larger context of resilient cities and food systems.

Dhaka's annual growth rate is over six per cent, one of the highest in the world. Rapid population growth and urbanization in Dhaka are creating pressure on adjacent agricultural lands, water bodies, forest areas, wetlands, as well as drinking water, sanitation and drainage facilities. Risks associated with Dhaka's unplanned urban growth are being further compounded by climate change, rapid industrialization, slum formation, and piecemeal transportation and other infrastructure.

Food production in and around Dhaka persists despite these high growth pressures. The UPA systems are quite diverse including horticulture, a vibrant fisheries and aquaculture sector, and meat and milk production. However, the sector faces substantial obstacles and challenges to its long-term sustainability stemming from haphazard urban sprawl and accompanying land-use changes, widespread pollution and other forms of environmental degradation that create health hazards for producers and consumers of food grown in and around urban centers, increasing risks to production systems and food chains from extreme climate events, and lack of visibility in urban development policies and planning frameworks. These are all critically important issues in Dhaka.

Addressing the various sustainability challenges that UPA faces requires addressing critical knowledge gaps and, in some cases, a fragmented and outdated knowledge base about UPA. This assessment attempts to redress these knowledge gaps by providing a synthesis of experience, knowledge and scientifically credible information about UPA activities in and around Dhaka, and the multi-stressor context of vulnerability facing the sector. It is hoped that the findings will stimulate dialogue within and across relevant sectors and actors and that its recommendations will inform and support more resilient urban planning that holds food security as a core concern.

As described in this report, Dhaka's UPA sector, particularly in peri-urban areas, faces pressures to abandon farming as the city continuously expands its border. The high cost of land and labor, tenural conflicts, pressure of inward migration, infrastructure and industrial development close to the city, increasing pollution loads, and flooding are major challenges for sustaining UPA in Dhaka.

1 Introduction

The world's population crossed the 7 billion mark in 2011. This historic landmark underscores the massive challenges of food, fiber, water and shelter created by an ever-increasing human population. The challenges will be greater by the middle of the current century, when the population is projected to increase to 11 billion (UNFPA, 2010). According to UNFPA projections, within the next two decades the world's urban population will increase to almost 5 billion (UNFPA, 2007). Between 2000 and 2030, urban populations in Asia and Africa are expected to double, and urban areas of the developing world will make up 81 per cent of urban humanity (UNFPA, 2007). Many of these urban centers, including Dhaka, are already mega-cities (with more than 10 million people). Growing populations in the mega-cities and urban centers are creating significant pressures on limited environmental resources.

More than one billion people in the developing world live in environmentally vulnerable areas, including urban slums, with limited access to basic health, water and sanitation services. The growing vulnerability of urban areas to environmental stresses exacerbated by climate change will further complicate the situation. Food security in rapidly urbanizing regions is emerging as a significant challenge, owing to a number of factors including intensifying climate risks to food production and to food chain infrastructure and other environmental pressures, such as declining soil productivity, abandonment of agriculture in rural areas, and migration of the agricultural labor force to urban areas and overseas.

Climate change is expected to negatively impact important cereal producing areas of Bangladesh. Bangladesh's agriculture is a key economic driver, accounting for nearly 20 per cent of the GDP and 48 per cent of the labor force. The World Bank (2009) estimates that national rice production will decline between the 2005-2050 period, and that wheat will also be negatively affected by warming trends in the winter and pre-monsoon periods.

The intertwined challenges of urbanization and climate change require new approaches for building urban resilience. Among the strategies being promoted is that of capturing the benefits of urban farming in relation to access, availability and acceptability of food, as well as interest in urban farming's potential contribution to the quality of life in urban areas. The ability of urban and peri-urban agriculture (UPA) to help address urban food needs depends on land and water resource availability, the intensity of cultivation and the extent to which these systems are vulnerable to disruption from extreme climatic events and other stresses.

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2 Objectives and methods

This assessment examines urban and peri-urban agriculture (UPA) in Dhaka in a multi-stressor context of rapid urban growth, climate variability and change, and environmental degradation. This assessment focuses on urban and in particular peri-urban environments of the city, and the farming systems – food crops, livestock and aquaculture – within them. The assessment's conceptual framework illustrates the key drivers and stressors, development factors and peri-urban products and services that were considered. The assessment framework is presented in Figure 2.1.

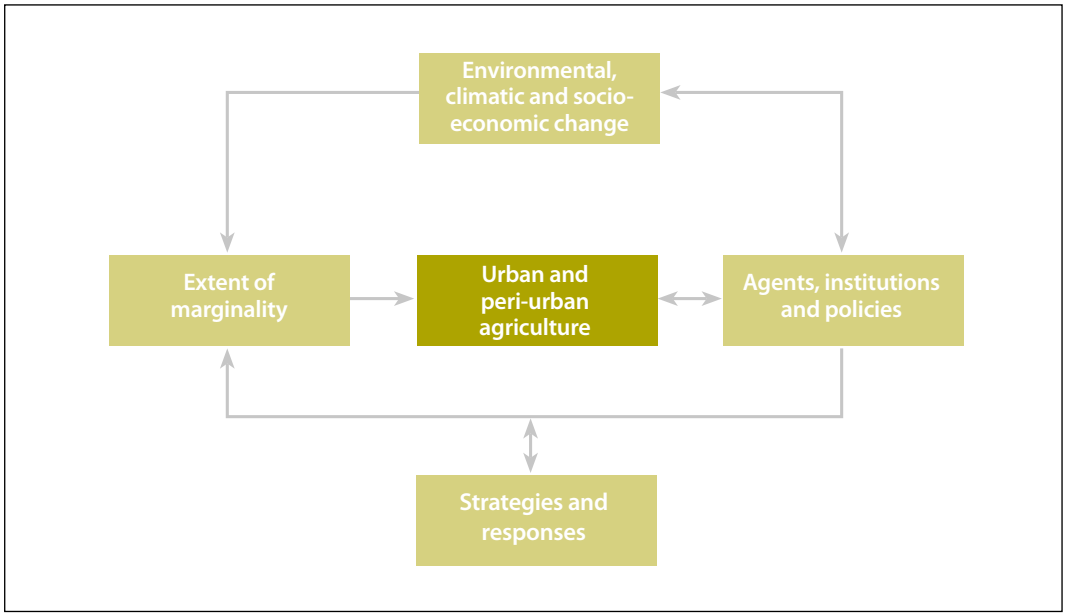


FIGURE 2.1
Conceptual framework

This assessment explores the dynamics of Dhaka's urban and peri-urban food systems, within larger, ongoing change processes. Its objectives are to:

1) Assemble and synthesize knowledge on agricultural activities in urban and peri-urban areas of Dhaka;
2) Identify where insufficient knowledge exists and highlight where additional research and assessment efforts are needed;
3) Provide relevant scientifically credible information that supports policy planning and decision-making at the city level, and that informs climate-aware development planning more broadly;
4) Build capacity of scientists within the city to undertake assessments, and foster networks of regional technical expertise, and to encourage stronger "communities of practice" engaged in the topic of urban food production and climate change.

Study area

The Detail Area Plan (DAP) for the Dhaka Metropolitan Area jurisdiction was considered in this assessment (Figure 2.2). It covers an area of 1 528 km^2, and is comprised of four city corporations (declared on 12 April 2011) viz., Dhaka South City Corporation (DSCC), Dhaka North City Corporation (DNCC), Narayanganj City Corporation (NCC) and Gazipur City Coporation (GCC).

FIGURE 2.2
Dhaka Metropolitan Development Plan: Study Area

Two upazilas (or sub-districts) of Dhaka (Keraniganj and Savar), four upazilas of Narayanganj (Sonargaon, Bandar, Narayanganj Sadar and Rupganj) and two upazilas from Gazipur district (Gazipur and Kaliganj) are in the new Detail Area Plan of Dhaka city. These upazilas are considered in the current study as peri-urban areas.

The assessment primarily focused on the synthesis of the secondary published information from peer reviewed literature, publicly available processed data, and reports and other grey literature from authentic sources. The assessment team reviewed a large volume of secondary data and information on population, land-uses, crop agriculture, aquaculture, poultry and livestock, agro-forestry, floriculture, water resources (both surface and ground waters), income, nutrition and waste management.

Agriculture and household income and inequality data were obtained from the Bangladesh Bureau of Statistics (BBS), Bangladesh Agriculture Research Council (BARC), Food and Agriculture Organization (FAO), International Rice Research Institute (IRRI), Dhaka Office. Water data was obtained from the Water Resources Planning Organization (WARPO), Dhaka WASA, the Bangladesh Agricultural Development Corporation (BADC).

Satellite images for different time-periods were purchased and processed to determine the dynamics of land-use changes (agriculture, water bodies, housing and settlements, infrastructures, etc.). Relevant data were used in the GIS tool to assess spatial trends and changes. Climatic trends data were obtained from the Bangladesh Meteorological Department (BMD), and climate change scenarios of global climate models were obtained from the IPCC 5th Assessment Report.

In order to assess the type, quantity and price of agro-products imported to the city from the urban and peri-urban areas, market analysis of the wholesale spots and interviews of whole-sellers were conducted. The BBS and other government sources do not adequately provide the precise sources of agro-food items.

High resolution GeoEye-1 satellite multi-spectral images covering Dhaka Metropolitan Development Plan area were procured for mapping the study area. Where archived GeoEye 1 data was not available, IKONOS data of similar resolution was obtained. To bring both sensors' data to a common resolution all data was resampled to .50m X .50m or 1m X 1m resolution. To facilitate analysis, all imagery data were converted to 'hdr' and 'img' formats and processed in ArcGIS, Erdas Imagine or eCognition software packages. Then radiometric correction, mosaic and sub setting of images, geometric correction, image registration and image enhancement was done for image processing.

3

Population growth in Dhaka city

Dhaka, the capitol of Bangladesh, is projected to become the world's third largest city by 2020 (Islam 2005; World Bank 2007). Globally, Dhaka was the second fastest growing megacity between 1975 and 2007 with an average annual growth of 5.65 per cent. Dhaka's urban growth rate is projected to have a slower growth rate of 2.72 per cent from 2007 to 2025 (UN 2007, UHS 2006). On a national basis, urban populations in Bangladesh have grown at an annual rate of more than three per cent since 1961, while rural populations have grown at rate of about 1.5 per cent per annually (Dutt and Noble 2004). The proportion of urban population in Bangladesh has increased from 5.2 percent in 1961 to 25.1 per cent in 2008 (BBS: 2009), and most of the urban growth is taking place in the four major cities of the country—Dhaka, Chittagong, Rajshahi and Khulna. Nearly half of the urban populations live in the agglomerations of Dhaka and Chittagong (BBS 2001; Dutt and Noble 2004). The degree of concentration of urban people is much higher in Bangladesh compared to other South Asian mega cities like Karachi in Pakistan and Mumbai, Kolkata, Delhi, and Chennai in India. Bangladesh has an estimated 42 million urban residents (UN 2011). The percentage of urban growth is increasing very rapidly and it is expected that more than 50 per cent of the population in Bangladesh will live in urban areas by the year 2025 (ESCAP 2007).

