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Edited by
Henk de Zeeuw and Pay Drechsel

Cities and Agriculture

Developing resilient urban food systems

CITIES AND AGRICULTURE

As people increasingly migrate to urban settings and more than half of the world's population now lives in cities, it is vital to plan and provide for sustainable and resilient food systems which reflect this challenge. This volume presents experience and evidence-based "state of the art" chapters on the key dimensions of urban food challenges and types of intra- and peri-urban agriculture.

The book provides urban planners, local policy makers and urban development practitioners with an overview of crucial aspects of urban food systems based on an up-to-date review of research results and practical experiences in both developed and developing countries. By doing so, the international team of authors provides a balanced textbook for students of the growing number of courses on sustainable agriculture and food and urban studies, as well as a solid basis for well-informed policy making, planning and implementation regarding the development of sustainable, resilient and just urban food systems.

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Edited by Henk de Zeeuw and Pay Drechsel

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PREFACE

Urban agriculture – both inside the built-up city and in the peri-urban area – has various functions in the urban system. It plays, for example, an important role in feeding the increasing urban populations, often with highly nutritious food; a role that is specific and complimentary to food supply from rural areas. This context has often been underestimated, but the latest data point at a global farm area of more than 60 million ha within urban agglomerations,[1] which is a larger area than what we see, for example, under rice in South Asia, and if we include all farms up to 20 km from a city, the area is larger than the one of the European Union.

Next to the specific role in urban food supply, urban agriculture also plays other important functions in the urban system including the provision of eco-services, offering opportunities for recreation and enabling synergies (water, energy, CO2, organic wastes) with other urban sectors.

Given the increasing recognition of urban food demand and other opportunities and challenges for agriculture in the urban context, the RUAF Foundation decided that it is timely to produce an up-to-date overview of the "state of the art" on agriculture in the urban context.

The developments in this innovative field of work in the last decade have been manifold, including amongst others:

- A growing interest of local governments and citizens in the Global North and Global South in food and agriculture and urban-rural linkages.
- The emergence of new drivers steering attention to urban agriculture and urban food systems.

For decades, many local governments have supported urban farming as a strategy for poverty alleviation, social inclusion and enhancing food security and nutrition of the urban poor. Also, the role of (intra- and peri-) urban agriculture and forestry in urban greening and providing recreational opportunities for the urban citizens has been recognized for quite some time. However, more recently:

- Local governments started to support urban agriculture for the eco-services it provides (e.g., urban heat reduction, storm water management, biodiversity management) and its role in disaster risk management and city adaptation to climate change.
- Other cities have set out to shorten the food supply chains and promote the consumption of food produced in the city region in order to enhance the resilience of the urban food system and stimulate the local economy.
- There is also an increasing consciousness for a stronger water-energy-food nexus and closed-loop processes (circular economy, ecosanitation) through resource recovery and reuse, turning, for example, organic wastes and wastewater and excess energy, heat or CO2 from industry, into valuable resources for urban food production.
- A broadening of the research and planning focus from urban agriculture to urban (or city-region) food systems, including (intra- and peri-) urban food production as well as the processing of the local produce, its marketing/distribution, food waste management (including resource recovery and reuse), and related inputs supply and support services.
- And as a consequence, a quickly growing body of evidence and experience-based knowledge.

With this publication we attempt not only to update earlier benchmark publications by the RUAF Foundation (*Growing Cities, Growing Food* with DSE, 2000; *Cities Farming for the Future* with IIRR, 2006; and *Cities, Poverty and Food* with Practical Action, 2011), but also to bridge between urban food and agriculture research and planning in the South and North. We hope that this publication will contribute to the intensified sharing of research results and policy and planning experiences between different regions and countries and to facilitate innovation and more effective urban food system research, policy planning and implementation. However, urban food systems, and the socio-economic, cultural and political factors shaping these systems, may differ substantially from region to region and even country to country, and lessons learned in one country or region might not fit another.

We expect that this publication will be of use for policy advisors, researchers, urban planners, specialists, practitioners and others involved in urban food system assessments and the design of urban food strategies and/or specific policies on urban agriculture or other components of the urban food system and that it will find its way to educational institutes that provide training in this field.

We want to thank all the authors that contributed to the various chapters: We are very grateful.

We also like to thank our chapter reviewers, Kingsley Kurukulasuryia for the language editing, Desiree Dirkzwager (RUAF Foundation) for the text editing and layout, and Ashley Wright (Earthscan) for coordinating the production and distribution of this book.

The editors,
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Dr. Pay Drechsel *(IMWI, Colombo, Sri Lanka)*

Note

1 Thebo, A. L.; Drechsel, P.; Lambin, E. F. 2014. Global assessment of urban and peri-urban agriculture: irrigated and rainfed croplands. *Environmental Research Letters* 9: 114002.

CLARENCE HOUSE

With so many challenges and pressures evident on the road to sustainability, it is easy to feel overwhelmed by the magnitude and diversity of barriers that must be passed in reaching the kinds of outcomes that the scientific community tell us are evermore urgently required. Anyone seeking solutions to the loss of biological diversity, depletion of critical resources, such as soils and water, or who is dealing with the causes and consequences of climate change will know what I mean.

One thing that I have learned during the four decades or so that I have paid close attention to these questions is that our lack of progress is not so much due to our inability to address individual parts of the sustainability challenge, but more to do with our inability to come up with truly integrated, systemic approaches that can tackle multiple facets of what are ultimately different expressions of common, underlying problems. Perhaps nowhere is this more evident than in relation to the rather important matter of how we feed ourselves.

This has been a key challenge for people down the ages, revolving around the conundrum of how to secure enough food to supply rising demand while at the same time keeping prices affordable. When one looks at the various indices of nutrition and how we have more or less managed to keep pace with recent explosive population growth, a record of apparent success is revealed. Despite a four-fold increase in human numbers during the 20th century, the supply of more and more food has meant that forecasts of epic famines affecting hundreds of millions of people have been largely avoided. There is, however, good reason to pause before declaring an unqualified triumph.

Our ever more globalized and high-input food systems have delivered massive increases in the supply of calories, but it is now becoming clear that not only has this performance not been enjoyed by all, it has also been bought largely at the expense of the overall health of the food system. Indeed, what we have seen is a kind of mining of the food system's key assets; ranging from the loss of farmers, soils and biodiversity to massive greenhouse gas emissions that are affecting the stability of our climate, and to changes in diets that are not only harmful to the health of our environment, but to people's health as well. This parlous situation is more and more widely recognized and a growing chorus of voices is now asking if there might be ways of doing things better, not only to ensure affordable nutrition, but also to sustain the healthy ecosystems that are an essential prerequisite for healthy people and to foster the healthy social systems that might enable societies to adapt better to the inevitable shocks that will come with changing conditions, not least shifts in climate.

The big question, of course, is how? One encouraging trend is the way that people in different contexts around the world are taking the opportunity to improve their food systems. This is being done through actions at the city level, and strengthening the linkages between urban areas and their rural hinterlands in ways that help reduce some of the negative consequences arising from the current conventional approach. Such actions can help to increase the resilience of farming in the face of the pressures that during the coming years we can only expect to grow. The potential benefits are manifold. They include improved security in nutrition, increased availability of healthier food, opportunities to secure the livelihoods of small producers and their businesses, increased local participation in decision-making and engagement with food culture, improved scope for the more sustainable management of landscapes and the natural assets they sustain, and increased opportunity for synergy in meeting other key priorities, for example in relation to energy, waste and water security. All this, and more, can be achieved from a more integrated and socially inclusive approach at the city level. Experience from different parts of the world is beginning to reveal the scale of the positive opportunities at hand, if only we can adopt the strategies to seize them.

One important way to render these benefits more transparent is to undertake what might be called true cost accounting. The negative impacts that come in the wake of our ever-more industrialized food system are often justified in the name of 'cheap' food. Stepping back, however, and taking a more comprehensive view reveals that our food is actually very far from cheap; it is just that the costs are cropping up elsewhere. The effects of soil damage are, for example, reflected in increased water bills as technology has to be installed to remove pesticides, chemicals and nitrates. Soil degradation also creates costs in protecting people and property from flooding, which can increase due to the silting up of watercourses. There are mammoth hidden costs in "dead zones" in the oceans caused by the run-off of agri-industrial pollutants. There are costs reflected in public health trends too, for example arising from diets dominated by cheap processed food and so called 'empty calories' with too few fresh fruits and vegetables. Then there are the costly social impacts arising from rural unemployment. Crucially, these and other costs often resonate more loudly at the city level than at the national level which is often more focussed on short term macroeconomic concerns. The true costs of cheap food can also often be more effectively minimized at a city-region level than they can globally, thus offering prospects not only for more resilient outcomes but, in the end, more cost-effective ones too.

Fortunately, and in large part due to the leadership of organizations such as R.U.A.F., there is now real interest and engagement with the question of how to re-embed the historic relationship that existed for thousands of years between cities and the countryside surrounding them. For example, a range of international processes have recently considered the different steps that might be taken. These include an agreement reached at the World Urban Forum in 2014, amongst key U.N. and other international organizations, to share knowledge and to improve the coordination of their actions under the City Region Food Systems Collaborative. Cities themselves have also begun to act together, generating and exchanging knowledge in order to develop frameworks for action such as the Global Urban Food Policy Pact that has been catalysed by the city of Milan in 2015.

This is why I am so pleased to see the publication of *Cities and Agriculture – towards resilient urban food systems*. This timely and thorough overview about the opportunities for enabling city regions to drive a transformation towards much more sustainable, resilient and healthy food systems will, I hope, raise awareness as to the potential for a different direction of travel to the one we are presently embarked upon. Such a transformation would be based on using our increased knowledge to empower partnerships and develop the kind of integrated approaches to policy and planning that take us beyond the simple trade-offs which place faith in 'cheap food' and toward seeing the wider picture.

I can only congratulate the many scientists and practitioners for their valuable contributions to this important publication and very much hope it will find its way to national and local policy-makers, urban planners, academia, non-governmental groups, producers and consumers organizations, private sector companies and others that can make a contribution to building more resilient food systems through concerted and far-sighted action at the level of the city region.

HRH The Prince of Wales

ABBREVIATIONS AND ACRONYMS

AAA	Atelier d'Architecture Autogérée
AB Bank	AB Bank Limited (Bangladesh)
ADB	Asian Development Bank
AESOP	Association of European Schools of Planning
AFSUN	African Food Security Urban Network
AMAP	Associations pour le Maintien de l'Agriculture Paysanne (Associations for the Maintenance of Peasant Agriculture)
APA	American Planning Association
AR5	Fifth Assessment Report of the IPCC
As	arsenic
ASF	animal source food
AVRDC	the World Vegetable Center (formerly: "Asian Vegetable Research Centre")
BMI	body mass index
BSE	bovine spongiform encephalopathy, commonly known as mad cow disease
CAP	Common Agricultural Policy of the European Union
CBA	cost benefit analysis
CBD	Convention on Biological Diversity (UN)
Cd	cadmium
CDKN	Climate Change and Development Knowledge Network (UK)
CFF	Cities Farming for the Future (a RUAF programme)
CFS	Committee on World Food Security
CGIAR	Consortium of 15 international agricultural research organisations (originally founded as the "Consultative Group on International Agricultural Research")
CIRAD	Centre de coopération Internationale en Recherche Agronomique pour le Développement

CLT	community land trusts
C/N	carbon/nitrogen ratio
CO_2	carbon dioxide
CPULs	continuous productive urban landscapes
Cr	chromium
CSA	Community Supported Agriculture
Cu	copper
CWP	Center for Watershed Protection (USA)
DEP	Department of Environmental Protection (New York City)
DPSIR	Driving forces, Pressures, State, Impacts, Responses (an assessment framework)
DPU	Bartlett Development Planning Unit, University College London
DRR	disaster risk reduction
ECHO	European Commission's Humanitarian Aid and Civil Protection Department
EKW	East Kolkata Wetlands
EKWMA	East Kolkata Wetlands Management Authority
EMPs	environmental management plans
ENPHO	Environment and Public Health Organization (NGO, Nepal) Top of Form
EPA	Environmental Protection Organization (USA)
FAO	Food and Agriculture Organisation of the United Nations
FEU	family economical unit
FStT	From Seed to Table (a RUAF programme)
GAP	good agricultural practices
GBH	gravel bed hydroponic system
GHG	greenhouse gas (emissions)
GIS	geographical information systems
HACCP	hazard analysis and critical control points
HighARCS	Highland Aquatic Resources Conservation and Sustainable development project (EU)
HIV	human immunodeficiency virus
HOPSCOM	Horticulture Cooperative Horticulture Marketing Society (India)
IAP	integrated action plan
ICLEI	ICLEI-Local Governments for Sustainability (founded as the International Council for Local Environmental Initiatives; an international association of local governments)
ICM	impervious cover model
ICRC	the International Committee of the Red Cross (Switzerland)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDPs	internally displaced persons
IDRC	International Development Research Centre (Canada)
IFA	International Federation of Landscape Architects
IICA	Inter-American Institute for Cooperation on Agriculture

IIED	International Institute for Environment and Development (UK)
ILRI	International Livestock Research Institute
INRA	L'Institut National de la Recherche Agronomique (French National Institute for Agricultural Research)
IPCC	Intergovernmental Panel on Climate Change
IPES	IPES-Promotion for Sustainable Development (NGO, Peru)
IPGRI	International Plant Genetic Resources Institute (now Bioversity International)
IPM	Integrated Pest and Disease Management
IRC	International Water and Sanitation Centre (the Netherlands)
IRRIGASC	an NGO based in Senegal working on sustainable development in the Sahel region, especially small-scale irrigation
ISA	International Society for Arboriculture
ISDR	International Strategy for Disaster Reduction (United Nations)
IUFRO	International Union of Forest Research Organizations
IWMI	International Water Management Institute
JEV	Japanese Encephalitis Virus
LAC	Latin America and the Caribbean
LEGS	livestock emergency guidelines and standards
LMR	limit maximal residues
LPI	lived poverty index
LRRD	linking relief, rehabilitation and development
LST	land surface temperatures
MAMC	Maulana Azad Medical College (India)
MDG	Millennium Development Goal
MENA	Middle East and North Africa
MFI	micro-finance institution
MOISA	The Markets, Organisations, Institutions and Actors' Strategies Unit of CIRAD
MPAP	multi-stakeholder policy formulation and action planning
MPSACCO	Mahila Prayas Savings and Credit Co-operative Ltd. (Nepal)
MSc	Master of Science
MSW	municipal solid waste
N	nitrogen
NBO Bank	National Bank of Oman
NFIs	national forest inventories
NGO	non-governmental organization
Ni	nickel
NO_2	nitrogen dioxide
NUFU	National Urban Forestry Unit (UK)
NYC	New York City
O_3	ozone
O&M	operation and maintenance
OECD	Organisation for Economic Co-operation and Development