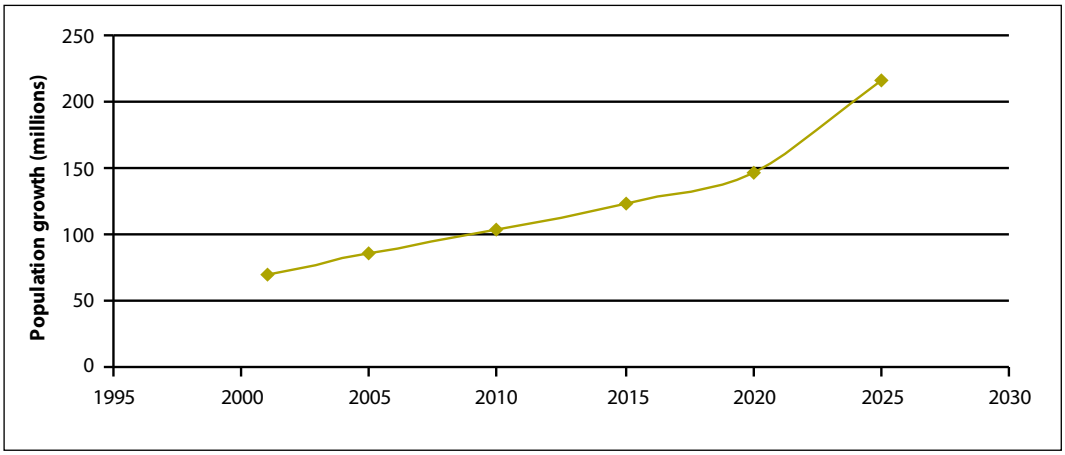
Dhaka city is the main destination for rural migrants, who respond to the population pressure and poverty 'push' factors from villages and the 'pull' provided by economic opportunities in the cities, such as in Dhaka's garment industry. As a result of this push-pull dynamic, municipal boundaries are expanding at a rapid rate, farmland is being converted for industry and settlement and administrative challenges are mounting. The situation is more serious in Dhaka as most of the urban growth is centered in and around the city (Islam 1999; BBS 2001; Rouf and Jahan 2007).

With 25 000 people per square kilometer, Dhaka City is one of the most densely populated urban areas in the world. At 15 700 people per square kilometer, the density of the Dhaka metropolitan area is higher than the density of the largest megacities in the world, such as Manila (10 550 people per square kilometer) and Jakarta (10 500 people per square kilometer) (World Bank 2013).

The extraordinary pace of urban growth in Bangladesh far exceeds economic development trajectories, leading to substantial environmental degradation and constant social tensions stemming from unemployment, poverty, inadequate health care services, poor sanitation, and urban slums. The implications of rapid urbanization and demographic trends for employment, food security, water supply, shelter and sanitation, especially the disposal of wastes (solid and liquid), are staggering. The proportion of the urban population living in the slums within the six major cities in Bangladesh ranges from approximately 20 to 40 per cent (CUS 2006). Approximately 12 per cent of the population of Dhaka city lives in slums and informal settlements (Siddique *et al.* 2000; CUS 2006) and 37 per cent in the Dhaka metropolitan areas are slum dwellers. Thus, the vast majority of slum dwellers occupy the unplanned expansion areas in the per-urban fringe (Banerjee-Guha 2010). The average

population density in the Dhaka slums exceeds 900 persons per acre or 570,000 per square mile (220 100 per square kilometers) (Demographia 2009; Banerjee-Guha 2010).

FIGURE 3.1
Projected population growth for Dhaka city
Source: adapted from Streatfield and Karar, 2008; Corner and Dewan, 2014.



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4

Land-use change in Dhaka city

Dhaka suffers from serial disasters associated with flooding, water logging and related problems. In the past, the city was regarded as the Venice of the East or the City of Channels (Dani 1962). There were many lowlands, khals and channels within and around Dhaka, up to a few decades ago, thus ensuring efficient natural drainage within the city. However, urban expansion in all directions in recent decades has resulted in shrinkage of the water bodies that support natural drainage. Unplanned urbanization, lack of coordination between government agencies responsible for monitoring encroachment, and poor maintenance of the canal system have all contributed to declining wetlands areas. Figure 4.1 shows the change in Dhaka's size over the last 400 years, indicating the accelerated expansion of the past 30 years.

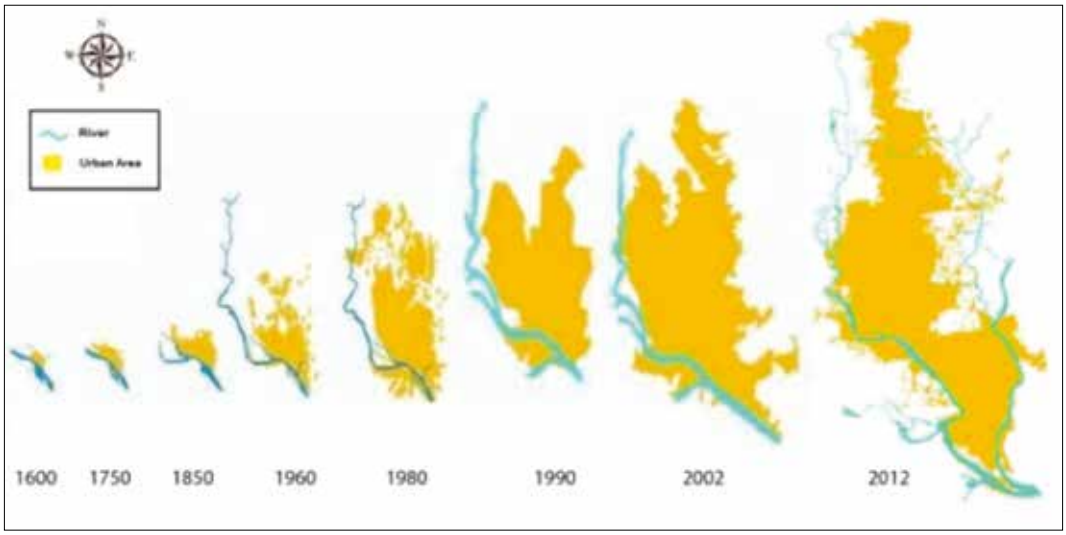


FIGURE 4.1
Aerial growth of Dhaka city 1600 to 2012
Source: Adapted from UPD 2004; Ahmed et al. 2014

The natural consequence of rapid urban growth is that peri-urban and rural lands are being converted to built-up areas. It is estimated that every year in Bangladesh more than 809 km2 of arable land is being converted for urban settlements, roads and other infrastructure (BBS 1996). Since agriculture is the base of the national economy, the loss of arable land is of significant concern in a country that has a history of high food insecurity.

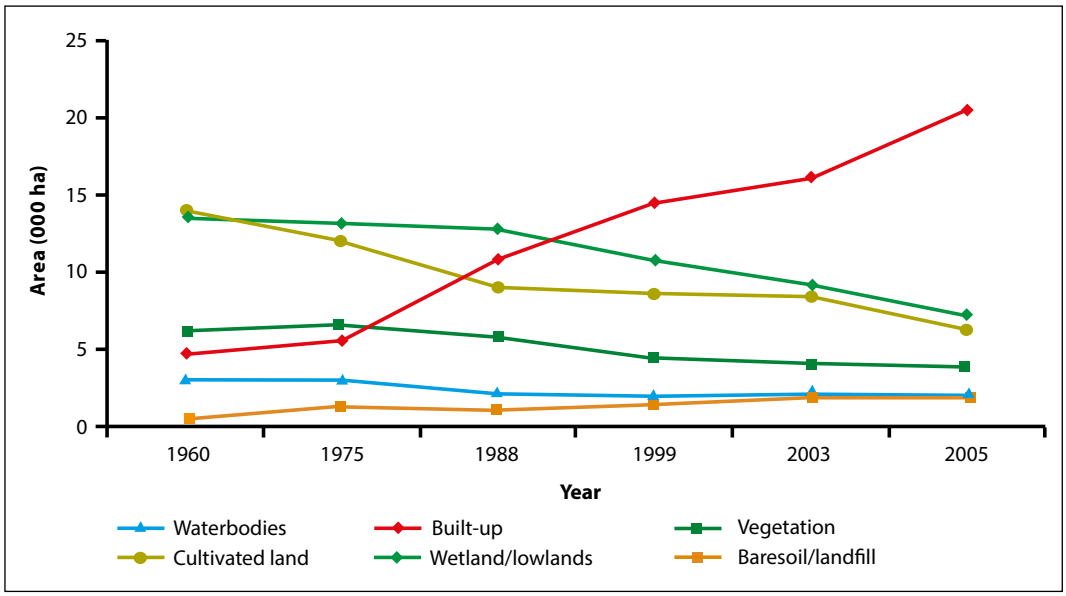
TABLE 4.1
Land use classification

Land use types	Description
Built-up	Residential, commercial and services, industrial, transportation, roads, mixed urban, and other urban
Bare soil/landfill	Exposed soils, landfill sites, and areas of active excavation
Cultivated land	Agricultural area, crop fields, fallow lands and vegetable fields
Vegetation	Deciduous forest, mixed forest lands, palms, conifer, scrub and others
Water bodies	River, permanent open water, lakes, ponds and reservoirs
Wetlands/Lowlands	Permanent and seasonal wetlands, low-lying areas, marshy land, rills and gully, swamps

Source: Dewan and Yamaguchi 2009

An examination of land use changes that have occurred over the last several decades clearly demonstrates the substantial loss of natural lands to urban expansion (Figures 4.2, 4.3, and 4.4). In Figure 4.2, spatial patterns of land use/cover change in the Dhaka study area for 1975, 1988, 1999 and 2005 reveal that low lying areas, cultivated lands and vegetation were the dominant cover in 1975 and the direction of urban development (collectively termed as 'builtup') confined to the north of the city. However by 1988, built-up land cover replaced cultivated land of the then fringe zone. The trajectory of urban development extended to further north and north-west between 1975 and 1988, when road transportation from Dhaka to the hinterland was provided by constructing bridges on the rivers (Islam 1996). Land utilization statistics of Dhaka region for the 2005-2009 period indicates that the net cropped area has increased slightly despite the fact that agricultural land is under pressure from urban expansion. However, the increase in agricultural land area is negligible and may be due to the increase in cropping intensity and decrease in fallow lands.