OPV	open-pollinated varieties
P	phosphorus
PAPUSSA	Production in Aquatic Peri-Urban Systems in Southeast Asia project (Stirling University)
Pb	lead
PB	participatory budgeting
PhD	Doctor of Philosophy
PROVE	Programa de Verticalisão da Produção (Verticalisation of Production Programme, Brazil)
PTE	potentially toxic element
PYMV	potato yellow mosaic virus
RCZI	Roadmap to Zoonosis Initiative
RGB image	digital aerial maps that are made by a special processing of perpendicular camera axis aerial images
RS	remote sensing
RUAF	RUAF Foundation (International network of Resource centres on Urban Agriculture and Food security)
SAD-APT	The joint interdisciplinary research team formed by INRA-SAD and AgroParisTech (France)
SDGs	Sustainable Development Goals (UN)
SFSC	short food supply chain
SISEF	Italian Society of Silviculture and Forest Ecology
SO_2	sulfur dioxide
SSHRC	Social Sciences and Humanities Research Council (Canada)
STEPS	Social, Technical, Environmental, Political, Sustainability (a planning framework)
SWOT	Strengths, Weaknesses, Opportunities, Threats (an assessment method)
T4P	training for performance
TFPC	Toronto Food Policy Council
TIPA	techno-agricultural innovations for poverty alleviation
TLVs	traditional leafy vegetables
ToF	trees out of forests
TYLCV	tomato yellow leaf curl virus
UAV	unmanned aerial vehicles
UCLG	United Cities and Local Governments
UHI	urban heat island
UK	United Kingdom
UMP	Urban Management Programme (UN-Habitat/UNDP)
UN	United Nations
UNEP	United Nations Environmental Programme
UNHCR	United Nations High Commission for Refugees
UNU	United Nations University
USA	United Sates of America
USDA	United States Department of Agriculture

VSLA	village savings and loans associations
WASH	water, sanitation and hygiene
WISDOM	Wood Fuel Integrated Supply and Demand Review Mapping
WHO	World Health Organization
WRAP	Wetland Resources Action Planning (a toolkit)
WTP	willingness to pay
WWF	World Wildlife Fund
Zn	Zinc

1

URBAN FOOD SYSTEMS

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Introduction

An important milestone occurred in mid-2009, when the world's population, at that time about 6.8 billion, became more urban than rural. By 2050, when the world population is expected to have increased to 9.5 billion, approximately 66% of the world's population will be living in urban areas (UN 2014). Levels of urbanization differ when one looks at different continents. As Cohen (2006: 70) states: "There are enormous differences in patterns of urbanization between regions and even greater variation in the level and speed with which individual countries or indeed individual cities within regions are growing". Currently, Asia and Africa still have a predominantly rural population, while Europe, North America and Oceania were already urbanized regions before 1950. By 2050, however, all major areas will be urbanized (see Table 1.1).

TABLE 1.1 Urbanization trends by major regions (1950–2050)

Major region	*Percentage urban*				
	1950	*1970*	*2014*	*2030*	*2050*
Africa	14.4	23.5	40.0	47.7	56.0
Asia	17.5	23.7	47.5	55.5	64.4
Europe	51.3	62.8	73.4	77.4	82.2
Latin America and the Caribbean	41.4	57.1	79.5	83.4	86.0
Northern America	63.9	73.8	81.5	85.8	87.3
Oceania	62.4	71.2	70.8	71.4	74.0

Source: UN 2014.

Urbanization is and will partially be taking place through the growth of mega cities, cities with a population of more than 10 million (Sorensen and Okata 2010). However, the vast majority of urban population growth will occur in smaller cities and towns (i.e., urban settlements with a population of less than 1 million residents), followed by medium-sized cities (1–5 million residents). According to Cohen (2006), about 10% of the world's urban population will be living in mega cities, while just over half of the total urban population will reside in the smaller cities and towns.

Both mega cities and smaller cities face several development, governance and sustainability challenges, albeit that in some cases the kind of challenges differ substantially between the two. According to Sorensen and Okata (2010: 7–8), the increasing speed of urbanization has major consequences for mega cities: "building infrastructure takes time as well as money, and rapid growth often means that there is not enough of either to keep up with needs. Perhaps more fundamentally, political processes and governance institutions take time to evolve and generate effective frameworks to manage complex systems that make giant cities more liveable". The governance capacity is also mentioned as a challenge for the smaller cities and towns: "many small cities lack the necessary institutional capacity to be able to manage their rapidly growing populations" (Cohen 2006: 74). The increasing governance complexity is not only due to the rapid urban population growth, but is also a result of the decentralization of regulatory responsibilities and policy implementation: "In the areas of health, education, and poverty alleviation, many national governments have begun to allow hitherto untested local governments to operate the levers of policy and programs" (ibid.: 74–75).

In addition to shifting governance responsibilities and growing governance complexities for cities, urbanization also poses a number of other challenges. One of these challenges is resource use (Madlener and Sunak 2011). Cities consume 75% of the world's resources, while covering only 2% of the world's surface (Pacione 2009), which means that the vast majority of resources used by a city are taken from, and produced in, places outside cities' borders. This is often referred to as the urban ecological footprint: "the total area of productive land and water required continuously to produce all the resources consumed and to assimilate all the wastes produced, by a defined population, wherever on Earth that land is located" (Rees and Wackernagel 1996: 228–229). Hence, the ecological footprint is "a land-based surrogate measure of the population's demands on natural capital" (ibid.: 229). In the process of urbanization, the urban ecological footprint, expressed in the annual demand for land and water per capita, has increased, particularly due to the growing energy demand for mobility, for cooling and heating of houses and offices, for all sorts of equipment for domestic use, and for long-distance transport, processing, packaging, cooling and storage of food (Lang 2010, Madlener and Sunak 2011). The growing ecological footprint of cities has also resulted in a characterization of cities as "parasites", exploiting the resources of its rural hinterland while simultaneously polluting land, water and air (Broto et al. 2012). A shortcoming of the urban ecological footprint approach is that it is based on the average annual resource use per capita, thereby obscuring differences between urban dwellers within cities.

This brings us to another urbanization challenge: growing inequalities in wealth, health, access to resources and availability and affordability of services (Cohen 2006, Broto et al. 2012). Historically, cities developed in places that had a natural advantage in resource supply or transport and that hence offered opportunities for social and economic development: "cities have always been focal points for economic growth, innovation and employment" (Cohen 2006: 64). In most major regions of the world urbanization has gone hand in hand with economic development. This does not hold true for Africa, where current urbanization seems to occur despite economic development: "cities in Africa are not serving as engines of growth and structural transformation" (World Bank 2000 cited in Cohen 2006). Rather, these cities serve as a magnet for those seeking a better quality of life. However, the structural investments to provide this are largely lacking or at least insufficient. Urban growth generally means that cities become culturally and socioeconomically more diverse. Typical for many cities in developing countries, regardless of whether these cities are small, medium-sized or very large, is the significant difference between the upper- and middle-class and the low-income class with regard to access to clean drinking water and electricity and presence of adequate sewerage and solid waste disposal facilities (Cohen 2006, Broto et al. 2012). The reproduction, or perhaps even acceleration, of urban inequalities is often attributed to poor urban governance – i.e., municipal authorities unable to keep up with the speed of urban growth and/or with the increasing complexity of urban governance as a result of decentralization of policies – and neo-liberal reforms of urban services, which tend to exclude the urban poor from access to these services (Broto et al. 2012).

A fourth challenge of urbanization often mentioned in the domain of urban studies is environmental pollution, like water pollution across the developing world and air pollution, in particular when it comes to mega cities (Mage et al. 1996, Cohen et al. 2005). The images of cities full of smog and pedestrians wearing face masks to protect themselves from air pollution are telling examples of the problem of urban air pollution. Traffic congestion is considered to be a major source of air pollution in developing countries: "Over 90% of air pollution in cities in these countries is attributed to vehicle emissions brought about by high number of older vehicles coupled with poor vehicle maintenance, inadequate infrastructure and low fuel quality" (www.unep.org/urban_environment/issues/urban_air.asp). The greatest environmental health concerns caused by air pollution are exposure to fine matter particles and lead. This contributes to learning disability in young children, increase in premature deaths and an overall decrease in quality of life (Cohen et al. 2005, Cohen 2006). As "vegetation can be an important component of pollution control strategies in dense urban areas" (Pugh et al. 2012: 7693), the prevalence of air pollution in cities worsens due to the disappearance of the urban green (Pataki et al. 2011). The lack of urban green also contributes to urban heat islands, an urban environmental health challenge that is aggravated by climate change (Susca et al. 2011). Heat islands "intensify the energy problem of cities, deteriorate comfort conditions, put in danger the vulnerable population and amplify the pollution problems" (Santamouris 2014: 682). Recent research indicates that green roofs can play an important role in mitigating urban heat islands and hence in reducing the urban environmental health problems resulting from climate change (Susca et al. 2011, Santamouris 2014).

An urban challenge that is gaining attention, but which was ignored for a long time in urban studies as well as in urban policies and planning, is food provisioning. Neglecting the dynamics and sustainability of food provisioning in scientific research on sustainable urban development is a serious omission, because, as Steel (2008) argues, "feeding cities arguably has a greater social and physical impact on us and our planet than anything else we do". Like Steel in her much acclaimed book *Hungry City: How Food Shapes Our Lives,* the founders of food planning in the USA, Pothukuchi and Kaufman (1999: 216) state that in urban policy "food issues are hardly given a second thought" because urban policies are usually associated with issues such as "the loss of manufacturing jobs, rising crime rates, downtown revitalization, maintaining the viability of ageing neighbourhoods, and coping with rising city government expenditures". This is also reflected in the names of municipal departments and the domains for which municipalities usually bear political responsibility (although this may differ between countries): planning and spatial development, finances, waste management, health, public transport, education, parks and recreation, and community development.

One reason why food has never been a prominent issue on the urban agenda is rooted in the persistent dichotomy between urban and rural policy. Food is often seen as part of the realm of agriculture and hence as belonging to rural policy. According to Sonnino (2009), this urban–rural policy divide is responsible for three shortcomings in urban food research, policy and planning:

a) The study of food provisioning is confined to rural and regional development, missing the fact that the city is the space, place and scale where demand is greatest for food products.
b) Urban food security failure is seen as a production failure instead of a distribution, access and affordability failure, constraining interventions in the realm of urban food security.
c) It has promoted the view of food policy as a non-urban strategy, delaying research on the role of cities as food system innovators.

Linked to the urban–rural policy dichotomy is ignorance among many urban dwellers and policy officials about the significance of food for sustainable urban development and quality of urban life (Pothukuchi and Kaufman 1999), although this is more likely to be the case in cities where the availability of food has never been a real issue of concern for the "average" urban dweller. According to Pothukuchi and Kaufman (1999: 217), food should be understood as an important urban issue as it is "affecting the local economy, the environment, public health, and quality of neighbourhoods".

In this chapter, I want to elaborate on this by presenting and discussing the conditions that are shaping urban food systems. An urban food system encompasses the different modes of urban food provisioning, in other words, the different ways in which locations where food eaten in cities is produced, processed, distributed and sold. This may range from green leafy vegetables produced on urban farms, to rice produced in the countryside surrounding the city, up to breakfast cereals produced, industrially processed and packaged thousands of kilometres away from the place of consumption. The food provisioning system of any city, whether small or large, in Europe, sub-Saharan Africa or Latin America, is always a hybrid food system, i.e., combining different modes of food provisioning. Some cities are mainly, though not exclusively, fed by intra-urban, peri-urban and nearby rural farms and food processors, while other cities are largely dependent, though not entirely, on food produced and processed in other countries or continents. Hence an urban food system is not only shaped by the dynamics characteristic for that particular city-region (i.e., the city and its urban fringe and rural hinterland), but also, and sometimes even predominantly, by dynamics at a distance. This is why the elaboration of the conditions shaping urban food systems is somewhat of a global and generic nature, introducing and explaining the main trends influencing urban food system dynamics. I will introduce some examples to highlight more concretely how and to what extent a city's food system is influenced by these conditions. However, the primary aim of this chapter is to introduce the different topics and themes related to urban food systems, and more in particular to (intra- and peri-) urban agriculture, elaborated upon in the following chapters in the book.

Building on these conditions, I want to conclude this chapter by proposing and discussing several guiding principles for designing and planning future urban food systems. Also this will touch upon issues that are further developed, discussed and illustrated in the following chapters.

The conditions shaping urban food systems

Living and eating in cities have increasingly become inextricably linked to globalized chains of food provisioning (Murdoch et al. 2000, Steel 2008). This is particularly true for industrialized economies, but also in many developing economies, processed foods, long-distance food transport and supermarkets as important food outlets for domestic consumption are on the rise (Reardon and Timmer 2007, Popkin et al. 2012). This globalized food system has brought many benefits to the urban population: food is usually constantly available at relatively low prices and many food products have a year-round supply. However, these benefits have also come at a series of costs (Wiskerke 2009, Lang 2010, De Schutter 2014), which are undermining a continuation of business as usual. Together with several current trends and dynamics that are impacting upon food provisioning activities, these costs inherent in the globalized industrial food system shape the conditions for current and future urban food systems. I will present and discuss below these trends, dynamics and costs.

Population growth, urbanization and changing diets

The first condition shaping current and future urban food systems is the combined process of population growth, urbanization and changing diets. As mentioned in the introduction to this chapter, the world population is expected to grow from 7 billion at present to 9.5 billion in 2050, of which 6.2 billion will be living in urban areas. Concomitant with population growth and urbanization, a change in diet is occurring, regularly referred to as the nutrition transition (Popkin 1999). The nutrition transition consists of two aspects: 1) an increase in energy intake and 2) a change in the composition of diets. The energy intake per capita per day has been increasing in the past decades and is expected to increase in the forthcoming decades (see Table 1.2).

TABLE 1.2 Global and regional food consumption patterns (in kcal per capita per day)

Region	*1964–1966*	*1974–1976*	*1984–1986*	*1995–1997*	*2006–2008*	*2030*
World	2,358	2,435	2,655	2,680	2,790	3,050
Developing countries	2,054	2,152	2,450	2,540	2,570	2,980
Near East and North Africa	2,290	2,591	2,953	3,100	3,150	3,170
Sub-Saharan Africa	2,058	2,079	2,057	2,150	2,270	2,540
Latin America and the Caribbean	2,393	2,546	2,689	2,740	2,920	3,140
East Asia	1,957	2,105	2,559	2,830	2,980	3,190
South Asia	2,017	1,986	2,205	2,300	2,360	2,900
Industrialized countries	2,947	3,065	3,206	3,250	3,430	3,500

Sources: Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases 2003 (1995–1997 data) and www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/FoodConsumptionNutrients_en.xls (2006–2008 data).