FIGURE 4.2
Temporal pattern of land use/cover change for Dhaka
Source: adapted from Dewan et al. 2010



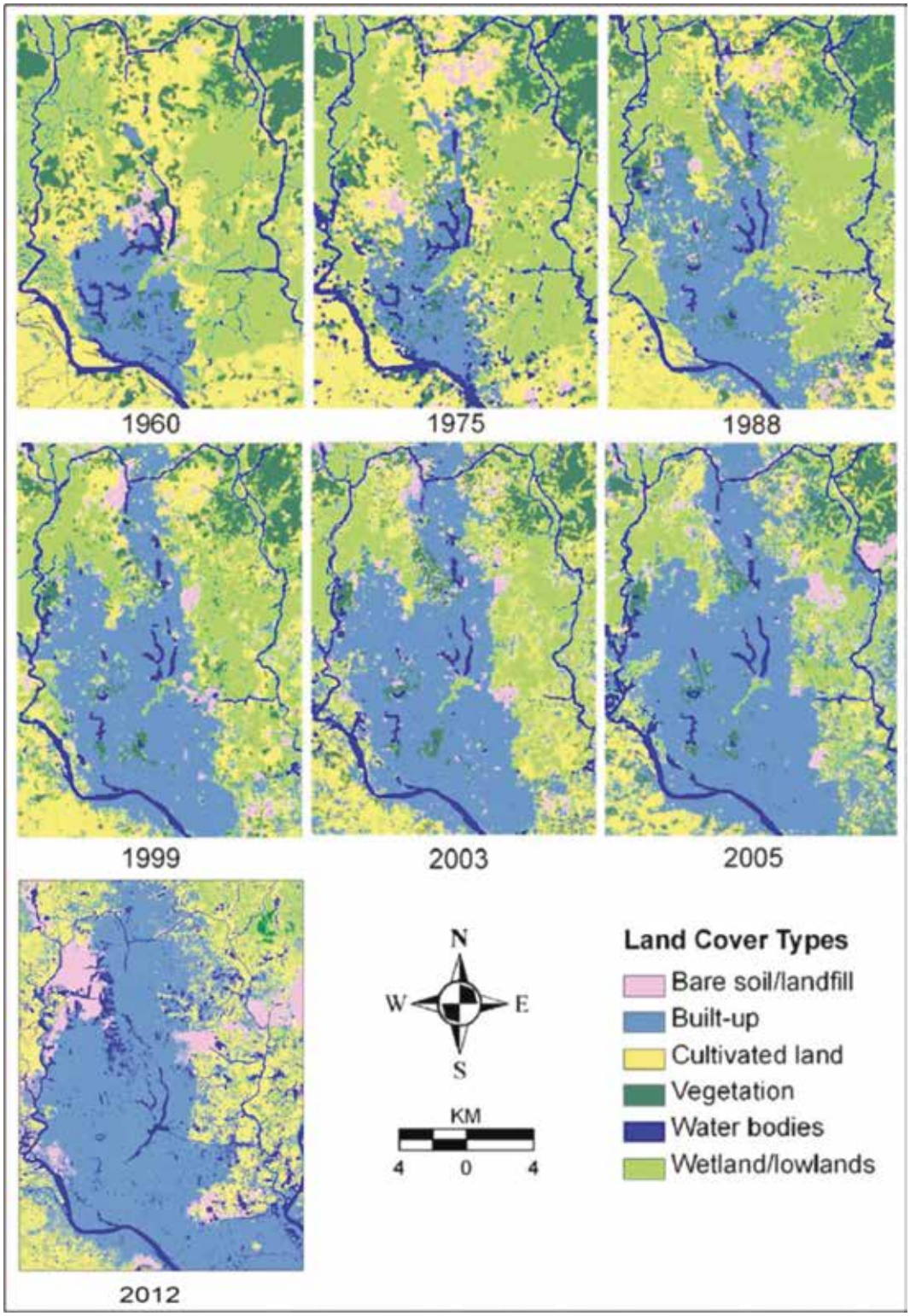
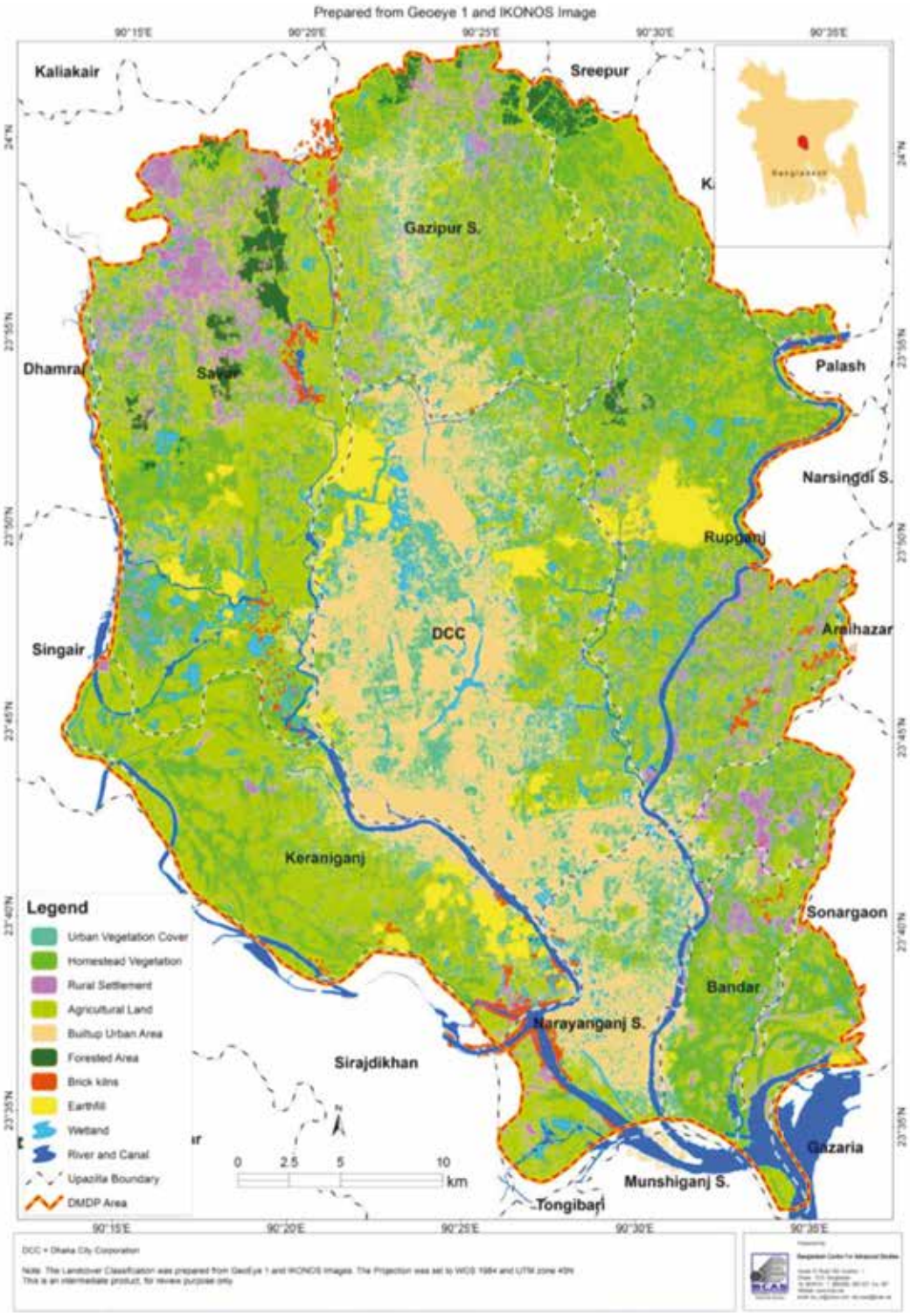


FIGURE 4.3
Changes in land cover types for Dhaka, 1960-2012

Source: Dewan and Yamaguchi, 2009

FIGURE 4.4
Land-cover map of Dhaka metropolitan development area, 2011-2012
Source: BCAS 2012



Loss of wetlands areas in greater Dhaka

Large-scale encroachment of water bodies and associated wetlands has occurred in response to the escalating price of land combined with weak enforcement of land-conversion regulations. Wetlands in the eastern and western parts of Dhaka are under particular pressure from urban encroachment (Sultana 2005).

The first step of encroachment involves building structures along the banks of wetlands, and out into the wetlands, by fixing bamboo posts upon which are constructed huts and shops. Then the owners of these structures slowly start to reclaim land by land filling or sometimes by dumping garbage. Filling in of wetlands occurs when the final elevation of the site is raised by using earthen or other miscellaneous material to fill in the area of a wetland (Nakashima *et al.* 1994). Rivers are also encroached in the same way by deliberately filling up of the water body and then claimed as private property (Khuda 2001). This is a common practice in Dhaka for providing new sites for urban expansion. There are a large number of land development companies who are involved in this kind of encroachment.

Private development companies earth filling in Dhaha's Badda © Abu Hayat Mahmud

Although there are laws to protect against this practice, the Private Land Development Companies (PLDCs) are implementing housing projects in low lying areas without consideration of these laws, and are in conflict with government agencies. RAJUK (Rajdhani Unnayan Korporation-Capital Development Corporation) is the key organization for the implementation of public sector housing projects. But they too flout the laws meant to protect wetlands. The total area of water bodies and lowlands has shrunk by approximately 33 and 53 per cent, respectively between 1960 and 2008 (Table 4.2). Figures 4.5 and 4.6 illustrate areas of wetland loss in greater Dhaka.