Diet composition is also changing with the transition from a rural to an urban diet as, for instance, illustrated by trends in the consumption of animal proteins (see Table 1.3). Popkin (1999) states:

> Urban residents obtain a much higher proportion of energy from fats and sweeteners than do rural residents, even in the poorest areas of very low-income countries. Most urban dwellers also eat greater amounts of animal products than their rural counterparts. Urbanites consume a more diversified diet and more micronutrients and animal proteins than rural residents but with considerably higher intakes of refined carbohydrates, processed foods, and saturated and total fat and lower intakes of fiber.

TABLE 1.3 Per capita consumption of livestock products

Region	*Meat (kg per year)*			*Milk (kg per year)*		
	1964–1966	*1997–1999*	*2030*	*1964–1966*	*1997–1999*	*2030*
World	24.2	36.4	45.3	73.9	78.1	89.5
Developing countries	10.2	25.5	36.7	28.0	44.6	65.8
Near East and North Africa	11.9	21.2	35.0	68.6	72.3	89.9
Sub-Saharan Africa	9.9	9.4	13.4	28.5	29.1	33.8
Latin America and the Caribbean	31.7	53.8	76.6	80.1	110.2	139.8
East Asia	8.7	37.7	58.5	3.6	10.0	17.8
South Asia	3.9	5.3	11.7	37.0	67.5	106.9
Industrialized countries	61.5	88.2	100.1	185.5	212.2	221.0

Sources: Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases 2003.

Hence the combined process of population growth, urbanization and nutrition transition implies that one of the grand societal challenges for the decades to come is how to feed the growing and urbanizing world population. An often heard slogan is that we "need to double food production to feed 9 billion" (Godfray et al. 2010, Foley 2011, Herrero 2013). This need to double food production is, however, criticized by different scholars (e.g., Holt-Giménez et al. 2012, Tomlinson 2013) for several reasons.

The first critique regards the production bias in the food security discussion. By focusing on food production as the means to address global food and nutrition insecurity, the real cause of food and nutrition insecurity is neglected. Food insecurity is first and foremost a problem of availability, accessibility, affordability and adequacy (De Schutter 2014). At the global level there are significant inequalities between countries and within countries in the availability of food; in some parts of the world there is an abundance of food available for consumption while in other parts there is insufficient food available, in terms of energy needs and/or nutritional needs. But even in places where there is sufficient food available, not everyone has equal access to nutritious food. The notion of "food deserts" (Wrigley 2002, Wrigley et al. 2002, Cummins and Macintyre 2006), i.e., impoverished urban neighbourhoods that lack supermarkets and grocery stores, but boast dozens of fast food and snack shops – has been introduced to highlight the problem of unequal access to food in cities in industrialized economies. With supermarkets and grocery stores moving to the outskirts of cities for logistical reasons, ownership of a car becomes more or less a prerequisite to have access to fresh food for home preparation and consumption (Pothukuchi and Kaufman 1999). If public transport facilities to these outskirts are underdeveloped or simply lacking, then disadvantaged people are deprived of access, or at least easy access, to nutritious foodstuffs.

A third aspect of food security is affordability, referring to the price of food and the amount of money a person or a household has to purchase food. This implies that poverty is an important, if not the major, cause of food and nutrition insecurity (De Schutter 2014, Wegerif 2014). There is no reason to assume that doubling world food production will change anything in the affordability of food. A final aspect of food and nutrition security that is quite often neglected in international debates is the adequacy of food (De Schutter 2014). Adequacy refers not only to safety and nutritional value, but also to cultural appropriateness. What is considered to be a normal food item or even a delicacy for one person may be too sweet, too heavy or a taboo for another one. This means that food and nutrition security cannot be reduced to having access to sufficient calories and micronutrients. Also the kinds of food products that are available, accessible, safe, nutritious and affordable define food security.

An illustrative example of the availability, accessibility and affordability side of the food security equation is Wegerif's study of patterns of food provisioning in Dar es Salaam, Tanzania's largest city and among the top ten fastest-growing cities in sub-Saharan Africa. In Dar es Salaam only 10% of the households have motorized transport, 16% of the households live under the basic needs poverty line, 41% of the households have only one room in a house they share with other households, 74% of the households have three or more members and 23% of the city's population has a refrigerator (Wegerif 2014). This implies that for the vast majority of the population food outlets at walking distance are crucial due to limited or no possibilities to travel far to purchase food. Furthermore, the statistics indicate that a large percentage of the population has little to no space to store food and no possibility for cool storage of food. Using eggs as a case study, Wegerif shows the importance of the egg-provisioning network consisting of (intra- and peri-) urban farmers and *dukas* (street shops). The farmers often not only produce the eggs but also transport them by bicycle to the *dukas*. According to Wegerif (2014) this network has four main strengths for the urban poor compared to the supermarket system:

1. The price of eggs in a *duka* is lower than in supermarkets.
2. *Dukas* are found in any street in the city, while there are only a few supermarket stores in Dar es Salaam. Hence, a *duka* is always within walking distance.
3. *Dukas* offer the flexibility of being able to buy fewer eggs from one upwards compared to the 6, 10 or 30 egg trays available in the supermarket.
4. *Duka* owners offer access to short-term interest-free credit, something that the supermarkets are unable to do.

Lower prices, proximity, flexibility and the possibility of interest-free credit are "crucial for people surviving on limited and sporadic incomes. In addition, these factors do away with the need for storage space, something not to be taken for granted by people who live in cramped spaces, often sharing, with uncertain tenure and with limited or no assets such as fridges or other furniture" (ibid.: 3768).

A second argument for criticizing the production-bias in the food security debate is that the perceived need to double food production is based on the assumption that food consumption trends in the past decade can be extrapolated to the future (see Tables 1.2 and 1.3). Recent figures show, however, that, in Europe and North America, consumption levels of red meat, in particular beef, are declining (Kearney 2010). Poultry consumption levels are increasing, which seems to indicate that red meat is replaced by white meat. Feed conversion efficiencies for poultry are much higher than for beef, implying that poultry consumption is less resource demanding than beef consumption (Cronje 2011, Mekonnen and Hoekstra 2012). Although the overall meat consumption levels in Europe and North America are not yet declining, the increase in recent years has been much more modest than in the second half of the 20th century (Kearney 2010).

The third argument to question the need to double food production is that, at the global level, enough food is currently produced to feed 10 billion, yet approximately 40% of the food produced is not consumed due to harvest losses on the farm and post-harvest losses further up the food chain, including post-consumer waste. According to Smil (2000) and Lundqvist et al. (2008), current agricultural production levels are equal to about 4,600 kcal per capita per day, of which 1,400 kcal per capita per day are lost in different stages of the food chain. Reducing harvest and post-harvest losses could therefore be as important as increasing yields (Herren 2011). Obviously, this does not mean that reducing food waste in Europe and North America will help to reduce the problem of food insecurity in sub-Saharan Africa and South Asia. In industrialized economies food losses primarily occur in the latter stages of the food chain: in supermarkets and restaurants and at home. Food is removed from supermarket shelves or is not bought or consumed because it is close to or past expiry date, because people buy too much or because the portions served are too large to consume (Steel 2008).

According to Lang (2010), approximately 33% of all food purchased in the United Kingdom is thrown away. Reducing food waste in the last stages of the food chain, in particular the still good and safe food that supermarkets dispose of, only contributes to reducing food security insofar as this food goes to nearby food banks and charities. For many developing countries, food waste primarily occurs in the first stages of the food chain, i.e., during harvest, storage and transport (Aulekh and Ragmi 2013). Especially for perishable products such as fruits and vegetables, harvest and post-harvest losses are high. In an emerging economy like India, which is the world's second-largest producer of fruits and vegetables, up to 30% of all food produced is lost during harvest, post-harvest storage and distribution. Poor transport infrastructure between city and countryside, together with a lack of cool storage, are the main causes of these food losses. Hence, improving rural–urban distribution connections and creating and preserving space for intra- and peri-urban production of fruits and vegetables are key means to enhance urban food security (Renting and Dubbeling 2013), as studies about urban agriculture in different cities in the Global South show that up to 40% of the urban demand for fruits and up to 90% of the urban demand for leafy vegetables are met by intra-urban and peri-urban agriculture (De Zeeuw and Dubbeling 2009). The contributions of (intra- and peri-) urban agriculture to safeguarding and enhancing urban food security and nutrition are further explored in Chapter 6.

Scarcity and depletion of resources

Food provision activities – referring to the whole range of activities from agricultural production to eating – depend on the availability and quality of a variety of natural and human resources, such as energy, nutrients, seeds, water, land and labour. The ways in which resources are used and the amounts of resources needed to produce food differ according to the system of urban food provisioning, but generally speaking, many of the crucial resources for food provisioning are depleting at a rate in which they are likely to become scarce. Changes in the use of resources – both in the way they are used and in the amounts needed – are therefore inevitable to safeguard urban food provisioning in the long term. The most important resource constraints for urban food provisioning are:

a) *Fossil fuel.* Food production, processing, distribution, storing and sales have become heavily dependent on fossil fuels and as a result the globalized food system contributes significantly to greenhouse gas (GHG) emissions and hence to climate change (Carlsson-Kanyama et al. 2003, Carlsson-Kanyama and Gonzalez 2009, Lang 2010). Life cycle analyses of Western diets indicate that it takes an average of seven calories of fossil fuel energy to produce one calorie of food energy (Heller and Keoleain 2000). Although different elements of the global food supply chain contribute to this energy inefficiency, the "heavy fossil fuel users" are pesticides and chemical fertilizer, food processing and packaging, food transport (depending on the means of transport) and cooling (during transport, storage and sales) (Pimentel et al. 2008). Regarding the type of food product, animal protein supply chains require more fossil fuels than do crop supply chains. This implies that the expected dietary changes occurring as a result of urbanization (more processed food and more animal protein) will lead to an increased demand for fossil fuel if nothing changes in the energy input-output ratio of food provisioning. The second implication is that the price of food will be strongly influenced by the price of oil – as actually happened during the food price hikes in 2008 – and this may worsen the food security situation for the urban poor in developing economies, who spend up to 80% of their income on food (De Schutter 2014).

b) *Water.* Most of the world's surface water and groundwater is used for the production of food. In the UK, the average use of tap water is 150 litres per person per day. If the amount of water embedded in the products that are used is included, the daily water consumption amounts to 3,400 litres per day. Of this, 65% is embedded in the food that is consumed: "A tomato has about 13 litres of water embedded in it; an apple has about 70 litres; a pint of beer about 170 litres; a glass of milk about 200 litres; and a hamburger about 2,400 litres" (www.waterwise.org.uk/pages/embedded-water.html).

Mekonnen and Hoekstra (2011: 1578) make a distinction between blue, green and grey water to calculate the water footprint of food products: "The blue water footprint refers to the volume of surface and groundwater consumed (evaporated) as a result of the production of a good; the green water footprint refers to the rainwater consumed. The grey water footprint of a product refers to the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards".

Mekonnen and Hoekstra (2011) conclude that 78% of the water used for crop production is green water and 12% is blue water, but that the fraction of blue water increases for crops produced in arid and semiarid regions. For the production of animal protein (meat, dairy and eggs) the water footprint is (much) higher. Beef cattle have the highest contribution to the global water footprint, followed by dairy cattle, pigs and chickens. Industrial forms of livestock husbandry have a higher water footprint than grazing systems. Also the share of blue water in the overall water footprint is higher for industrialized forms of animal husbandry. Mekonnen and Hoekstra (2012) conclude that "from a freshwater resource perspective, it is more efficient to obtain calories, protein and fat through crop products than animal products". A similar conclusion was already drawn for the use of fossil fuels. It has been estimated that if the entire world population were to adopt a Western-style diet, 75% more water would be necessary for agriculture and this could imply that the world runs out of freshwater (Lang 2010).

c) *Land.* At a global scale land is becoming a scarce resource (Lambin and Mayfroidt 2011), which implies that the competition over land use is becoming increasingly fierce (Lang 2010). Agricultural land is needed for the expansion of cities (or construction of new cities), for industrial development and for infrastructure. As many cities, though not all, have developed in areas that were (and often still are) very suitable for agricultural production, the expansion of cities usually goes at the expense of land for agricultural production, triggering deforestation to maintain sufficient amounts of land for agricultural production. In many countries we also witness a growing demand for other forms of land use in rural areas, such as land for recreation, nature and rural dwelling (Van Dam et al. 2006). Another competing claim regarding agricultural land use is the competition between food production and the production of biofuels (Matondi et al. 2011). With an increase in the price of oil, the production of biofuels becomes an economically interesting alternative for food production. Finally, there is also competition over land use for food production, especially in Africa and South East Asia, with foreign governments and transnational corporations buying large areas of land ("land grabbing") that can serve as sites for fuel and food production in the event of future price spikes (Borras et al. 2011).

These three resource constraints – energy, water and land – have for example been identified by New York's City Council as potential threats to New York City's food supply. To improve the resilience of New York City's food system its City Council has developed a food strategy that promotes agricultural production methods that are less energy demanding, supports regional food production to reduce food transport, encourages the development of urban agriculture and preserves farmland in the city's rural hinterland. New York City's food strategy entitled "FoodWorks: a vision to improve NYC's food system" is a perfect example of a City Council's understanding of the relations between these general and global trends like resource depletion and the future resilience of its urban food system:

> Although many of these problems are national and global in nature, there are immediate steps that can be taken within New York City to strengthen our food system. The city can facilitate urban-rural linkages, support a market for regional products, and use its institutional purchasing power to support small and local producers. Moreover, by helping green the city's landscape, assisting companies with adopting new technologies, and exploring better distribution networks, we can begin to address the high energy usage and greenhouse gas emissions characteristic of our food system.
>
> *(Quinn 2012: 8)*

Climate change

Climate change is another condition that will impact on the dynamics and resilience of urban food systems in a twofold way. First of all, climate change already has and will have a tremendous impact on the productive capacity of agriculture across the globe (Garnett 2008). Some regions are expected to benefit from global warming, as this will create a more productive environment (longer growing season, sufficient rainfall), while many other regions are likely to suffer from global warming due to severe droughts and floods and will hence be confronted with food shortages. In particular, some of the currently most food-insecure regions in the world (sub-Saharan Africa, the Middle East and South Asia), which are also the regions with the highest population growth and urbanization rates, are expected to face significant declines in agricultural production. This is partly due to the long-term average temperature increase; but particularly for the most food-insecure regions in the world the frequency and severity of extreme climate events will have the highest negative consequences for food production and food insecurity (Easterling et al. 2007), affecting food availability, food accessibility, food utilization and food systems stability (FAO 2008). The relation between agricultural production and climate change is a dualistic one. On the one hand, agricultural production is largely negatively affected by climate change but, on the other hand, it also contributes to climate change by emitting GHG. This implies that agriculture can also "contribute to climate change mitigation through reducing greenhouse gas emissions by changing agricultural practices" (FAO 2008).