TABLE 4.2
Changes in water bodies and lowlands, 1960-2008

Categories of land use/ cover types	Area in 1960	Area in 1988	Area in 2008	Changes in area 1960-1988	Change (%)	Changes in area 1988-2008	Change (%)	Changes in area d 1960-2008	Change (%)
Water bodies	2952.02	2103.62	1990.71	-848.40	28.74	-112.91	5.37	-961.31	32.57
Lowlands	13527.58	12717.73	6414.57	-809.85	5.99	-6303.16	49.56	-7113.01	52.58

Source: Author team; data compiled from government statistics

FIGURE 4.5
Earth filling in Badda, Dhaka

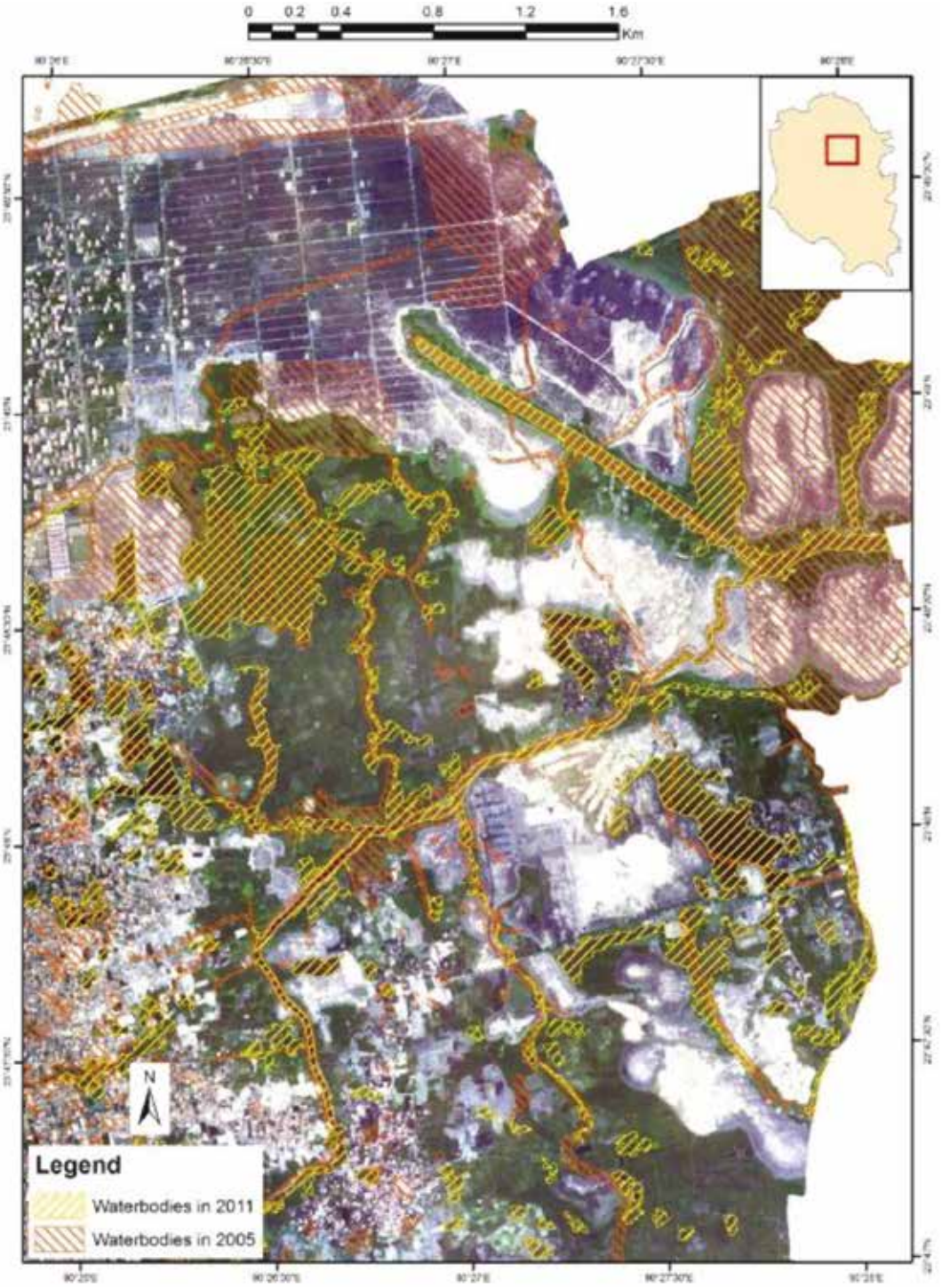


FIGURE 4.6
Change in water bodies in one area of peri-urban Dhaka

5 Climate trends and projections

Temperature and rainfall trends

Meteorological data obtained from the Bangladesh Meteorological Department were used to analyze temperature and rainfall trends for Dhaka for the 30-year period of 1978 to 2007, based on the four distinct climatic seasons of Bangladesh. These four seasons are pre-monsoon (March to May) with high temperature and high evaporation rates, monsoon (June to September) with high intensity rainfall, post-monsoon (October to November) characterized by hot and humid conditions, and winter (December to February), which is the driest and coolest time of the year.

The analysis of climate trends reveals that, overall, maximum temperatures are increasing very slightly for all seasons except winter, while minimum temperatures are increasing in all seasons except the monsoon. However, there is substantial variability in the data sets and none of the temperature changes are statistically significant. Decadal rainfall data indicate a slight reduction in pre-monsoon and winter rainfall and a slight increase in rainfall during the monsoon and post-monsoon seasons. However, there is high inter-annual variability in rainfall, making it impossible to detect any actual trends.

FIGURE 5.1
Average Annual Maximum Temperature
Source: Bangladesh Meteorological Department

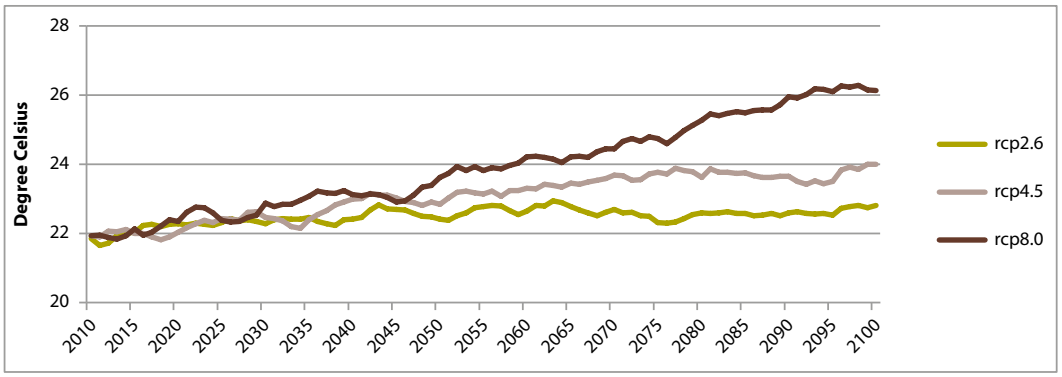


FIGURE 5.2
Average Annual Minimum Temperature
Source: Bangladesh Meteorological Department

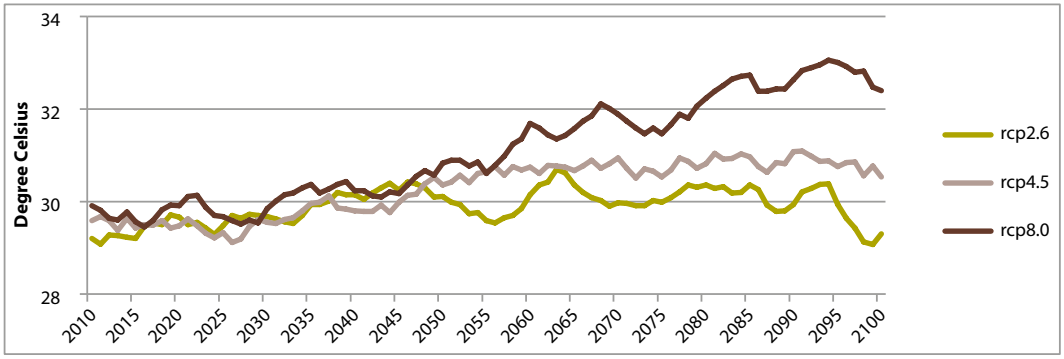
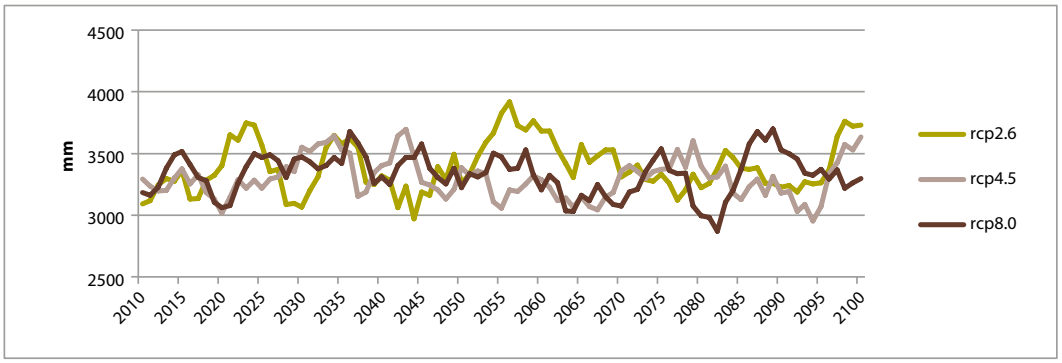


FIGURE 5.3
Total Annual Rainfall
Source: Bangladesh Meteorological Department



Temperature and rainfall projections

Projections based on different scenarios of the Special Report on Emission Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC) indicate that warming will accelerate over the course of this century, resulting in projected mean annual temperature increases for Bangladesh of 0.9-2.6°C by the 2060s and 1.3-4.1°C by the 2090s (Figures 5.1 and 5.2) depending on the scenario used. There is no perceptible change in projected total annual rainfall.

Extreme events

Extreme climatic events are a defining characteristic of life in Bangladesh. Dhaka is no exception due to its low and flat topography (average ground elevation of 0.5-12 meter) and close proximity to the Buriganga, Turag, Balu and Shitalakkhya rivers that ring the city. The city experiences flooding on an annual basis and was affected by severe floods in 1954, 1955, 1970, 1974, 1980, 1987, 1988, 1998 and 2004 (Yahya et al. 2010). The 1998 flood was particularly bad, with the eastern part of Dhaka (nearly 119 square kilometers) completely inundated. This devastating flood caused damage to approximately 860 550 households in the Dhaka Metropolitan Area, at a cost of US$ 30 million, and more than 600 kilometers of road were damaged. The total loss to large-scale industry in Dhaka exceeded US$ 30 million while the loss to small and medium size industry including agro-based industries was US$ 36 million (Alam, 2007). Although there was no specific data on damage to crop, livestock, poultry and fisheries in Dhaka during 1998 flood, it can be easily assumed that all of these sub-sectors faced severe damage.