This brings us to the second relation between climate change and urban food systems. As mentioned in the introduction to this chapter, urban heat islands are the result of the combined effect of global warming and the decline in the urban green. Urban agriculture is increasingly recognized for its role in climate change adaptation and mitigation (Dubbeling 2014, see also Chapter 8 in this volume) by creating and maintaining green open spaces and increasing vegetation cover in the city. This can help to reduce urban heat islands by providing shade and increasing evapotranspiration. Preliminary analyses of the impact of (intra- and peri-) urban agriculture on climate change mitigation and adaptation in the municipality of Rosaria in Argentina show that average temperatures in the urban gardens are 2.4 °C lower than in the centrally built environment (Piacentini et al. 2014). Furthermore, green productive urban spaces can help to store excess rainfall and thus reduce flood risks in cities. Urban agriculture can also help to reduce food transport and cool storage of perishable products, which are food-provisioning activities that contribute to GHG emissions. Finally, urban agriculture can play a role in the productive reuse of urban organic waste and wastewater, which may help to reduce energy use in fertilizer production and in organic waste collection and disposal (Dubbeling 2014, Piacentini et al. 2014) and in lowering emissions from wastewater treatment (see also Chapter 7 in this volume).

Public health

Of the 7 billion people on the planet more than 2 billion suffer from diet-related ill-health: obesity, malnutrition and hunger (Lang 2010, De Schutter 2014). According to the *European Strategy for Child and Adolescent Health and Development* of the World Health Organization, "the growing obesity epidemic is one of the most worrying emerging health concerns in many European countries" (WHO 2005: 5). Obesity rates in Europe range from 10 to 38% of the population. In particular, the rapidly rising prevalence of overweight children is alarming (Lobstein et al. 2005). Obesity costs society tens to hundreds of Euros per person per year (Van Baal et al. 2006) and is responsible for approximately 25% of the annual increase in medical spending (Thorpe et al. 2004). Simultaneously, malnutrition is also a growing health concern which, like obesity, is more prevalent among the socially and economically disadvantaged sections of the urban population. Surveys in the United States in the 1990s revealed that up to 80% of elderly people in homes were suffering from malnutrition (Pothukuchi and Kaufman 1999). Research carried out by the charity Age Concern in the UK shows that 40% of people aged over 65 admitted to a National Health Service hospital are malnourished, while an additional 20% may develop malnutrition during their hospital stay (Age Concern 2006).

Child malnutrition is a major concern in many developing countries. Although the overall percentage of child malnutrition is decreasing worldwide, the prevalence of stunting among young children remains high in Africa (in particular western and eastern Africa) and South-Central Asia (De Onis et al. 2012). Particularly in Africa the slow decline in the percentage of malnourished children combined with the rapid population growth leads to an increase in the numbers of stunted children: from 44.9 million stunted pre-school children in 1990 to an expected 64.1 million stunted pre-school children in 2020 (ibid.: 4). Hunger in its most extreme form has decreased globally from over 1 billion people in 1990–1992 (18.9% of the world's population) to 842 million in 2011–2013 (12% of the world's population). According to De Schutter (2014: 4), these figures are an underestimation of the global hunger problem as "these figures do not capture short-term undernourishment, because of their focus on year-long averages; they neglect inequalities in intra-household distribution of food; and the calculations are based on a low threshold of daily energy requirements that assume a sedentary lifestyle, whereas many of the poor perform physically demanding activities".

In many cities, diet-related ill-health is increasingly becoming a driver of change in urban food systems. The origin of the Toronto Food Policy Council (TFPC) can be traced back to the city's Department of Health incorporating food and nutrition in its health policy in the 1980s (Blay-Palmer 2009). The TFPC, established in 1990, has been an advisory body for the Toronto Department of Health for a long time. Similarly, the London Food Strategy developed by Mayor Ken Livingstone was largely inspired by his public health agenda (Reynolds 2009). An example of public health concerns driving urban food system reforms in the Global South is Belo Horizonte's policy to increase the access to healthy food for all urban dwellers along three action lines (Rocha and Lessa 2009):

1. Preventing and reducing malnutrition by assisting poor families and individuals at risk to supplement their food consumption needs, and promoting healthy eating habits throughout the metropolitan region.
2. Bringing food to areas of the city previously neglected by commercial outlets, through partnerships with private food vendors, and regulating prices and controlling quality of basic staples, fruits and vegetables.
3. Increasing food production and supply by providing support to small producers, creating direct links between rural producers and urban consumers, and promoting different forms of urban agriculture.

Belo Horizonte has received national and international recognition for its successful approach in reducing hunger and malnutrition and has been the prime source of inspiration for Brazil's national Zero Hunger *(Fome Zero)* campaign initiated by the Lula administration.

Guiding principles for resilient urban food systems

The variety and complexity of the conditions shaping current and future urban food systems, combined with the interdependency of these conditions, indicate that it is an enormous challenge to create resilient urban food systems. To quote Lang (2010), these conditions "cannot be addressed singly, but must be addressed comprehensively and collectively" as "there is the danger of unintended consequences in single solutions". I will therefore not present solutions but limit myself to a set of guiding principles for designing and developing resilient urban food systems which provide stepping stones for addressing the aforementioned conditions in a comprehensive way.

Adopt a city region perspective

The 2007/2008 food crisis has made municipal authorities more aware of the need to strengthen the resilience of the urban food system. As a result, intra- and peri-urban agriculture have been taken up in municipal and sometimes also in national policies (Blay-Palmer 2009, Rocha and Lessa 2009, De Zeeuw et al. 2011, Moragues-Faus et al. 2013) in many developing countries, initially with a strong focus on enhancing food security and reducing poverty. With climate change becoming a more prominent urban challenge in recent years, strategies to reduce the urban ecological footprint and urban heat islands and to mitigate climate change have been incorporated as additional goals for intra-urban and peri-urban food production programmes in cities in developing countries. In Europe and North America public health concerns (obesity and malnutrition) together with concerns about the ecological footprint of urban food systems, have been the main reasons for municipal and regional authorities to place food on the urban agenda (Moragues-Faus et al. 2013). According to De Zeeuw et al. (2011), these trends in both developing and developed countries "fit with concepts in urban development that stress the regionality of city space", which indicates "a spatial and economic urban development model that focuses on a regional urban system in which various nodes interact with each other and with the open spaces included in such a functional urban region".

Hence, the first guiding principle is to adopt a city region perspective on urban food systems, implying that the city region is the most appropriate level of scale to develop and implement an integrated and comprehensive solution for a future-proof urban food system. Due to the diversity in the characteristics, problems and challenges of urban food provisioning systems, it is impossible to develop an integrated comprehensive set of solutions that can work in all city regions. Each city region has its specific characteristics, challenges and solutions and hence it is vital that city regions "assess their food dependencies, identify weaknesses and potential pressure points and, where possible, develop a variety of channels through which they can procure their food" (De Schutter 2014: 15).The Zero Hunger policy of the Brazilian city of Belo Horizonte (Rocha and Lessa 2009) and New

York City's food vision FoodWorks (Quinn 2012) are both based on a thorough analysis of the strengths and weaknesses of the city's food system, including the city's relation with its rural hinterland through its different food provisioning channels. As weaknesses and opportunities are context specific, the programmes developed by Belo Horizonte and New York City differ greatly: in Belo Horizonte the focus has been on reducing hunger and malnutrition among the urban poor and on creating direct access to food markets for peri-urban family farmers (Rocha and Lessa 2009), while in New York City the emphasis has been on fighting obesity, preserving farmland and supporting urban agriculture to create a green infrastructure to mitigate climate change (Cohen and Wijsman 2014).

Furthermore, the city region is increasingly becoming the appropriate level of action as a result of the aforementioned decentralization of policy responsibilities (Cohen 2006). Many of the conditions shaping urban food systems refer to policy domains for which many local governments bear responsibility (e.g., waste management, transport, spatial planning, environmental health) or are expected to develop programmes and strategies (e.g., biodiversity, climate change, public health).

Connect flows

A second guiding principle is to connect different urban flows, allowing resources in waste to be recovered for flows creating value. Due to the sanitary-environmental approach to urban waste management (Geels 2006), different urban flows that were once interdependent (e.g., pigs in cities fed on organic waste) have become disconnected from one another. In most cities in developed countries and in (parts of) some cities in developing countries, domestic wastewater and urban rainwater disappear from the urban scenery through sewage systems. In many cities in developing countries the lack of sewage systems and floods resulting from heavy rainfall pose an enormous challenge. Solid waste (organic and non-organic) is put into a landfill or is being incinerated. The collection and disposal of urban waste generally take up a large percentage of municipal budgets and contribute to GHG emissions. However, urban waste can be used for other purposes as well, that may have a higher rather than lower value (up-cycling rather than down-cycling).

When it comes to food waste there is a systematic approach developed in the Netherlands, called Moerman's ladder, which starts with preventing food waste, followed by a range of possibilities for optimizing residual food waste streams (Van der Schans et al. 2014):

- Use for human food (e.g., food banks).
- Conversion to human food (processing).
- Use as animal feed.
- Raw material for the industry (bio-based economy).
- Transforming into fertilizer through cofermentation (+ energy generation).
- Transforming into fertilizer through composting.

- Input for sustainable energy (goal is provision of energy).
- Incineration (goal is destruction, with potential benefit of providing energy).

Using food waste as animal feed not only reduces the amount of food gone to waste but also reduces the amount of water needed for the production of animal protein: "Animal farming puts the lowest pressure on freshwater systems when dominantly based on crop residues, waste and roughages" (Mekonnen and Hoekstra 2012: 413). In Europe it is, however, not allowed to feed kitchen waste to pigs, as this has been restricted after the Boviene Spongiforme Encefalopathie (BSE, also known as mad cow disease) crisis.

Another waste flow that could be converted into a valuable resource is that of human excrements (Cofie and Jackson 2013), which are rich in nutrients, in particular phosphate, which is one of the resources that may become scarce in the future. From a sanitary hygiene perspective there are quite a few legal and cultural barriers to use human excrements as a resource for food production (Geels 2006, Jewitt 2011). Pilot studies about collecting and co-composting faecal sludge and solid organic waste are, however, promising (Cofie and Jackson 2013) and may create both sanitary and economic solutions for cities in developing countries where sewage systems are lacking in large parts of the city. The potential of intra- and peri-urban agriculture in the productive reuse of urban organic waste and wastewater is further explained in Chapter 7.

Using the waste generated by one flow as the input for another flow implies that the approach to waste management should shift from reducing something harmful to adding something useful. This is, for instance, central to the Cradle-to-Cradle approach of McDonough and Braungart (2002) in which waste equals food. Circular metabolism is a similar concept increasingly featuring in the academic debates about creating more sustainable cities: "the long-term viability and sustainability of cities is reliant on them shifting from a linear model to a circular model of metabolism in which outputs are recycled back into the system to become inputs" (Broto et al. 2012: 853).

There are many different ways in which flows can be (re-)connected, ranging from decentralized low-tech systems to more centralized high-tech systems. Within agro-ecological production systems the production of compost from household waste and the use of human urine as liquid fertilizer in agriculture or urban wastewater-fed aquaculture are examples of decentralized low-tech systems of connecting flows (Cofie and Jackson 2013). Within agro-industrial production systems, metropolitan food clusters and agroparks based on the concept of industrial ecology are examples of spatially clustered and connected chains of food production, in which the waste or by-product of one chain can serve as a resource for another chain (Smeets 2011). Which kind of system or combination of systems works best will depend on the specific characteristics of a city region. Agroparks may be the best solution for mega cities with a small or poor productive rural hinterland and/or with a small percentage of the population working in agriculture, while other systems may perform better in cities that lack sewage systems, in which a large part of the population earns a living from intra- or and peri-urban agriculture.

Create synergies

A third guiding principle in the design of resilient urban food systems is to create synergies. The aforementioned guiding principle of connecting flows can also be seen as an example of creating synergies by constructing urban food systems in which waste can be used as, or converted into, a valuable resource. In this section the emphasis will be more on spatial synergies by achieving multiple benefits from the same place and on creating synergies by using food as a medium to link different urban policy objectives. Developing multifunctional urban and peri-urban agriculture and agroforestry spaces in city-regions may serve different purposes simultaneously. For instance, the cultivation of rice in the floodplains in Antananarivo (Madagascar) provides a staple crop for a large part of the urban population, mitigates floods during the rainy season, contributes to income generation and job creation for farmers and reuses urban wastewater that flows onto (intra- and peri-) urban agricultural land (Renting et al. 2013).

Another example is rooftop farming, which can contribute to greening of cities, reduce energy consumption for heating and cooling buildings, help to combat urban heat islands, be used for storm water containment and generate biodiversity in cities (Mandel 2013, Ackerman et al. 2014). Other examples of creating spatial synergies through intra- and peri-urban agriculture are, for instance, the synergies between food supply, leisure and education in agro-recreational parks in different Chinese cities, the synergies between food production, climate change adaptation and water management in Amman (Jordan), and the synergies between food provisioning, green urban infrastructure and biodiversity conservation in Cape Town (South Africa) (Renting et al. 2013).

By rethinking and redesigning systems of urban food provisioning, several urban policy domains can be addressed simultaneously, for instance enhancing environmental quality, alleviating poverty, reducing nutrition insecurity and generating jobs. In the Introduction, the problem of air pollution caused by vehicle emissions was mentioned. As a significant percentage of vehicle movements in cities is related to food delivery and food purchase (Pothukuchi and Kaufman 1999), measures to reduce food transport and to use modes of transport that emit less GHG, fewer fine particles and less lead may help to improve air quality. The aforementioned case of egg supply in Dar es Salaam by bicycle from intra- and peri-urban farms to street shops and wet markets is an interesting example in this respect. This system of food provisioning is not only one without GHG emissions during transport and little to no waste as egg trays are being reused, it also outperforms the more corporate system of industrialized agriculture and supermarkets with regard to the accessibility and affordability of eggs (Wegerif 2014).

Protecting land for urban farming, developing people's markets within walking distance of as many people as possible and better designed cycle paths to increase safety and extend the effective range of bicycles would be important measures to reduce air pollution caused by food transport, enhance food and nutrition security for the urban poor and safeguard jobs and income generation in the urban food economy (ibid.: 3775). Other urban policy domains that can be addressed by redesigning the urban food systems are, for instance, public health, community building and education (Pothukuchi and Kaufman 1999, Brown and Jameton 2000, Mikkelsen 2011). Creating synergies between urban sustainable development goals through rethinking and redesigning the way food is produced, transported, sold and eaten requires the support from governments by including food as a topic in urban policy and planning (Pothukuchi and Kaufman 1999, Viljoen and Wiskerke 2012).