The intensity and frequency of flood incident in the Ganges-Brahmaputra-Meghna river basin is expected to increase as a result of climate change. Kamal et al. (2013) and Mirza et al. (2003) estimated that increases in future peak discharge associated with climate change will intensify flooding in Bangladesh, especially in the flood-prone areas of central Bangladesh, including Dhaka, and northeastern Bangladesh. In addition to water logging, the Dhaka region also has a high risk associated with inland and river flooding (e.g. Ahmad et al. 2001; Brammer, 2004; Braun and Shoeb 2008; Dewan et al., 2007; Islam, 2005, MünchenerRück, 2004; Rashid, 2000), which further contributes to the problems faced by the city's population.

6

Urban and peri-urban agriculture in Dhaka

Despite significant urban pressures on the land base, a sizable area of Dhaka and its periphery are still engaged in agricultural pursuits. For example, the metropolitan area of Tejgaon has 38 per cent of the land available for agriculture, while Mohammadpur and Gulshan have only 4 to 5 per cent of land available for agriculture.

In the periphery of Dhaka city, urbanization has not yet engaged a sizable land area for settlement and infra-structural development (Table 6.1). Natural forest cover is quite negligible with the exception of GazipurSadar, which has 5 452 hectares of land under forest cover, while the rest of the upazilas (sub-districts) including Dhaka metropolitan city, forest cover ranges land area of 0-7 hectares only.

TABLE 6.1
Agricultural land area in the Dhaka region

District	Upazila	Total Area (ha)	Total Agricultural Land Area (ha)
Dhaka	Savar	28013	17580 (63%)
	Keraniganj	16697	9510 (57%)
Gazipur	Kaliganj	15900	14508 (91.25 %)
	GazipurSadar	44600	18405 (41.27%)
Narayanganj	Rupganj	17618	13448(76.33 %)
	Sonargaon	17166	11317 (65.6%)
	Bandar	5115	3707 (72.5%)
	NarayanganjSadar	10080	3752 (35.24%)

Source: Census of Agriculture 2008, Bangladesh Bureau of Statistics
Note: Figures in the parenthesis indicates % of agricultural area on total area

Crop production systems in peri-urban Dhaka still maintain important characteristics of rural areas. Here, the main agricultural crops are rice, jute, wheat, sugarcane, vegetables, oil seeds, tobacco, spices etc. Rice is the dominant agricultural crop. Among rice crops, Boro (irrigated winter rice) covers the largest area and production that is followed by Aman (monsoon season) and Aus (pre-monsoon) rice (Census of Agriculture 2008). There are three cropping seasons Kharif 1 (April-July), Kharif 2 (July-December) and Rabi (December-May) during which an array of crop rotations are practiced (table below). Despite the ample rains that the Dhaka area receives, adequate water resources are a major concern for urban and peri-urban agriculture (Box 6.1).

TABLE 6.2.
Major Cropping Patterns in Agricultural Land of the Study Area

Name of the Area	Major Cropping Patterns
Urban Area	Boro-Fallow-Fallow Fallow-Fallow-Transplanted Aman Vegetables-Fallow-Transplanted Aman Cauliflower-Boro-Red Amaranth Vegetables (e.g. Cabbage)-Boro-Fallow Tomato-Boro-Fallow Cauliflower/Cabbage –Stem Amaranth –Red Amaranth Beans-Stem Amaranth-Red Amaranth
Peri-urban area	Boro-Fallow-T.aman Boro-Fallow-Fallow Mustard-Boro-T.aman Boro-Aus-Aman Boro-Vegetables-Fallow Vegetables-Vegetables-Vegetables Flowers-Flowers-Flowers Fruits-Fruits-Fruits Mustard-Boro-Broadcast Aman Boro-Broadcast Aman Boro-Vegetables-Transplanted Aman Potato-Broadcast Aman Wheat/Vegetables-Jute-Late Aman Rabi vegetables-Transplanted Aman Tomato-Okra-Sponge gourd Brinjal,-Ridge gourd- Bitter gourd Beans-Red amaranth-Okra Radish-Stem amaranth-Bitter gourd Boro-Fallow-Fallow Boro-Fallow-Transplanted Aman Vegetables-Vegetables-Vegetables Boro-Transplanted Aus-Fallow Mustard/Boro-Fallow-Fallow Mustard-Fallow-Transplanted Aman Year round local sugarcane Boro-Broadcast Aman-Fallow Boro-Fallow-Fallow Mustard-Boro-Fallow Pulses (lentil)-Broadcast Aman-Fallow Potato-Jute-Fallow Vegetables-B roadcast.Aman-Fallow Vegetables-Green manure (dhaincha)-Fallow

Source: Metropolitan Agricultural Offices, Dhaka City and Upazila Agricultural Offices, Department of Agricultural Extension (DAE), January 2012

Box 6.1. Water security in Dhaka

Dhaka is facing significant challenges with respect to groundwater resources. The Bangladesh Agricultural Development Corporation (BADC) conducted a survey on supply and demand of water in Dhaka over the 2005-2010 period. BADC found that ground water levels in Dhaka have fallen by nearly 15 meters, from 54 meters to 69 meters, over this period. In another study, Baten and Uddin (2011) projected that at a depletion rate of 2.81 m/y, the groundwater table will go down to 120 meters by 2050. The drop in groundwater levels is compounded by increased urbanization, illegal occupation, and encroachment that reduce the quantity and quality of surface water bodies around the city (Baten and Uddin 2011).

Diminished groundwater resources will exacerbate water shortages. According to the Dhaka Water Supply and Sewerage Authority (DWASA), there is presently a 500 million liter per day (MLD) gap between demand and supply of water. This gap will increase with increasing population and land use change pressures in Dhaka. Bate and Uddin (2011) projected the demand and supply of water up to 2050 under three scenarios. The worst-case scenario indicated a gap of 2 451 MLD, the middle scenario a gap of 1 012 MLD, and the best-case scenario, which assumed only 10 per cent unaccounted for water and 10 per cent system loss (where the current unaccounted for water is 31.68 per cent and current system loss is 30 per cent), projected a gap of 704 MLD.

The situations of current and future water supply have negative implications for UPA production, particularly given that agriculture is viewed as an afterthought in urban planning. The water trends and projections presented above clearly demonstrates that ensuring a regular supply of water for UPA from groundwater sources is going to be quite difficult in the coming decades. Temperature rise and irregular patterns of precipitation will worsen this situation. While use of wastewater for irrigation could mitigate water shortages for UPA, the current potential of wastewater reuse is poor. In Dhaka, wastewater is not readily available to urban farmers because sewage systems are designed to remove sewage from the city, not to reuse it locally. Moreover, because of rapid urbanization and encroachment of water bodies, surface water is also becoming scare for use by UPA, which is compounded by the unwillingness of Dhaka City authorities to make provisions for reuse of surface water in agriculture. The lack of access to alternative sources of water sometimes compels urban farmers of Dhaka to use illegal sources.

Rice Production and Supply for Dhaka City

Total rice production in the Dhaka metropolitan area was 0.23 million metric ton in 2010-2011, which is a fraction of the 2.19 million metric ton of rice that the population of Dhaka required that year (BBS 2011). Dhaka receives the bulk of its rice from other rice producing areas of the country. Assuming the rate of production of rice was to remain constant, the rice deficit in Dhaka is expected to increase significantly over the next decade and create additional pressure on national production to meet the rice needs of Dhaka.

Vegetable Production and Supply for Dhaka City

Bangladesh's climate and soils are suitable for growing more than 100 different kinds of vegetables. About 60 per cent of vegetables are grown in the winter season (October-March) and remainder in the monsoon and post-monsoon season (April-September). During the last five years, total

vegetable production has increased. Peri-urban areas of Dhaka, districts outside of Dhaka and urban households produce vegetables for the city. No statistics are available as to the relative importance of each source to the city's overall vegetable supply.

In spite of wide variety of vegetables and increasing production, the country is still unable to satisfy the minimum daily requirement of 200 g/day/person. The consumption of vegetables is only about 25 per cent of the daily requirement (national production of 3 million MT with estimated requirement of about 12 million MT).

TABLE 6.3
Projected Vegetable Requirements for Dhaka City

Year	*Population (Million)	Vegetable requirements per day (MT)	Vegetable requirements per month (MT)	Vegetable requirements per year (million MT)
2010	14.63	2926	87780	1.05
2015	16.84	3368	101040	1.21
2020	19.42	3884	116520	1.40
2025	20.90	4326	129780	1.56

Source: Bangladesh Bureau of Statistics

Vegetables, like other major crops in Bangladesh, faces constraints stemming from loss of cultivatable land, soil degradation, pest and disease pressure and climate risks. Strategic interventions for increasing vegetable production span rural and urban/peri-urban production systems. Such interventions include:

i. *Diversify away from rice production:* At present, rice cultivated area covers about 80 per cent (11.53 million ha) of the country's total cropped area of about 14.42 million ha (Bangladesh Bureau of Statistics & Department of Agricultural Extension 2011). If five per cent of total cropped area for rice is reduced by intensifying rice production through the adoption improved open-pollinated varieties or hybrids, integrated nutrient, pest and water management, then 0.72 million ha may be released to grow vegetables and other crops.

ii. *Promote IPM:* Pests (weeds, insects and diseases) cause average losses of vegetables of around 40 per cent, which could be decreased through varietal resistance and other integrated pest management practices (e.g. sex pheromone, bio-pesticides etc.). IPM research on vegetables is lagging that of cereal crops. Yield potential of vegetable crops could also be improved by developing improved varieties including hybrids and increasing access to irrigation.

iii. *Develop location specific production technologies* for hilly, char land and the saline belt.

iv. *Reduce post-harvest losses:* On average, the post-harvest loss of vegetables in Bangladesh is about 26 per cent, which could be reduced through investments in improved handling, packaging, storage and transportation systems. (Source: Supply Chain Development Component (SCDC) of National Agricultural Technology Project (NATP), Hortex Foundation, Dhaka)

v. *Promote rainy season/aquatic vegetables like Ipomoea reptans L., Nymphaeastellata, Otteliaalismoides, Enhydrafluctuans* etc., and protective culture to grow vegetables during summer-rainy seasons.

vi. *Strengthen rural/urban homestead gardening and rooftop gardening.*

vii. *Strengthen the extension activities* of vegetables production and marketing by improving the capacity of farmers and traders.