Plan for resilient urban food systems

This brings us to the fourth and final guiding principle, i.e., to plan for resilient urban food systems. As discussed in the introduction to this chapter, food has been absent on the urban policy and planning agenda for many decades. Urbanization, combined with decentralization of policies and a growing understanding that many urban challenges are either directly related to, or influenced by, the system of food provisioning, makes food a suitable vehicle to integrate the economic, social and environmental dimensions of sustainability, as well as addressing justice and health issues.

In recent years, a rapidly growing number of cities in Europe and North America are developing food policies or strategies (Moragues-Faus et al. 2013, Morgan 2013) in which food provisioning challenges are addressed simultaneously with concerns and problems related to public health, quality of neighbourhoods, climate change, biodiversity, energy and transport. But cities in developing countries and emerging economies are also developing or have already well-developed programmes and policies in support of resilient urban food systems. Examples are Rosario (Argentina), Lima (Peru), Belo Horizonte (Brazil), Kesbewa (Sri Lanka), Antananarivo (Madagascar), Casablanca (Morocco) and Bogota (Colombia) (De Zeeuw et al. 2011, Renting and Dubbeling 2013). Urban food strategies, described as "a process consisting of how a city envisions change in its food system, and how it strives toward this change" (Moragues Faus et al. 2013: 6), differ tremendously between cities as they are shaped by the particular characteristics and circumstances of a city, like historical and cultural factors, strength and basis of the local economy, geographical setting, access to food sources and infrastructure, the political and democratic system, and strength of the state and of civil society (ibid.: 5). Developing comprehensive urban food strategies capable of, or at least enabling, the aforementioned connection of flows and creation of synergies are difficult, but not impossible, as the cases of Belo Horizonte (Rocha and Lessa 2009) and Toronto (Blay-Palmer 2009) show.

As the food policies and strategies of many cities are relatively new, it is difficult to assess if, and to what extent, these integrated comprehensive approaches are capable of successfully addressing the challenges that urban food systems are facing. However, the few city regions that began developing and implementing a food strategy about two decades ago, such as Belo Horizonte and Toronto, show that significant progress can be made in different domains simultaneously (Rocha and Lessa 2009, Blay-Palmer 2009). The importance of developing such integrated and comprehensive strategies at city-region level is increasingly understood by local authorities in all regions of the world, as for instance symbolized by the 2013 Bonn Declaration of Mayors at the 4th Global Forum on Urban Resilience and Adaptation: "We invite local governments to develop and implement a holistic ecosystems-based approach for developing city-region food systems that ensure food security, contribute to urban poverty eradication, protect and enhance local biodiversity and that are integrated in development plans that strengthen urban resilience and adaptation" (http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/ Resilient_Cities_2013/ MAF_2013_Bonn Declaration_of_Mayors.pdf.).

As integrated urban food strategies cross different policy domains, one of the key challenges is to organize the administrative and political responsibility for an urban food strategy. Pothukuchi and Kaufman (1999) propose three different options: a municipal department of food, food as the responsibility of the planning department or a food policy council. A department of food might offer a new focal point for urban food issues but which has the danger of becoming a department in itself, and thereby losing the possibility of using food as a vehicle to link different urban policy domains and goals. In that respect it would be better to have an interdepartmental body linked to, and governed by, the different municipal departments that are responsible for food-related issues. The success of Belo Horizonte's food strategy is largely attributed to the Secretariat for Food Policy and Supply (Secretaria Municipal Adjunta de Abastecimento – SMAAB), an example of such an interdepartmental body (Rocha and Lessa 2009). Food as the responsibility of the planning department can bring a more holistic understanding of the food system by putting food in the centre of urban and regional planning.

A food policy council, which can also be complementary to a food department, the planning department, or any other relevant municipal department or even the city council or the mayor's office, is a steering group or network of actors from public, civil society and private sectors involved in the formulation and implementation of a food strategy (Moragues Faus et al. 2013). Having stakeholders from the public, private and the civic sphere involved in a food policy council or another kind of partnership has proven to be extremely important for the development of a long-term food strategy and to be less vulnerable to political change (Wiskerke 2009). To what extent this could work in cities and city-regions where the institutional capacity is still weak remains to be seen. The many inspiring cases of urban food policy and planning around the globe are promising and encouraging examples of cities having the energy and capacity to design and construct more resilient urban food systems, capable of addressing the urban challenges of food security, resource depletion, environmental pollution, climate change and public health.

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2

URBAN FOOD POLICIES AND PROGRAMMES

An overview

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1 CITY OF TORONTO/PUBLIC HEALTH, TORONTO FOOD POLICY COUNCIL, CANADA

2 RUAF FOUNDATION, THE NETHERLANDS

Introduction

Historically, the development of cities was intimately intertwined with the development of food and agriculture in the city region. Over the past 65 years this connection has been increasingly lost due to the industrialization and globalization of food systems. Urban policy development and planning increasingly got separated from policy development regarding food and agriculture – and the planning and management of the ecosystem and natural resources – in the hinterland of the cities.

As a consequence, with the exception of land use planning, municipal authorities usually have little influence on defining agricultural and food policies and mainly play roles related to the delivery of national or provincial programmes (Steel 2008; Friedmann 2011; Crush and Frayne 2011).

Many local governments, not only in the Global North but also increasingly in developing countries, have started to acknowledge and reclaim jurisdictional responsibility for food systems activities that directly impact the health and well-being of their residents. Cities and citizens increasingly recognize that local authorities and governments have a role to play to address problems related to urban food insecurity, hunger, the increase of diet-related chronic diseases, the growing dependency on global food markets and large-scale supermarket chains, and the growing vulnerability of the urban food system (distortions in globalized food supply chains, impacts of climate change). For example, over the last 30 years across Toronto a vibrant food movement has sprung up to confront this situation, developing alternatives to the corporate food retail format such as farmers markets, food box programmes, coops, etc. Toronto's food movement is linked directly to the municipal government through the Toronto Food Policy Council, a multi-stakeholder citizen's advisory committee created by Toronto City Council in the early 1990s when it recognized that the city had a role to play to address the food security of its residents (MacRae et al. 2011; Mah and Baker 2012).

To date, hundreds of cities in the USA, Canada, China, Brazil, South Africa, UK, the Netherlands, Germany, and other countries have developed, often in collaboration with civil society and private sector stakeholders in the food system, policies and programmes on urban food security, nutrition, urban agriculture, etc.

The scope and focus of these policies and/or programmes vary widely, ranging from single-issue policies and plans that address one or more specific elements of the food system (e.g., policies to support residential and community gardening, municipal local food procurement policies, policies to improve the food distribution network in underserved areas of the city, food waste reduction and management plans) to comprehensive approaches that seek to assess and plan the urban (or city region) agro-food system including the complex interactions between its various components (production, transport, processing, distribution, consumption and waste-management) and the social, ecological and economic interactions between the agro-food system and other urban systems (see also Chapter 3 of this volume). The spatial scope of these policies and programmes varies (from neighbourhood level to a wide geographic area including various urban centres and substantial peri-urban or even rural areas).

Below we provide an overview of the variety of policies and programmes that cities apply related to the urban and regional food system. To identify these policies and programmes we have drawn on a number of inventories that have been published over the last several years, as well as literature on individual cases. For the USA and Canada the main sources used are Hatfield (2012), MacRae and Donahue (2013) and Hodgson (2014). For Europe the main sources have been the articles on various European cities included in the book *Sustainable Food Planning* (Viljoen and Wiskerke 2012) and the inventory prepared by the Food Links project (Moragues et al. 2013). For urban food and agriculture policies and plans of cities in developing countries we mainly relied on RUAF working paper #2, "Key Issues and Courses of Action for Municipal Policy Making on Urban Agriculture" (de Zeeuw et al. 2007) and the Growing Greener Cities publications by the UN Food and Agriculture Organization (FAO) (FAO 2012; Thomas 2014). From a global perspective, these inventories are incomplete, but do provide a sense of how various municipalities in the North and South are acting on food systems issues. The municipal documents in which these policies and programmes are mentioned include city development plans, sustainability plans, food policy strategies and plans, etc. We could not always determine if these documents were formally adopted by the municipality/council or still had the status of a plan or proposal.

BOX 2.1 TORONTO, CANADA: FOOD POLICY COUNCIL

Toronto's focus on food policy began with the creation of the Toronto Food Policy Council (TFPC) in 1991. Toronto City Council was concerned about the institutionalization of emergency food programmes (food banks) and created the TFPC to look at the systemic causes of hunger and food insecurity. The TFPC is a subcommittee of the Board of Health and advises Toronto City Council on policies and programmes that will increase food security for Torontonians.

In 2001 Toronto City Council endorsed a Food Charter that recognizes Toronto's commitment to realizing the United Nations Covenant on Social, Economic and Cultural Rights, which include "the fundamental right of everyone to be free from hunger" and outlines a series of actions for the city to improve food security. Food security is also embedded in the city's Official Plan that recognizes the importance of rural–urban linkages, and in the city's Environmental Action Plan, which acknowledges that urban agriculture and local food procurement can help the city achieve its environmental goals. In 2010 Toronto Public Health endorsed a food strategy for the City of Toronto, and created a new team to implement the priorities articulated in the strategy. Current initiatives include a food retail analysis, a healthy corner store pilot project, a community food sector procurement pilot and an urban agriculture action plan. The TFPC now has an expanded mandate to act as the community reference group for the food strategy.

The City of Toronto has passed numerous policies and developed programmes related to improving the food system over the past 20 years. These include:

- A community gardens policy with the goal of creating a garden for every ward in the city and a programme in the Parks and Recreation Department that supports community garden development.
- Supporting the establishment of farmers markets in city parks and at civic centres.
- Food and beverage sector specialist on staff to support new and existing food businesses.
- Creating and providing financial support to a student nutrition programme.
- Local food procurement policy with the goal of 50% local food purchased by City Divisions.
- Toronto Food Strategy endorsed with financial support dedicated for implementation.
- Food truck policy.
- Regional Food and Farm Action Plan endorsed with financial support dedicated for implementation.

- Toronto Agriculture Programme created to support scaling up of urban agriculture.

The TFPC continues to bring new policy ideas forward to the city, most recently illustrated by its advocacy for increased city support for urban agriculture that resulted in the creation of the Toronto Agriculture Program and an urban agriculture steering committee chaired by the Deputy City Manager. The City of Toronto also endorsed and contributes staff time and financial resources to a regional economic development strategy for the food and agriculture sector: The Golden Horseshoe Food and Farm Action Plan.

A number of factors contribute to the success of Toronto's food policy activities: 1. Toronto Public Health's ongoing staff support and resources for the TFPC and Food Strategy implementation; 2. embedding responsibility for programmes and activities across various City Divisions including Parks, Forestry and Recreation, Environment and Energy Division, Social Development, Administration and Finance, etc.; and 3. drawing on the expertise of food system stakeholders to provide strategic advice and support for policy and programme implementation.

More information about Toronto's food policy development can be found at www.tfpc.to.

Sources: Blay-Palmer 2009; Mah and Baker 2012; Roberts 2014.

Main objectives of urban food policies and programmes

Our review suggests that the various food and agricultural policies and programmes developed by cities can be grouped under four main objectives:

1 *Realize equitable (physical and economic) access for all citizens* to safe, healthy, affordable, culturally appropriate food and reduce hunger and dependency on food aid/charity.
2 *Secure adequate nutrition and public health,* especially for people at risk of (under or over) malnutrition and related health problems.
3 Promote (sustainable) food production, processing and distribution within the city region (especially by small-scale producers) in order to *stimulate the local/regional economy and enhance urban food security.*
4 Optimize the contributions of the urban food system to *urban environmental sustainability, diversity and resilience.*

The first and second objectives focus on the social and health dimensions of the urban food system, while the third and fourth objectives focus on the contributions of the urban food system to the local/city-regional economy and ecology, respectively.

Many of the documents reviewed contain specific policies and programmes that relate to only one or two of the above four objectives. Only the few comprehensive urban food strategies or plans cover several or all of these objectives.

Municipal policies and programmes regarding the urban food system

We provide below an overview of the (planned or ongoing) municipal policies and programmes regarding the urban (or city-region) food system. We grouped these policies around the above-mentioned four main objectives. Some policies are mentioned more than once since such a policy might be used to realize different objectives. In such cases, we provide details about the policy only once.

For each policy identified, we give one or more examples to illustrate the variation in the way cities implement a certain food policy. For several policies it was easy to find many examples (e.g., creation of farmers markets, preferential food procurement, supporting community gardening or school food programmes), of which we include only a few. For other policies (like policy measures aiming to enhance access of the urban poor to food by means of regulating food prices, raising minimum wages or creating job/income opportunities for poor or disadvantaged households) it was more difficult to find examples of application by municipalities.

This overview is by no way exhaustive and is only meant to provide insight into the diversity of policies and programmes cities have developed – often in close interaction with other local stakeholders in the urban food system – in order to strengthen the urban food system, or certain component(s) of that system.

BOX 2.2 BELO HORIZONTE (BRAZIL): ENHANCING FOOD SECURITY, EMPLOYMENT AND INCOME FOR THE URBAN POOR

In 1993 the City of Belo Horizonte created the Municipal Secretariat of Food Supplies (Secretaria Municipal de Abastecimento, SMAB) to address food security ("that all citizens have the right to adequate quantity and quality of food throughout their lives"), recognizing that it is the duty of governments to guarantee this right. The creation of the SMAB, with a separate administrative structure and budget, mainstreamed food security into the municipal public policy (Rocha 2001). The programme is advised by COMASA (Conselho Municipal de Abastecimento e Segurança Alimentar), a 20-member council with representatives from other governmental orders and institutions, labour unions (agricultural and industrial workers), food producers and distributers, and civil society organizations.

The municipal programme implemented by SMAB includes three parallel and interconnected programmes (Rocha 2001). The first provides supplementary food assistance to food-insecure households. The second addresses equitable food access by regulating the price of basic healthy staples and linking the private sector to areas with poor food access. The third programme provides technical and financial incentives to local and small-scale food producers to grow, distribute and market their products by creating supply-chain connections between rural producers and urban consumers and promoting (intra- and peri-) urban food production.

The municipal programme is embedded within the national "Fome Zero" (Zero Hunger) Strategy that aims to reduce hunger and address food insecurity across Brazil. "Fome Zero" includes measures to create jobs for the urban poor and increase the minimum wage in order to enhance their food security, links healthy food access to family farming in the city region, and recognizes the importance of partnerships between the public, private and civil society sectors.

The World Future Council notes the following achievements and results of the Belo Horizonte policy and associated programmes:

- A reduction of child mortality by 60% in the first 12 years.
- A reduction of malnourishment among children under the age of five by 75%.
- An increase of fruit and vegetable consumption by 25%.

Sources: Rocha and Lessa 2009; World Future Council 2013.

Objective 1. Enhance equitable (physical and economic) access to safe, healthy, affordable, culturally appropriate food especially of the urban poor and disadvantaged households and reduce hunger and dependency on food aid/charity

Policies applied in relation to this objective are the following:

1.1 Policy measures to generate job and income for the urban poor

- Belo Horizonte (Brazil) adopted measures to increase the minimum wage and stimulates commercial food production projects to employ urban poor and disadvantaged (see Box 2.2 and Rocha and Lessa 2009).

1.2 Policy measures to regulate prices and control quality of basic staples, fruits and vegetables

- Belo Horizonte: see Box 2.2 and Rocha and Lessa 2009.
- Toronto (Canada) supported the creation of – and provides funding for – FoodShare Toronto's Good Food Box, a non-profit food access and distribution

programme that makes healthy, good-quality fruit and vegetables (sourced directly from local farmers when possible) available for the wholesale price (www.foodshare.net).

1.3 Policy measures to improve food distribution within the city

1.3.1 Protection of shops in low-income neighbourhoods that provide day-to-day food needs (especially fresh and healthy food)

- United Kingdom: the "Town first" policy protects inner-city shops from superstores in the city fringe (DC&LG 2012).
- Portland (USA) supports the viability of grocery stores in neighbourhood centres (especially sole shops), e.g., by abatement of property taxes (Portland Council 2012).

1.3.2 Support for the establishment of (healthy) food outlets in underserved areas

- Chicago (USA): The Chicago Retail Programme provides incentives (e.g., property tax abatements and low-interest loans) to private food vendors (supermarkets and other grocery stores) who invest them in underserved areas (Pothukuchi 2005).
- Belo Horizonte supports the establishment of ABC-markets ("food at low prices") and People's Restaurants in low-income neighbourhoods (Rocha and Lessa 2009).
- Baltimore (USA): The City Health Department operates a Virtual Supermarket Program (VSP) that increases access to healthy foods for low-income residents with low vehicle and low internet access by allowing them to place and receive grocery orders at their local library, elementary school, or senior/disabled housing site without paying a delivery fee (see: http://archive.baltimorecity.gov/Government/AgenciesDepartments/Planning/BaltimoreFoodPolicyInitiative/VirtualSupermarket.aspx).

1.3.3 Facilitating the establishment of farmers markets especially in or close to neighbourhoods that lack access to fresh and healthy produce

- Philadelphia (USA) identifies potential farmers market sites on public property (including streets, parks, bus stations, schools, institutions) and on private property (e.g., hospitals and commercial centres) and incorporates spaces suitable for new farmers markets into larger development projects (DVRPC 2011).
- Sacramento (USA) provides incentives for street and farmers markets (e.g., low market fees and stall costs) (City of Sacramento 2009).
- Bristol (UK) seeks to maintain independent retailers – especially in underserved areas – by promoting to buy (preferably locally produced food) in independent retail shops (http://bristolindependents.co.uk/).

FIGURE 2.1 Malmö sustainable development and food policy
Source: City of Malmö.

1.3.4 Support for the establishment of consumers' food-buying cooperatives by low-income groups

- Manchester (UK): The Manchester Food Futures funding scheme supports consumers' food-buying cooperatives (Manchester City Council 2007).
- Brighton and Hove Food Partnership (UK) promotes the creation of buying groups and food cooperatives by provisioning information on suppliers and creation process (www.bhfood.org.uk/food-buying-groups).

1.4 Policy measures to facilitate home and community gardening and small-scale livestock keeping especially by low-income and disadvantaged categories of the urban population

1.4.1 Accommodation of zoning regulations to allow front and back yard gardening/small livestock keeping and community gardening in residential areas

- London (UK) incorporated urban agriculture in the London Development Plan which commits the city to support urban agriculture especially in locations near food-insecure and vulnerable urban communities, and obliges local authorities to include space for urban agriculture in local spatial planning (London Assembly 2010).

1.4.2 Provision of access to vacant municipal land (especially close to low-income areas) and facilitate access to semi-public spaces (like the grounds of schools, hospitals, community centres) for community and school gardens

- Cape Town (South Africa) leases out underutilized land around public facilities, road verges, etc., to groups of urban poor households and to prospective individual urban farmers and gardeners (City of Cape Town 2007).
- Pretoria (South Africa) entered into a partnership with low-income citizens to manage municipal open spaces that combine community gardening with other functions (park or recreational area) (de Zeeuw et al. 2007).
- Baltimore maintains a land bank of available vacant city-owned land and provides such land to commercial small-scale urban farmers in five-year leases (2 years' notice) (BCPC 2013).

1.4.3 Facilitating access of poor urban producers to private vacant land (e.g., land bank, tax incentives)

- Rosario (Argentina) created a Municipal Agricultural Land Bank (a cadastral-based land registry) and brings those in need of agricultural land in contact with the owners of vacant land. The city also leases vacant land from private landowners to sub-lease it to community groups interested in using the land productively. A third effective instrument used in Rosario is the increase of municipal taxes on idle urban land and reduction of taxes for landowners who make idle land available for farming (temporary or permanent) (Dubbeling 2004).
- Minneapolis (USA) is creating an online web "match-making" service to connect public and private landowners with people and organizations looking for land to grow food and to establish tax incentives for private landowners who lease land to urban farmers (Minneapolis-DHFS 2009).

1.4.4 Integration of permanent garden space in block and neighbourhood planning and upgrading projects

- Kampala (Uganda) integrates space for home and community gardening in new public housing projects and slum-upgrading schemes (Wolfe and McCans 2009).
- Toronto's policy to establish one community garden in every city ward has resulted in over 100 community gardens in city parks (Toronto Food Policy Council 2012).

1.4.5 Enhancing security of land use for community gardens

- Chicago established NeighborSpace, a land trust to acquire (hitherto vacant) land on which local community groups developed community gardens, in order to ensure their survival and preserve these gardens as a valuable community asset (see the NeighborSpace website: http://neighbor-space.org/about/history-of-neighborspace).

- Amsterdam (the Netherlands) provides longer-term leases to urban gardeners' associations (that rent out plots on an annual renewable basis to individuals) under the agreement that if these areas are needed for other planned uses, the municipality will provide an alternative location and assist with basic infrastructural development (Agenda Proeftuin Amsterdam 2007).

1.4.6 Provision of training, technical assistance and (funds for) inputs, equipment and basic infrastructure to food growing initiatives by the urban poor

- Cape Town provides technical assistance, fencing, basic infrastructure (water connection, storage room), vegetable seeds and seedlings, compost and hand tools to community gardening groups in low-income neighbourhoods (City of Cape Town 2007).
- Brighton and Hove (UK) provides grants for school and community gardening projects (Brighton and Hove Food Partnership 2012).
- London: The Capital Growth programme provides grants, technical assistance and training to growers in new community-based urban food growing initiatives (Reynolds 2009).
- Cleveland (USA) provides infrastructure to collect rainwater runoff from adjacent building roofs to community and school gardens (City of Cleveland 2008).
- Toronto provides grants under the Live Green programme to community groups for training, infrastructure, etc.

BOX 2.3 ROTTERDAM, THE NETHERLANDS: URBAN AGRICULTURE FOR IMPROVED HEALTH AND SUSTAINABLE REGIONAL ECONOMIC DEVELOPMENT

The City of Rotterdam adopted in 2012 the strategic policy document "Food and the City" as part of its "Agenda for Sustainable Rotterdam" (2011).

The main focus in the Rotterdam policy is on three main targets:

1 Improve health of citizens

The main actions in this area undertaken are:

- Public education programmes on healthy food and gardening.
- Stimulation of the creation of new community gardens and rooftop food gardens in dense urban districts.

- Promoting the establishment of school gardens and food education.

2 Reinforce sustainable economic development

The main actions undertaken in this area are:

- Abolishment of land use regulations that hinder initiatives for (including commercial) urban agriculture.
- Provision of municipal land for creating (intra- and peri-) urban farms; inventory of vacant open spaces.
- Support for the establishment of farmers' shops and markets in the city.
- Organize "regional trade missions" to shorten the food chains: Connect local producers with potential urban customers (consumers, restaurants, hospitals, supermarkets, agribusinesses, etc.).
- Preferential procurement of regional food products for municipal catering. Yearly competition for best initiative for urban agriculture by citizens.

3 Improve quality of public spaces

This is implemented as component of the above-mentioned actions (e.g., community- and school-gardens, urban farms) as well as green roofs, cleaning up/greening of vacant open spaces, etc.

Source: van Oorschot 2014.

Objective 2. Improve nutrition and public health especially of people under risk of malnutrition and related health risks

Policies applied in relation to this objective are the following:

2.1 Enhancing access to home and community gardening by the urban poor and disadvantaged

- (See 1.4 above for more details.)

2.2 Prevention of over-concentration of hot food takeaway shops, fast food eateries, liquor and convenience stores in residential areas and around schools and youth facilities

- Tower Hamlets (a municipality of Greater London, UK) adopted a policy regarding fast-food takeaways (A5 restaurants), regulating that applications for new establishments of an A5 are only approved if the A5 is located in a city centre, where A5s are not surpassing 5% of the total number of shops, at least two non-food shops are on both sides of the new A5 and the A5 is not within a 200-metre zone of a school (200–400 metres: approved with restrictions) (Tower Hamlets 2012). Greater London developed a toolkit to guide local councils on this issue: www.london.gov.uk/sites/default/files/TakeawaysToolkit_0.pdf.

2.3 Policy measures that enhance supply of fresh and nutritious food and reduce the supply of unhealthy food

2.3.1 Promoting that healthier food is provided at municipal buildings, schools, business and sports canteens, care centres and hospitals and that the supply of carbonated beverages, processed foods and foods containing trans fat or with high sugar contents are reduced

- Marin County (USA) provides reliable information, training and technical assistance on food and nutrition (and its connections with health and environment) to municipal catering staff, teachers, community organizations and other facilities (MCCDA 2007).
- Malmö (Sweden) established a food procurement scheme for restaurants at schools, nurseries and service centres that is applying the SMART concept (smaller amount of meat, minimize intake of junk food, increase in organic food: right sort of meat and vegetables, transport efficient) (City of Malmö 2010).

2.3.2 Promoting provision of healthy foods at super markets, small grocery stores and restaurants

- Philadelphia requires: a. neighbourhood corner stores and markets to stock a certain amount of fresh and locally grown fruits and vegetables, and b. nutritional information on the labels of food products and menus (DVRPC 2011).
- Portland (USA) supports the viability of grocery stores and local markets in neighbourhood centres that supply healthy, affordable food in underserved areas (Portland Council 2012).
- Toronto Public Health has supported a mobile good food market to travel to underserved communities to sell fresh fruit and vegetables.

2.3.3 Stimulating agro-enterprises in the region to improve the nutritious quality of the food products they provide

- Amsterdam (the Netherlands) stimulates agro-processing industry in the city region that participate in the "Proeftuin Food Centre Amsterdam" to process food produced within the city region and to enhance the nutritious quality of their products (Vermeulen 2008).

2.3.4 Assisting households and individuals at risk to supplement their food consumption needs

- The US Department of Agriculture (USDA) provides supplemental nutritional assistance in the form of food vouchers/stamps to vulnerable households and has made these also exchangeable at farmers markets and similar outlets in order to enhance their access to fresh and nutritious vegetables and fruits (see www.fns.usda.gov/ebt/learn-about-snap-benefits-farmers-markets). In Philadelphia, 31% of the urban households receive such nutritional support.
- Chicago supports food banks collecting surplus food from grocery stores, farms and manufacturers and redistributing it to urban households in underserved areas of the city (Chicago Council on Global Affairs 2013).
- Toronto has committed to a five-year plan to increase investments for the student nutrition programme from US$5 million in 2013/14 to US$9.5 million in 2017/18 (City of Toronto 2014).

2.4 Support for healthy food and nutrition education (especially in low-income areas)

- Philadelphia promotes the integration of training on nutrition, gardening and sustainable food systems into existing school curricula (DVRPC 2011).
- Quito (Ecuador) supports the establishment of school gardens and food education (some 128 to date) (Thomas 2014).
- Manchester (UK) organizes public awareness campaigns about the importance of locally produced and organic food and agricultural products (Manchester City Council 2007).
- Marin County supports local food banks and other organizations providing nutrition education and healthy cooking classes to vulnerable households (MCCDA 2007).
- Brighton and Hove delivers advice on how to shop and cook healthy nutritious food with a low budget (www.bhfood.org.uk).

BOX 2.4 LONDON, UK: IMPROVING FOOD SECURITY, FOOD(T) PRINT, FOOD ECONOMY AND FOOD CULTURE

In 2006, the Greater London Authority Food Team, under the leadership of then-mayor, Ken Livingstone, developed the London Food Strategy: a ten-year timeframe to reform London's food system towards health, sustainability and economic viability, and to:

1. Improve Londoners' health and reduce health inequalities via the food they eat.

2 Reduce the negative environmental impacts of London's food system.
3 Support a vibrant food economy.
4 Celebrate and promote London's food culture.
5 Develop London's food security.

The London Food Board was created to support the implementation of the Food Strategy, and continues to meet and coordinate initiatives with policy and staff support from the Greater London Authority (London Development Agency 2006).

Initially, the Food Strategy has focused on public procurement of school meals and increasing green spaces to grow food. With a change in mayoral leadership, the "Capital Growth Initiative" was launched and created 2012 food garden spaces before the 2012 Olympics and continues to provide support to London's food growing community.

Other initiatives include support for small food enterprises, a food waste project with the goal of preventing food waste and diverting surplus food, and the creation of an apprenticeship programme to attract workers and link them to the food sector (see: www.london.gov.uk/priorities/business-economy/working-in-partnership/london-food-board).

Factors that have led to success for the London Food Strategy are the dynamic food community and multiple partnerships to enable implementation of key priorities, as well as the ability to adapt to the shifting political context and climate. Challenges include a limited budget and fragmented local governance across broader London.

Sources: Reynolds 2009; Morgan and Sonnino 2010.

Objective 3. Enhance sustainable food production in the city region (especially by small-scale producers) in order to stimulate the local/regional economy and enhance urban food security and resilience of the urban food system

Policies applied in relation to this objective are the following:

3.1 Policy measures that facilitate access to land and land use security for commercial (intra- and peri-) urban agriculture

3.1.1 Modification of spatial planning and land-use zoning codes and norms to accommodate commercial farming in (certain parts of) the city

- Dar es Salaam (Tanzania) accepted urban agriculture (crop and livestock) as a major urban land use and included urban agriculture in land use zoning and the Strategic Urban Development Plan (IDRC 2006a).