Table 6.4 illustrates the significant yield gap that exists in vegetable production in Bangladesh. Technological interventions in production, as described above and efficient supply chain management systems could help to narrow this yield gap. In Dhaka, the production environment has a blend of favorable and unfavorable factors. Favorable factors include land suitability, easy access to farm inputs and markets, strong communications network, availability of better extension services (relative to rural areas) and opportunities to get high market prices. Unfavorable factors for vegetable production include hot, wet and foggy weather, high levels of environmental pollutants, tenurial conflict and increasingly limited access to land and water resources as Dhaka City expands.

TABLE 6.4
Present and Potential Yield of Some Major Vegetables in Bangladesh

Name of the Vegetables	*National Average Yield (MT/ha)	**Potential Yield (MT/ha)
Eggplant	7.51	43
Tomato	7.98	80
Cauliflower	9.59	28
Cabbage	13.19	65
Hyacinth bean	5.33	16
Radish	9.58	78
Pumpkin	8.81	30
Bottle gourd	9.63	60
Bitter gourd	4.62	28
Yard long bean	5.15	18
Okra	4.15	16
Pointed gourd	7.79	38
Teasle gourd	5.40	38

Sources: *Yearbook of Agricultural Statistics of Bangladesh, BBS (2010); Bangladesh Agricultural Research Institute (BARI), 2009

Box 6.2. Rooftop urban agriculture

Urban dwellers grow horticultural crops at homesteads and on rooftops, balconies, vacant commercial/residential plots, road strips, railway side spaces etc. They use both traditional and improved technologies for the crop production, and food is primarily grown for household consumption. Rooftop gardening is increasingly being viewed for its potential to address vegetable and small livestock needs for urban dwellers.

A study by Kabiret *et al.* (2011) showed that Dhaka has roughly 10 000 km^2 of 'bright' rooftops within the Dhaka City Corporation (DCC) ward, which are vacant and unproductive, and could be used for local food production. A community approach (self-help basis) rearing of goats and pigeons on the rooftop has been ongoing for years in Dhaka with the aim of building community and strengthening local economies. Rooftop gardening has the potential to efficiently reuse wastewater.

Fisheries

Fish area a major source of protein in Bangladesh. Fisheries in Bangladesh are comprised of inland capture fisheries in rivers, canals, depressions (beels/haor), large lake and seasonal flood plain; aquaculture in ponds and impoundments; and marine fisheries in the Bay of Bengal. Aquaculture is rapidly expanding in response to the high demand for fish products, particularly in the cities, and the ready availability of technology and suitable production environments.

Inland Capture Fisheries (Open Water)

There are several inland fisheries in close proximity to Dhaka. The main rivers in urban and peri-urban Dhaka are the Buriganga, the Shitalakshya, the Dhaleshwari, the Turag and the Balu. Among them the Buriganga, the Turag and the Balu are highly polluted with industrial effluents. There are also many other small rivers in the peri-urban areas such as the Bangshi, Menikhal, and the SonargaonUpazilais partly bisected by the Meghna and the Brahmaputra rivers. The floodplains of these rivers are inundated seasonally during monsoon months and become good sources of fish production. In addition, there are beels (depressions) and canals in the peri-urban areas for fish production.

Open water fisheries in Dhaka City and its surrounding areas are facing a variety of challenges. During the early 1970s, inland open water capture fisheries contributed about 90 per cent of total fish production, whereas in 2007–08 it contributed only up to 41 per cent, a marked decline due to environmental degradation and species depletion. Among the 260 fin-fish species, about 143 are termed as small indigenous species, which were abundantly available in the past. However, because of habitat destruction and overfishing, most of those species are no longer available in the markets. Meanwhile, 21 fish species have become extinct in Bangladesh, and 54 have been listed as critically endangered and vulnerable in the red book of IUCN (2000).

Carp, including major carps, large catfish and large fish in general, have significantly declined in abundance. Migratory *hilsa* used to dominate the river catch in terms of both value and production. This is no longer the case as water pollution, loss of water flow and heavy fishing of juvenile stocks have led to the disappearance of riverine *hilsa* in peri-urban areas. Smaller Koi (*climbing perch*), snakeheads, other catfish and beel resident species with the ability to tolerate low oxygen levels, comprise a significant proportion of the catch. In some of the smaller beels and enclosed floodplain areas stocking takes place, and in these systems the proportion of major carps, silver carp, common carp and grass carp is significant. Other important species consist of *Clupisomagarua, Pangasisuspangasius, Puntiussophore, Glossogobiusgiurus, Aorichthysseenghala, Labeorohita, Catlacatla, Wallaguattu, Mystuscavasius* and *Macrobrachium spp.*

Inland Culture Fisheries (Aquaculture)

Increasing demand for fish in Dhaka's markets has encouraged the expansion of peri-urban pond aquaculture in the last decade. Aquaculture systems generally use free water sources, but some receive commercial irrigation or hire irrigation equipment. Rice-fish culture (either rice and fish together or rice followed by fish) on seasonal farmland is becoming increasingly common in peri-urban areas of the city. Cage and pen culture is rare in peri-urban Dhaka, though Islam *et al.* (2004) reported that cage and pen culture in floodplains were evident in and around Dhaka city. Income generating activities associated with aquaculture are also increasing in peri-urban Dhaka. Based on data collected from Upazilla Fisheries Offices during 2012, in the nine Upazillas (Savar, Keraniganj, NarayanganjSadar, Sonargaon, Rupganj, GazipurSadar, Kaliganj, Kaliakoir and Bandar) under the UPA study area, 185 fish nurseries occupying 167 hectares land have been established. They supply fingerlings to the traditional and commercial culture farms. These farms produced some 121 million fingerlings (Schultz, 2012).

The pond area under domestic production is nearly 10-times greater than that of the commercial area (Table 6.5). The lagging commercialization of aquaculture is due to higher population densities and scarcity of sufficient land area (Islam *et al.* 2004). Aquaculture activities are also found within the Dhaka Metropolitan Area. Urban water bodies encompass about 950 hectares, and include several lakes, government and private ponds.

TABLE 6.5
Aquaculture production of different periphery upazillas (sub-districts) of Dhaka city during year 2010-2011 (July 2010 to June 2011)

	Domestic Pond		Commercial Pond		Total
Upazila	Area (ha)	Production (tons)	Area (ha)	Production (tons)	Production (tons)
Savar	538.8	1754	-	-	1754
Keraniganj	93.9	300	4.5	15	315
NarayanganjSadar	542.55	2355	-	-	2355
Sonargaon	287.5	860	-	-	860
Rupganj.	191.3	493	33	121.5	614.5
GazipurSadar	1204	4042	61.28	172	4214
Kaliganj	616.16	2075	68.3	240	2315
Bander	8	8.5	201.88	449.9	458.4
Total	3482.21	11887.5	368.96	998.4	12885.9

Source: Upazilla Fisheries Offices, 2012

Output of fresh fish from aquaculture is expected to rise 2.77 per cent per year in Bangladesh, (Dey *et al.* 2008) resulting in aquaculture production from urban and peri-urban Dhaka increasing to about 26 700 metric tons by 2025. The increasing productivity from aquaculture will help to offset the decline in capture fisheries, which are expected to produce less than 30 thousand metric tons by 2025. Trends in capture fisheries (usually zero growth or modest declines) will not unduly endanger overall fish supplies. However, the decline of capture fisheries can be a cause for concern given the potential repercussions for fish consumption.

Islam *et al.* (2004) estimated that approximately 7 to 10 per cent over the 100 000 tons of fresh fish sold in the markets of Dhaka city annually come from peri-urban areas. However, distribution and marketing networks for fish within Dhaka are very complex and this estimate does not capture the fish trade that occurs in the informal market. All the selected upazillas except the Kaliakoir of Gazipur and Bandar of Narayanganj district produce less fish than demand. High-value fish from peri-urban areas such as carp, and catfish are sold to affluent people, while a diverse mix of lower quality fish are sold to middle and low income groups.

Climate Change and Fisheries Productivity

Climate change will cause increased water temperatures and amplify effects of decreased dissolved oxygen levels and the increased toxicity of pollutants on aquatic species (Ficke *et al.* 2007). Such changes could potentially affect freshwater fisheries in Bangladesh, including the UPA study area, in several ways. Firstly, reduced concentrations of dissolved oxygen will negatively affect fish metabolism. Secondly, fish will become increasingly susceptible to diseases and parasites to the extent that their immune systems are already weakened by warm water and low oxygen. Moreover, toxic algae growth in warm water can lead to massive fish die-offs. Thirdly, rising temperature can reduce hatchery based seed production in Bangladesh. As Indian and Chinese carps are the main contributors to

the aquaculture production in Bangladesh, dependency on hatchery-based seed production of these species could be significantly affected by rising temperatures. While the impacts of climate change on crops have been modeled in Bangladesh, modeling of fisheries is yet to be carried out. This is an important knowledge gap. Despite significant knowledge gaps about future change, a pro-active, no-regrets adaptation planning would make Bangladesh better equipped to address future climate change impacts on the fishery sector.

TABLE 6.6
Climate change related impacts and potential adaptation measures in aquaculture

Climate Change Element	Impacts on aquaculture or related function	Adaptation measure
Warming	Raise above optimal range of tolerance of farmed species	Better feeds; more care in handling; selective breeding and genetic improvements for higher temperature tolerance (and other related conditions)
	Increase in growth: higher production but quality deteriorates	Increase feed input, adjust harvest and market schedules
	Eutrophication and upwelling: mortality of farmed stock	Better planning: consideration of climate extremes impacts in siting production sites, regular monitoring, develop emergency responses
	Increase virulence of dominant pathogens and expansion of new and existing diseases	Better management to reduce stress; monitoring to better manage disease and parasite risks; improved treatment strategies; genetic improvements of higher resistance
Water stress and drought conditions	Limitation for freshwater abstraction	
	Water retention period changed (reduced in inland systems)	Improve efficacy of water usage; encourage non-consumptive water use in aquaculture; encourage development of mari-culture where possible.
	Availability of wild seed stocks reduced/period changed	Shift to artificially propagated seed (extra cost), improve seed quality and production efficiency, close the life cycle of more farmed species
Extreme weather events	Acute aquaculture losses through severe damage of dykes, hatcheries, nurseries, embankments, ponds etc. Loss of stock; mass scale escape with the potential to impacts on biodiversity	Encourage uptake of individual/group insurance; improve siting and design to minimize damage loss and mass escapes, encourage use of indigenous species to minimize impacts on biodiversity, use non reproducing stock in farming systems

Source: Mustafa 2010

In addition to these technological options for supporting adaptation, there are a number of policy responses that could strengthen the sector in the face of climate change and other stresses. These include:

- Increased credit access for resource-poor processors and producers;
- Adoption of community-based or collective action approaches in the management of fishery resources, as well as in other commercial aspects of fishing, i.e., in fish trade and marketing;
- Rigorous implementation of other management measures in capture fisheries such as protection and restoration of critical habitats, removal of excess fishing capacity, restrictions on potentially destructive gears, and provision of alternative livelihoods for small fishers;
- Infrastructure development for improved marketing of fish; promotion of investments in hatchery and input distribution systems for the sustained and widespread dissemination of quality fingerlings;
- Increased investments and quality of extension to reduce technical inefficiencies in fish culture;
- More research to increase productivity of priority species, e.g., selective breeding of carp, as well as the development of technologies to reduce costs of fish farming (e.g., low input systems, alternative feeds).

Livestock in urban and peri-urban Dhaka

Poultry and Dairy

Poultry and dairy production are by far the most important elements of livestock keeping in urban and peri-urban Dhaka. According to the Government of Bangladesh's Livestock Department estimates, the poultry population throughout Bangladesh has been steadily increasing, from about 143 million birds in 2001 to 195 million birds in 2006. Over the same period, the duck population increased from 25.8 million in 2001 to 38.1 million in 2006 (Bangladesh Bureau of Statistics (BBS 2006). An analysis of the data for the districts of Dhaka division reveals a further concentration within the division as eight of the sixteen districts contain 81 per cent of the commercial chicken. Within metropolitan Dhaka, the district of Gazipur has experienced the greatest concentration of production. The presence of commercial poultry is also very strong in Narsingdi and Dhaka districts.

Dhaka and other parts of Bangladesh are increasingly contending with pollution problems associated with poultry waste. The pollution load of poultry waste in certain areas of concentrated farms, and recent outbreaks of bird flu, have begun to change attitudes towards poultry waste disposal. Alternatives to open waste dumping exist that, if done properly can reduce environmental hazards and increase the profitability of waste reuse (Table 6.7).

TABLE 6.7
Major environmental impacts of existing poultry waste disposal practices

No.	Disposal method	Important Environmental risks to manage	Mitigation Measures
1.	On-site waste composting	Odor, water pollution and insects/ vermin menace	Proper composting technique should be taught to the farmers
2.	Marketing for fish feed	Water pollution and over-fertilization	BOD testing and controlled discharge should be practiced
3.	Sold off as cooking fuel	Indoor air pollution	Adequate ventilation should be ensured
4.	Sold off to compost manufacturers	Minimal, only slight problem during transportation	Use of covered trucks to minimize odor and spillage
5.	Used in digesters	Minimal, but only if all handling measures are adopted	Proper handling of all stages of the operations

For decades, Bangladesh has had a large domestic market for milk and milk products. Milk production has more than doubled between 1991/92 and 2001/02, primarily due to recent government policies that support the dairy sector and to NGO involvement in the provision of soft loans to establish small dairy farms and improve veterinary health care services. Despite these increases, milk consumption among slum dwellers remains quite low. The majority of dairy farms that supply milk to the Dhaka Metropolis are located in the peri-urban districts of Munshiganj and Manikganj. In addition, several large milk cooperatives in the area, both public (Milk Vita) and private (e.g., Arong, Pran, Tatka, Aftab, Rangpur Dairy etc.) play important roles in meeting daily milk requirements of Dhaka's urban population.

Livestock and climate change

Few studies have been done to estimate the impacts of climate change on livestock in Bangladesh. Chowdhury and Karim (2009) indicated that livestock production could be affected by climate change through a reduction in the quality and availability of feed and water, heat and other environmental stresses, and preponderance of livestock parasites, pests, and diseases. A 2°C increase in temperatures by 2050, together with high humidity conditions would impose significant heat stress on livestock causing elevated body temperatures, increased respiration rates, increased maintenance energy requirements, increased feed nutrient utilization, decreased dry matter intake, reduced milk production and diminished reproductive performance. Arim (2009) estimates that crossbred cows will suffer more than the native cows, goat and sheep. High livestock losses during flood events are another important climate factor that could worsen with climate change.

Climate change factors	Adverse impacts
Flood/Cyclone/storm	Damage livestock farms and homestead production, widespread livestock mortality; disruption of pasture land, increase diseases; salinity intrusion also damage feed stock in pastures; damages landing and marketing centres;
Drought	Reduce feed productivity, reduce feed intake of animals and metabolism, increase diseases exposures and thereby reduce livestock productivity; anthrax breaks out after drought; increases management costs.
High temperature	Virus infection; increased disease occurrence; high morality of poultry; loss of production

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Agroforestry

Agroforestry is not widespread in peri-urban areas of Dhaka, though there is potential for its expanded use in districts like Gazipur and Narayangonj, which are within the Detailed Area Plan of Dhaka City (1 528 km^2) (Uddin, 2005). A pilot agro-forestry research and demonstration project was recently implemented by the Bangladesh Forest Department in the *Sal* forest (dipterocarp-*Sorea robusta*) areas. The project was developed to create agroforestry models that would be environmentally feasible, socially acceptable, and that would enhance tree and crop production and positive socio-economic outcomes. The project aimed at using 120 ha of encroached *Sal* forest land of Dhaka, Mymensingh and Tangail Forest Division to develop suitable participatory plantation models. Although Dhaka is under continuous pressure from housing demands, which will not allow giving more land for crop production, multipurpose tree plantations around the parks and valleys, along roads, rivers and canals can be one possible way to initiate this programme. Plantation of several types of multipurpose local tree species such as Mango, Jackfruit, Tamarind etc. can be selected for this purpose.

Floriculture

Market surveys associated with this assessment reveals that the main source points of flower supply (approximately 105 to 147 ton/day) for Dhaka city are mostly from outside the city. However, potted plants and floriculture are now a popular trade in Dhaka city. Around 1 200 large and small nurseries are currently operating in Dhaka, its outskirts and neighboring areas. The nurseries provide employment for people migrating into the city from other parts of the country in search of livelihood. New jobs like plant suppliers and caretakers have been created in offices and apartments buildings. Educated young people are joining the business. Nursery production has increased despite a lack of support from the government. Nurseries are typically developed in the open with a small investment and are thus susceptible to disruption from natural calamities. Government support for promoting risk management in nursery production would aid the sector, which predominately provides livelihoods for the urban poor. For example, promoting nurseries in the outskirts of Dhaka, such as in Gazipur, Savar and Ashulia could help to advance UPA development in Dhaka.

7 Policy, institutions and governance aspects that influence UPA

Over 20 ministries and 50 agencies are involved in the governance of Dhaka Metropolitan Area. At the national level, the Planning Commission coordinates the urban administration of civic and planning activities. Three ministries, namely the Local Government Division of the Ministry of Local Government, Rural Development and Cooperatives, the Ministry of Housing and Public Works and the Ministry of Communication, are largely responsible for urban planning and administration.

Key agencies that are directly responsible for urban service in the Dhaka Metropolitan Area include:

- Urban Local Governments
  - Dhaka City Corporation (DCC)
  - Five Paurashavas (Municipalities) e.g. Gazipur, Tongi, Savar, Narayanganj and Bandar
  - 52 Union Parishads
  - Cantonment Boards of Dhaka, Mirpur and Savar
- Planning and Development Authority
  - RajdhaniUnnayanKartipakkha (RAJUK)
- Special Purpose Authorities
  - Dhaka Water and Sewerage Authority (DWASA)
  - Bangladesh House Building and Finance Corporation
  - Dhaka Electric Supply Authority (DESA)
  - Bangladesh Power Development Board (PDB)
  - Bangladesh Telephone and Telegraph Board (T&T)
  - Titas Gas
- Special Government Departments/Directorates
  - Urban Development Directorate (UDD)
  - Public Works Department (PWD)
  - National Housing Authority (NHA)
  - Department of Public Health Engineering (DPHE)
  - Local Government Engineering Department (LGED)
  - Department of Architecture
  - Department of Environment (DoE)
  - Roads and Highways Department (RHD)
  - Dhaka Metropolitan Police (DMP)

Policies of relevance to food, agriculture and the urban environment

Various national policies directly address the agriculture sector but within these policies there is no specific policy focus on urban and peri-urban agriculture. There is a wide range of national policies, which can be considered in devising entry points for promoting UPA, include those related to food security, the agriculture sector, natural resources (environment, land and water, and housing and urban development.

	Sub-sector policies	Major goals and policy thrusts	Implementing ministry
Policies related to food security			
	(NFP) 2006)	National food policy ensure adequate and stable of safe and nutritious food, Plan of Action for period of 2008-15 enhance purchasing power of people for increased food accessibility, and ensure adequate nutrition for all; especially for women and children.	
Policies related to agriculture sector			
A. Crop			
1	National Agriculture Policy (NAP), 1999	Food security, profitable and sustainable production, land productivity and income gains, IPM, smooth input supplies, fair output prices, improving credit, marketing and agro-based industries, protecting small farmers interest	Ministry of Agriculture
2	New Agricultural Extension Policy (NAEP), 1996	Provision of efficient decentralized & demand led extension services to all types of farmers, training extension workers, strengthening research-extension linkage, and supporting environmental protection	Ministry of Agriculture
3	Department of Agricultural Extension (DAE)-Strategic Plan, 1999-2002	Adoption of Revised Extension Approach, assessment of farmers' information needs, supervision, use of low or no cost extension methods, promotion of food and non-food crops, and mainstream gender and social development issues into extension service delivery.	Ministry of Agriculture
4	Agricultural Extension Manual, 1999	Annual crop planning, seasonal extension monitoring, participatory technology development and rural approval partnership, technical audit, attitude and practice surveys.	Ministry of Agriculture
B. Non-crop			
5	National Livestock Development Policy, 2007	Improvement of small scale poultry and dairy farming replicating CLDDP, reform of DLS, enforcement of low and regulations towards animal feeds, vaccines and privatization of veterinary services adoption of breeding policy, and establishment of livestock insurance development fund and livestock credit food	Ministry of Fisheries and Livestock