- Kampala (Uganda) changed its land use regulations and developed a new set of ordinances on urban horticulture, fish culture and livestock rearing, each including sections on production, processing and sales (IDRC 2006b).
- Baltimore adapted its zoning regulations and included commercial urban agriculture as a conditional permanent land use category (urban agriculture defined as the cultivation, processing and marketing of food within the city: horticulture, animal husbandry, aquaculture, agro forestry, vineyards and wineries) (BCPC 2013).

3.1.2 Enabling access to municipal and private land for commercial urban agriculture

- See the policies mentioned under 1.4.2–6 above, but now applied to commercial agriculture.

3.1.3 Preserving and sustaining best and most versatile land in the city region and reserve for agricultural or multi-functional use (e.g., in green belts and corridors)

- Marin County (neighbouring San Francisco) prohibits non-agricultural buildings, impermeable surfaces, or other non-agricultural uses on soils classified as prime or normal farmland soils of state-wide importance (MCCDA 2007).

FIGURE 2.2 Cape Town urban agriculture policy 2007

Source: City of Cape Town.

- Mexico City (Mexico) established a legally protected "conservation area" (organic agriculture + eco-services) (Thomas 2014).
- Allegheny County (USA) encourages infill- and re-development within the existing urban areas of the city (e.g., recycling of an 178-acre former steel factory site in Hazelwood into residential housing areas) in order to minimize the pressure for premature conversion of productive agricultural lands into other uses (Allegheny County 2008).
- Philadelphia maintains affordable land for farmers through a range of potential innovations and new business models, including identification of opportunities for transition of preserved land into food production, and creating investment vehicles for long-term agricultural production on preserved land (DVRPC 2011).
- Minneapolis supports affordable land ownership and/or affordable long-term leases for small enterprise urban agriculture on various types of land and rooftops (Minneapolis-DHFS 2009).

3.1.4 Adaptation of building regulations and zoning codes to enable commercial rooftop gardening and green houses and other building-integrated forms of commercial agriculture

- Seattle (USA) adapted its building regulations to enable rooftop gardening and runs a municipal green roof programme that also promotes rooftop farms (City of Seattle 2012).
- Tilburg (the Netherlands) provides incentives to promote green roofs at residential and non-residential buildings (Plantinga and Derksen 2014).

3.2 Policy measures to enhance the viability of small-scale agricultural producers in the city region

3.2.1 Provision of access to information sources, training, technical advice and business development services to (actual and starting) entrepreneurs in small- and medium-scale urban agriculture

- Minneapolis enhances access to information on new market opportunities, technologies, available sources of financing, technical and business development services, city policies and regulations (Minneapolis-DHFS 2009).
- Tilburg stimulates technological and organizational innovation in commercial urban agriculture (Plantinga and Derksen 2014).
- Chicago (USA) provides job training on food production and processing (CMAP 2010).

3.2.2 Providing access to financing opportunities for agricultural producers in the city region

- Philadelphia incorporates farming and food into its economic development policies and funding programmes and, amongst others, supports farm-to-buyers marketing schemes for nutritious and affordable food with finance for inventory and capital items, technical assistance and advertising support (DVRPC 2011).

- Minneapolis is expanding city-sponsored small business financing opportunities to agricultural producers in the city region (Minneapolis-DHFS 2009).
- Sacramento (USA) is reducing property taxes for agricultural producers within the city administrative boundaries (City of Sacramento 2014).

3.2.3 Defining municipal procurement norms that give preference to buying food from small farmers in the city region to enhance their viability and stimulate the regional economy

- Malmö adopted SMART food procurement regulations (see 2.4.2 above).
- Amsterdam signed a covenant with caterers to purchase organic and regional products for cafeteria services in local government buildings and in organizations and at events sponsored by the municipality (Brand et al. 2010).
- Paris (France) is establishing a local supply chain for school restaurants, procuring organic school meals from local producers (fresh foods within 20 km; bread and beef within 100 km) and subsidizing related extra costs plus technical assistance to involved local organic farmers (Darly 2012).

3.2.4 Promote supermarket chains and other agro-food businesses in the city region to make their products more locally/regionally based

- Amsterdam stimulates agro-processing industry in the city region that participate in the "Proeftuin Food Centre Amsterdam" to preferably process food that is produced within the city region (Vermeulen 2008).

3.3 Policy measures to stimulate the processing and distribution of food produced in the region

3.3.1 Support to collective value adding and direct marketing initiatives by local farmers and social enterprises creating green jobs for the urban poor (e.g., farmers markets, e-marketing, box schemes, crop share schemes, etc.) with land, infrastructure, training, technical support and funding

- Brasilia FD (Brazil) operated the PROVE programme that assisted urban producer groups to establish value adding enterprises by providing organizational and legal support, land, infrastructure, technical and business development advice and marketing support (e.g., establishing brands, farmers markets) (Homem de Carvalho 2005).
- Detroit (USA): The Recovery Park programme provides US$25 million of mixed funding and 100 acres of reclaimed land to support food-related entrepreneurs and community projects to create jobs for people with low access to employment and improve the local economy and neighbourhood (FWP 2013).

FIGURE 2.3 Good food policy London
Source: Sustain.

- Minneapolis established a food business development centre that provides start-up funds, such as low-interest matching loans, and access to technical assistance tailored to starting entrepreneurs and cooperative food initiatives (see: www.minneapolismn.gov/cped/ba/cped_homegrown_business_center).
- Manchester: The Food Futures scheme provides funding to collective processing and marketing initiatives like farmers markets, box schemes, food hubs and other forms (Manchester City Council 2007).
- New York: The Green Thumbs programme supports the establishment and functioning of farmers markets (now over 600) (see: www.greenthumbnyc.org/about.html).
- Northumberland County (Ontario, Canada) is building a processing facility with flash freezing capacity and a commercial kitchen to support local farmers.

3.3.2 Revision of city regulations in order to provide a hospitable but safe regulatory environment for networks aggregating, processing, packing and distributing (healthy, ecologically produced, regional) food to urban consumers

- Minneapolis revised the city regulations in order to provide a hospitable regulatory environment for local foods operations including year-round food production, processing, aggregation and distribution and on site and industrial composting efforts (Minneapolis-DHFS 2009).
- Kampala (Uganda): health and agricultural and town planning specialists closely cooperated in the development of a series of evidence-based ordinances on urban agriculture livestock and fisheries, replacing old regulations containing a lot of ungrounded restrictions for urban horticulturists and livestock keepers (IDRC 2006b).

3.3.3 Promotion of networking and cooperation among local/regional producers and facilitate their communication and cooperation with other actors in the regional food system

- Rosario: The Municipal Urban Agriculture Programme supports the development of the Network of Urban Producers and has assisted the network to establish working relations with strategic governmental and private organizations (Lattuca et al. 2005).
- Mexico City: The Federal District established a Rural Council, representing producer organizations, traders and service providers, to guide its policies and programmes for sustainable sub-urban and peri-urban agriculture (Thomas 2014).
- Amsterdam established a regional food network "Proeftuin Food Centre Amsterdam-Alkmaar" (Tuin = garden; Proef = "experiment" as well as "tasting"), including agricultural producers, agro-processing industries, consumers' organizations and local food initiatives in the city region that promotes regional products amongst others through establishing a regional brand, culinary festivals and fairs of regional products, and organizing "fruit and vegetables" car and biking routes in the city region (Vermeulen 2008).

BOX 2.5 QUITO, ECUADOR: URBAN AGRICULTURE AS A DRIVER OF SOCIAL INCLUSION AND COMPETITIVE LOCAL ECONOMIC DEVELOPMENT

Quito's Participatory Urban Agriculture Programme (AGRUPAR), implemented by the municipality's Economic Development Agency, ConQuito, aims at improving the employment, income and food security of vulnerable populations in the urban and peri-urban areas of Metropolitan Quito. The programme was launched in 2002 and today brings together some 12,250 intra- and peri-urban farmers and 380 community-based organizations, supported by local and national government departments, universities, NGOs and the private sector.

AGRUPAR's primary focus is on enhancing food security and promoting food processing, access to microcredit, microenterprise management and marketing. At the last count, the project had helped establish 140 community gardens, 800 (semi-) commercial gardeners and 314 livestock keepers, and 128 school gardens. Between 2004 and 2012, the project provided training for more than 7,350 people, most of them women, including recent migrants to the city and underemployed workers. The staff of AGRUPAR provide fencing, seeds and seedlings, equipment, animals (such as poultry, guinea pigs and bees), and half of the investment in productive infrastructure such as drip irrigation, small greenhouses and sheds for animal husbandry to groups of at least six persons. The groups also receive technical training on (organic) agricultural production, nutrition and management skills. For those urban famers who lack the capital to invest in productive infrastructure for the agricultural production and/or for the processing and packaging of produce, the project helped to establish 35 grassroots investment societies, to which each member contributes between US$10 and US$20 in start-up capital.

About half of the production is sold; the rest is kept for home consumption. AGRUPAR assists the producer groups with the certification of their products. Certified organic vegetables are sold through farmers markets as well as through home delivery of organic food baskets including vegetables, fruits, herbs, pickles, jams and bread.

AGRUPAR also encourages the participating groups to form microenterprises in food processing and the production of organic inputs, trains them in business planning, marketing and accounting, and has introduced improved processing technologies and the use of packaging and labels. Certified organic chilli and tomato paste are also sold to local food processing companies, free-range chicken meat to restaurants, and jams and pickles through the home delivery scheme. In fact, adding value to surplus production has recently become one of the most prominent features of Quito's urban agriculture, generating revenue and providing full- or part-time employment for half of the project participants.

The average income of households joining the project is around US$350 per month. They make a further saving of at least US$72 a month on food purchases by consuming what they grow. Total savings are 2.5 times the value of the government's human development voucher, which provides US$50 a month to vulnerable households. Urban agriculture has helped diversify the diet of urban farmers and their families. Among the environmental benefits of urban agriculture is the conservation of biodiversity (some 50 edible plant species are maintained in Quito's urban gardens) and the recycling of kitchen wastes as compost. An estimated 1,820 tonnes of organic wastes are recycled each year by AGRUPAR project participants. The increased availability of fresh produce also means less need to transport it from rural areas, which generates fuel savings and reduces air pollution.

A notable AGRUPAR innovation has been the opening of organic produce markets – or *bioferias* – that have become sources of healthy food for Quito residents and a practical example of Ecuador's solidarity economy. The city now has 14 one-day *bioferias,* open weekly between Thursday and Sunday. To ensure the widest possible availability and consumption of organic food produced in urban gardens, *bioferias* are located in low-income neighbourhoods and peri-urban zones, as well as in better-off parts of the city. In 2012, the *bioferias* of Quito sold more than 100 tonnes of organic produce (valued at US$176,000), which amounts to one-quarter of the programme's total estimated garden production.

Quito's experience has shown that intensive agriculture is feasible in an urban environment, and that it helps reduce malnutrition in poor households, strengthens household food security, and generates employment and income. For the municipal government, AGRUPAR is a flagship programme of its social inclusion policy and its vision of competitive economic development. The programme's challenges relate to the lack of a facilitating legal framework for urban agriculture and the need to integrate urban agriculture further into the municipal spatial planning.

Source: Thomas 2014.

Objective 4. Enhancing environmental sustainability, diversity and resilience of the city region

Policies applied in relation to this objective are the following:

4.1 Inclusion of sustainability criteria in the norms for municipal food procurement

- Malmö established SMART norms for municipal food procurement for restaurants at schools, nurseries and service centres: organic food, smaller amount and right sort of meat, minimize intake of junk food, right sort of vegetables, food preferably produced and prepared close to consumers with low GHG emissions and efficient transport, food wastes to be minimized, food wastes to be used in biogas production (City of Malmö 2010).

4.2 Promotion of sustainable eco-friendly agricultural production/processing/distribution methods in the city region

- Montreal (Canada): The municipal community gardening programme promotes ecological gardening methods and only environmentally friendly methods to control bugs, plant diseases and weed infestation are allowed in the city's community garden parks (Reid and Pedneault 2006).
- Havana: The urban agriculture programme in Havana prohibits the use of agrochemicals in the city and supports the establishment of decentralized low-cost facilities for compost production and the production and supply of bio-fertilizers and bio-pesticides (packaged in small quantities) to urban farmers through a network of 52 agricultural stores that also provide technical services, advice and training to the city's farmers. The Havana urban agriculture programme has calculated that producing 1 million tonnes of vegetables applying

agro-ecological production methods saves over US$41 million in the costs of fertilization and pest control as compared to conventional agriculture (Thomas 2014).

- King County provides incentives for agricultural practices that maintain water quality, protect public health, fish and wildlife habitat and historic resources, maintain flood conveyance and storage, reduce greenhouse gas emissions, control noxious weeds, and prevent erosion of valuable agricultural soils while maintaining the functions needed for agricultural production (King County 2011).
- Governador Valadares (Brazil) stimulates the use of ecological techniques in urban agriculture production, processing and marketing by organizing training courses and providing technical assistance to urban farmers' groups (Lovo and Pereira Costa 2006).

4.3 Supporting decrease of GHG emissions related to food production, processing, distribution, consumption and food waste management in the city region

- Amman (Jordan) included urban agriculture/forestry in its plan to mitigate and adapt to climate change and enhance urban resilience (Dubbeling 2013).
- Antananarivo (Madagascar) is protecting agriculture in flood zones to prevent construction of houses and enhance urban resilience (Aubry et al. 2012).
- Philadelphia pays farmers for the ecosystem services they provide, such as carbon sequestration and groundwater recharge (DVRPC 2011).
- Ghent (Belgium) operates a meat consumption moderation campaign (one meat/fish free day/week): maps indicating restaurants serving vegetarian meals (Leenaert 2014).
- Brighton and Howe (UK) supports the set up and running of community compost projects by providing advice, resources and training (www.bhfood.org.uk).

4.4 Providing regulations and incentives to stimulate recovery and agricultural reuse of nutrients and irrigation water from urban organic wastes and wastewater

- Bulawayo (Zimbabwe) provides treated wastewater to poor urban farmers in community gardens (Mubvami and Toriro 2008).
- Amman is actively promoting the recovery, treatment of wastewater and its reuse in peri-urban agriculture, fruticulture and (agro-) forestry (Kfouri et al. 2009).
- Mexico City promotes systems for rainwater collection and storage, construction of wells and the establishment of localized water-efficient irrigation systems (e.g., drip irrigation) in urban agriculture to stimulate production and to reduce the demand for potable water (Thomas 2014).