6	National Fishery Policy, 1998	Development of fishery resources, increasing fish production and self-employment, meeting demand for animal proteins accelerating fish exports, and improvement of public health.	Ministry of Fisheries and Livestock
Policies related to natural resources			
1	Environmental Policy and Implementation Programme (EPIP) 1992	Conservation of environment, wet lands, RAMSAR sites. Prevention of environmental degradation; air, water, soil and noise pollution and conservation of forests.	Ministry of Environment and Forests
2	Land Use Policy, 2001	The main objectives of the land use policy are prevention of excessive land use due to the ever increasing demand for crop production, maximum utilization of inlands and wetlands, preservation of 'Khas Lands' and helping in reducing the number of landless people in Bangladesh.	Ministry of Land
3	National Water Policy 1999	Promote optimum use of water resources across all sectors.	Ministry of Water Resources
Polices related to housing and urban development			
1	National Housing Policy 1993 (Amendment 1999)	Ensure housing for all strata of society and to accelerate housing production in urban and rural areas with major emphasis on needs of low and middle-income groups. Make available suitably located land at affordable price for various target groups, especially for the low and middle-income group.	Ministry of Housing and Public Works
2	Detailed Area Plan (DAP)	• To provide a quality urban design having aesthetic, functional and flexibility characteristics; • To develop a programme for public sector action aiming at the implementation of the plan; • To prepare database and disseminate it in professional manner; • To provide and guide private sector development; • To provide clarity and security to future inhabitants and investors; • To prepare guidelines for future infrastructure development.	Rajdhani Unnayan Kartripakkhya

In addition to these sector specific policies the revised National Strategy for Accelerated Poverty Reduction II (December 2009) emphasizes the role of agriculture as a major contributor to pro-poor economic growth, food security and nutrition. The current Government has also developed a "Vision 2021" plan that aims to make Bangladesh a middle-income country. "Vision 2021" contains a supplementary National Strategy plan that strongly emphasizes reducing inequity, i.e. reducing vulnerability to natural disasters and strengthening governance. In meeting the Vision 2021, the recently developed Bangladesh Country Investment Plan (A Roadmap towards investment in Agriculture, Food Security and Nutrition) addresses issues of food availability, food access and food utilization issues in the changing climatic and socio-economic context.

Policies related to climate change

Food security has been afforded high priority in the Bangladesh Climate Change Strategy and Action Plan (BCSAP) 2009. The first pillar of that plan prioritized nine programmes with a goal to promote food security for the poorest and most vulnerable people of the community. The nine programmes under pillar one include research and development of climate resilient cropping systems and production technologies, capacity building, and piloting of adaptation measures. However, the programmes lack sufficient specificity with respect to meeting the needs of urban populations. Bangladesh's National Adaptation Programme of Action (NAPA) 2009, with its Food Security and Pro-poor Social Safety Nets pillar, includes broad actions related to reducing climate change impacts to crops, fisheries and livestock and ensuring food security. Additionally, this pillar contains 11 response measures intended to reduce vulnerabilities of the poor related to their access to food, employment and basic services.

Although progress is being made in developing climate change strategies for Bangladesh, greater effort is needed to amend existing policy documents in order to mainstream climate change issues. For example, the National Food Policy 2006 and National Food Policy Plan of Action (2008-2015) in its proposed 26 intervention areas cover a range of critical issues related to food production, markets and food system infrastructure but these policies do not make explicit mention of future climate change. More generally, the mapping and review of policy documents undertaken in the assessment revealed that urban development policies for Dhaka do not pay sufficient attention to potential impact from climate change hazards.

Urban Governance in Dhaka

Despite the plethora of policies described above, the national government has failed to devise effective urban development and management policies. This failure is reflected in Dhaka's existing urban governance systems, which are poorly equipped to face the challenges of a megacity, related to Dhaka's rapid growth, socio-political tensions, and environmental problems. The central government and urban local government bodies are struggling to provide housing, water, sanitation, electricity, food and other civic services to city people. The existing urban governance system is occupied with multidimensional problems related to structure, capacity, knowledge, skill, monitoring and supervision of growth, and service delivery, and as such is ill-equipped to advance adaptation planning for climate change. The increasing food demand of the city population will add further pressure on the city government. Critical constraints to effective urban governance include the lack of strategic policy leadership; vague and overlapping mandates between different government authorities from local to national and lack of effective coordination; public harassment and bureaucratic entanglement; and, lack of requisite capacities to properly enforce policies

A single apex (e.g., City Government) body on city governance is needed in order to ensure better integrated governance (more vertically and horizontally coordinated agencies) and more effective development outcomes. A structural reform in the existing city governance system would not only promote good urban governance but also create the potential for mainstreaming urban and peri-urban agriculture in urban policies. Under the leadership of proposed single apex body, the DCC, RAJUK, single purpose agencies (DWASA, DESA) and special government departments (UDD, NHA) will continue their regular activities. A separate urban and peri-urban agriculture extension wing can be established under the Single Apex Body and this wing will comprise of four separate cells, i.e. climate change and disaster risks reduction (DRR) cell, agricultural extension cell, livestock and poultry cell and fisheries cell.

The waste management, street and open space management departments of DCC and land use control regulatory section of RAJUK can be directly linked with the proposed urban and peri-urban agriculture extension wing. This will create opportunities for promoting agricultural practice in the street islands and open spaces and will also ensure proper management of agricultural, livestock and poultry waste. The coordination between land use regulatory cell and urban and peri-urban agriculture extension wing would help to reduce urban encroachment pressures on urban and peri-urban agricultural lands.

8 Recommendations

Linkages between research institutions and farming associations working on urban development issues need to be strengthened. A large number of research projects and demonstrations are taking place all over Bangladesh but they are fragmented. A review of current research and project efforts has revealed that there is limited coordination and knowledge sharing taking place within and across researchers and farmer groups. Moreover, the yield increases reported from the research stations are far from those registered at the farm level, thus calling into question the applicability of research station-generated technologies to on-farm conditions.

In order to promote urban and peri-urban agriculture, there is a need for more context specific approaches to strengthening the sector that includes responses for climate change adaptation. To date, analysis of possible climate change impacts in Bangladesh has been mainly conceived at the macro level, partly due to data limitations and lack of systematic knowledge of micro-level conditions. Such a basis for adaptation work has its limitations, since each of the agro ecosystems hides considerable local variation in the resource, which makes generalization of technologies and management approaches difficult. Currently, there is limited knowledge of which adaptation options work best under an urban environment. Moreover, many on-going community based adaptation projects have a rather narrow and short-term focus and are mainly based on rural conditions. This perspective of adaptation practices should be changed and more research and pilot initiatives on urban agricultural should be encouraged.

More strategic and integrated approaches are needed to support livelihood development,

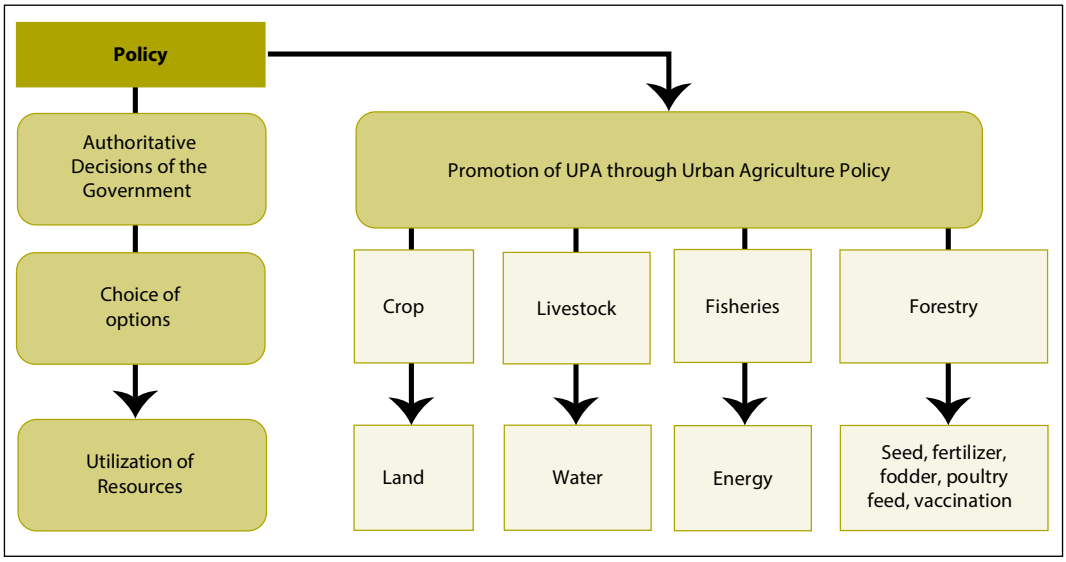

FIGURE 8.1
Conceptual framework for a more strategic and integrated UPA approach

considering the gradual changes in the environment caused by increases in population and climate change. These changes point to the need for integrated approaches of how to optimize utilization of land and water resources in urban areas. Such approaches are currently not integrated into the sector policy planning.

Urban and peri-urban agriculture needs to be better integrated in the policy domain. The following actions are recommended:

- An explicit Urban Agriculture Policy along with a City Adaptation Programme of Action (CAPA) should be formulated in line with the existing BCCSAP and NAPA document. Some policy decisions are also required to create greater awareness on promoting urban and peri-urban agriculture and to eliminate the socio-cultural bias that hinders acceptance of urban and peri-urban agriculture. An important action is that all of the policy and strategy documents described in Section 7 need to be updated to more fully consider potential climatic changes as well as rapid urban population growth.
- Strong political commitment and solid policy guidelines are required to promote alternative approaches of urban agriculture, such as rooftop gardening. One option could be to amend building regulations and laws. The Bangladesh National Building Code (BNBC) can be amended with inclusion of a specific clause encouraging rooftop gardening.
- The Detailed Area Plan of RAJUK, which is the sole guiding document for regulating the planned urban growth if Dhaka city, could encourage plantation on street islands and vacant lands through including necessary provisions in the plan. Conservation of wetlands/ditches/canals can also be encouraged and monitored through the DAP.
- Consideration of a waste to energy conversion plant. Such a plant has the potential to generate significant amounts of organic manure which can be a good supplement for improving soil micro-environments.

The fisheries sector needs greater support in order to sustain an important course of locally produced food. In order to facilitate that process, the following actions are recommended:

- Adoption of community-based or collective action approaches in the management of fishery resources, as well as in other commercial aspects of fishing, i.e., in fish trade and marketing;
- Rigorous implementation of management measures in capture fisheries such as protection and restoration of critical habitats, removal of excess fishing capacity, restrictions on potentially destructive gears, and provision of alternative livelihoods for small fishers;
- Infrastructure development for improved marketing of fish; promotion of investments in hatchery and input distribution systems for the sustained and widespread dissemination of quality fingerlings;
- Increased investments and quality of extension to reduce technical inefficiencies in fish culture;
- More research to increase productivity of priority species, e.g., selective breeding of carp, as well as the development of technologies to reduce costs of fish farming (e.g., low input systems, alternative feeds).

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