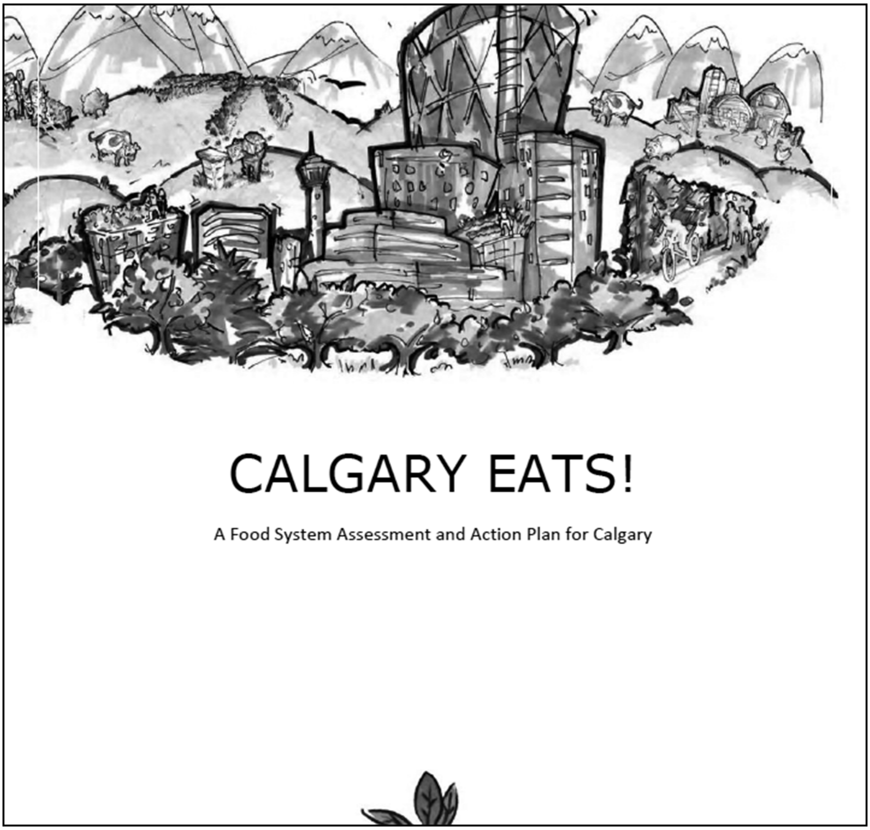

FIGURE 2.4 Calgary eats
Source: City of Calgary.

- King County supports the development and use of innovative technologies to process dairy and other livestock wastes to reduce wastes and create energy and compost. King County also operates a municipal food recovery programme and provision of this food to organizations that distribute food to low-income groups (King County 2011).
- Portland is developing efficient systems for the separation and collection of organic wastes from households and vegetable markets (Portland Council 2012).
- Minneapolis supports the establishment and expansion of composting infrastructure in the city region (Minneapolis-DHFS 2009).

4.5 Facilitating protection and conservation of agricultural land and water resources

- See 3.1.3 but now with the emphasis on management of natural resources, biodiversity, and land- and water-conservation.

4.6 Adoption of new productive and environmentally friendly approaches to neighbourhood planning

- Tilburg developed "De Groene Kamer" (the Green Room, an estate combining retail, nature, agricultural production and recreation) and "De Nieuwe Waranda" (a residential area integrating housing, retail, agriculture and eco-education/agro-recreation) (Plantinga and Derksen 2014).
- Almere developed the Oosterwold area (4000 ha) as a "rurban" area: a continuous productive landscape including housing, food production, water management and biodiversity and recreational services; in 2030 the area should produce 10% of locally consumed fruit and vegetables, which would reduce food-related GHG emissions in Almere with an equivalent of about 5,000 households (if organic production methods are applied) (Jansma et al. 2014).
- Chicago includes space for urban agriculture in several neighbourhood plans (CMAP 2010).
- Detroit is adapting neighbourhood plans to include mixed use zones and facilitating the transformation of vacant properties to urban green spaces by local actors (gardening, forestry, etc.) with joint planning and technical advice (FWP 2013).
- Minneapolis established norms and provides incentives to require/encourage developers to include space for food production and distribution and composting in new developments (Minneapolis-DHFS 2009).

BOX 2.6 MEXICO CITY, MEXICO: ORGANIC AGRICULTURE PRESERVING THE PERI-URBAN ENVIRONMENT

Since 2000, Mexico City's government has increased its support to agriculture in the Federal District, with the main objective of protecting the ecosystem services that suburban and peri-urban areas provide to the city and, to a lesser extent, to ensure a local food supply. The Federal Environmental Law promotes organic farming systems and prohibits the use of agrochemicals and synthetic fertilizers in the demarcated conservation zone. Training, technology development, agro-processing and marketing support are provided to the producers and the amounts spent between 2007 and 2012 were some US$24.6 million in horticulture, floriculture, and crop and livestock production, US$37 million in the conservation and sustainable use of natural resources in primary production, and US$1.8 million in emergency assistance to farmers affected by extreme weather events, such as drought and flooding. Another programme, for the promotion of traditional food culture, helps rural farmers to enter local, national and international markets, and organizes trade fairs and exhibitions in the Federal District and provides subsidies to farmers who preserve local maize varieties under traditional production systems with low environmental impact. Meanwhile, the city's Secretariat for the Environment has instituted Mexico's first system of organic certification of produce, known as the Green Seal, and has set standards for organic agriculture in the conservation zone.

Source: Thomas 2014.

Final observations and recommendations

This chapter reviewed the specific policies and programmes developed by municipalities related to the urban – or city-region – food system. We observe a trend to link specific policies and programmes through comprehensive urban food system strategies or plans. We also observe a gradual shift from food planning at the neighbourhood-city level to the city-region level (or more correctly: the city-region level is added).

Governance is critical for both the development of these policies, as well as their implementation. Many jurisdictions are engaging multi-stakeholder groups to support this policy development. This is discussed in Chapter 3.

In urban food policies and plans prepared by cities in the Global South, more attention is often given to social inclusion, employment creation and income generation for/by the urban poor through (intra- and peri-) urban agriculture, providing access to urban markets for small-scale producers in the city region and more recently the role of urban agriculture in city climate change mitigation and adaptation strategies.

In urban food policies and plans formulated in the Global North, often the focus has been on improving physical access to (healthy, nutritious) food, support for community gardens, urban agriculture and farmers markets, and local food linkages. More recently, strengthening the regional food production, processing and distribution system is getting attention.

Many food policies or programmes do not contain measurable goals, which makes it difficult to monitor to what extent the expected changes in the urban food system are realized. Hodgson (2014) also observed this and recommended to include aspirational goals (indicating the longer term perspective) and specific measurable goals (to be attained in a certain period of time along the route indicated by the aspirational goals). There is a strong need for comparative evaluation of the impacts of urban and city-region food policies, strategies, plans or programmes in order to get a better understanding of the effectiveness of the various policy measures applied and results obtained in relation to the investments in such programmes. Such information will be of great importance for the planning and decision making on future food policies.

In many cities the ambitions of the food policy or strategy are not in balance with the funding made available for implementation. Bock and Caraher (2014), reviewing a number of European experiences, come to the conclusion that the activities implemented in the context of an urban food policy, plan or strategy are mainly rather small scale and dispersed and that these will not lead to structural system change. However, examples of more mature implementation of an urban food policy implementation suggest the potential for transformative reform (i.e., Belo Horizonte).

Many food policies and programmes and plans also face complex jurisdictional problems. Urban food planning requires alignment across various orders of government, as well as the involvement of various departments/disciplines and a range of civil society and private actors. There is a clear need for linked and supportive policy across orders of government and across government departments. The urban food system does not neatly coincide with the municipal area. Moreover, few municipalities will have the human and financial resources to analyse the food system, develop food policy and make significant investments without support and incentives from other orders of government and pioneering funders. This creates the need for food and agriculture planning beyond the municipal administrative boundaries (OECD 2013; Harrison and Hoyler 2014). National governments should support, encourage and incentivize municipal food policy development as a way of realizing their own policy goals and meeting international commitments related to a broad range of food systems issues.

Sharing of experiences across countries and continents should be enabled. Emerging international urban food policy and practice networks, such as the CityFood Network under development by ICLEI (Local Governments for Sustainability) and the RUAF Foundation, may provide essential avenues for sharing urban food policy experiences and could provide capacity building opportunities for municipal staff and officials (see www.ruaf.org/sites/default/files/CITYFOOD%20 brochure%20final.pdf).

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3

PROCESS AND TOOLS FOR MULTI-STAKEHOLDER PLANNING OF THE URBAN AGRO-FOOD SYSTEM

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Introduction

The foregoing chapter focused on the policies and programmes certain cities apply in order to strengthen the agro-food system in their city region. In this chapter we will discuss the experiences gained regarding the *process* of multi-stakeholder planning of the agro-food system in a community, city or city region in countries of the global North or South and *tools* that may be used in that process.

Our point of departure will be the experiences gained in the "Cities Farming for the Future" (CFF) and "From Seed to Table (FStT)" programmes implemented by the RUAF Foundation in close cooperation with international, regional and local partners in 20 cities in 17 developing countries during the years 2004–2011 (Dubbeling et al. 2010; Dubbeling et al. 2011; Amerasinghe et al. 2013) and the experiences gained in a large number of cities in the USA/Canada and Europe as summarized in a number of recent international publications (including Harper 2009; Freedgood et al. 2011; White and Natelson 2011; Viljoen and Wiskerke 2012; MacRae and Donahue 2013; Moragues et al. 2013).

Before discussing the various phases in the process of multi-stakeholder planning of the urban agro-food system and assessment and planning tools that may be applied in that process, some general considerations have to be made:

City-region agro-food system

The UN Food and Agriculture Organization (FAO) and partners defined at the World Urban Forum "City-region food systems" as follows: "the complex relation of actors, relations and processes related to food production, processing, marketing, and consumption, and related wastes and nutrient management and support services (technical assistance, credit, quality control) in a given geographical region that includes one main or several smaller urban centres and surrounding peri-urban and rural areas that exchange people, goods and services across the urban rural continuum" (FAO 2014).

Although in the literature it has become widespread to speak of the urban or city-region "food system," we prefer the term "*agro*-food system" to indicate that the planning does not relate to food alone. Most urban food planning exercises in Western countries initially focused mainly on enhancing the food security of the urban population especially by improving access of the urban poor to (healthy) food and later also by enhancing food production in the city region (Harper 2009; Freegood et al. 2011). But in recent years such exercises are also undertaken to enhance the resilience of the urban region against the impacts of climate change, reduce food-related greenhouse gas (GHG) emissions, reclaim nutrients and irrigation water from urban wastes and wastewater, stimulate the regional economy and support local farmers also by broadening to non-agro services: e.g., recreational and eco-services they supply (see Chapter 1 by Wiskerke; Morgan, 2009). That is the reason why we prefer to use "agro-food system" (with multiple functions) rather than "food system."

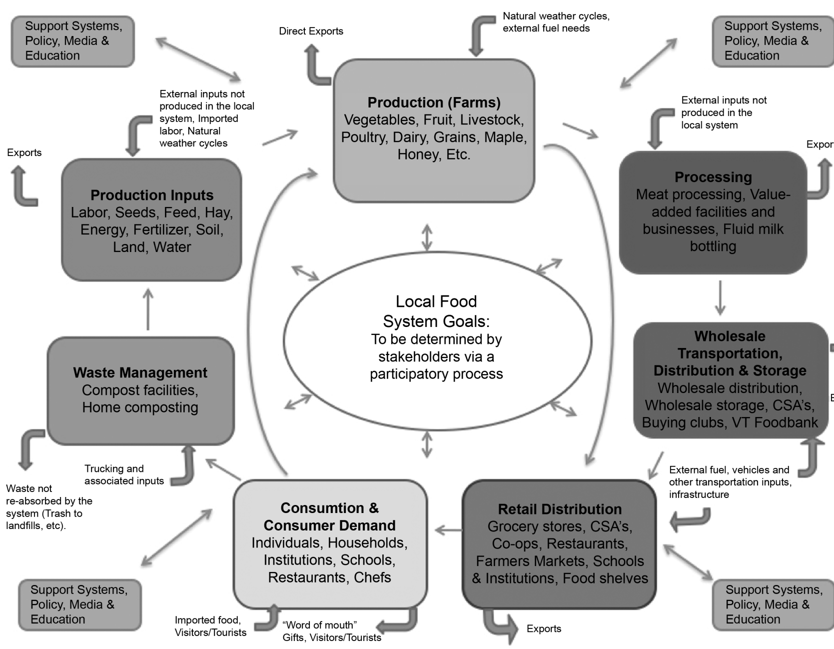

FIGURE 3.1 A model of the city-region food system

Source: Koliba et al. 2011; figure reprinted with permission of the Center for Rural Studies, University of Vermont.

Multi-stakeholder planning

Multi-stakeholder planning approaches are characterized by the following (Dubbeling and de Zeeuw 2007):

- The participation of various stakeholders in the agro-food system in the city region including local government authorities, civil society actors and private enterprises.
- In a transparent and open strategic planning process: situation analysis/problem diagnosis, formulation of vision and objectives, identification of development strategies, etc.
- In these, the final (political) decisions take honour – to the greatest extent possible – of the contributions of all participants.

In, especially, the case of the urban agro-food system, it is highly recommended to apply a multi-stakeholder approach (by now a common practice in several countries): the agro-food system is complex in itself and links with so many sectors (including urban development and spatial planning, health, social development, local economic development, environmental management) it is only by involving the various stakeholders directly in the planning process that a sustainable result may be obtained.

Multi-stakeholder planning has a number of advantages/benefits as compared to more conventional approaches (Hemmati 2002; Dubbeling et al. 2010; Amerasinghe 2013):

- Contributes to more participatory governance and public–private partnerships.
- Allows better situation analysis and quality of decision making through a better understanding of (the complex relations between) the various components of the urban agro-food system by linking the knowledge and views of the various actors who have a stake in that system.
- Enhances the likelihood of implementation success and sustainability through improved coordination, mobilization of scarce human, technical and financial resources, and enhanced acceptance and ownership of the resulting strategic plan or policies.
- Improves the problem solving and innovation capacity of the participating actors.

But it has also a number of disadvantages/costs (Dubbeling and de Zeeuw 2007):

- It often takes more time.
- It adds complexity to the planning process and is more difficult to manage/facilitate.
- In certain cases it may not lead to satisfactory results due to this complexity, difficulties to overcome tensions between contrasting views/interests and problems to arrive at a joint vision at the desired development of the agro-food system in the city region.

Policy vs action; top-down vs bottom-up; mainstream vs alternative

Agro-food system planning in a city region has a number of built-in tensions that the organizers have to deal with:

Top-down versus bottom-up

In some cities the planning process is led by the local or regional government and their departments and/or researchers hired and controlled by them. In this case the risk is high that certain stakeholders in the regional agro-food system do not see their problems and potentials taken into account and do not develop a sense of ownership and thus the social acceptability of the resulting agro-food plan and the active participation of the various stakeholders in the realization thereof will be low.

In other cities the initiative for the agro-food planning process was taken by civil society actors; participation of local/regional government in the exercise in these processes might be low (e.g., at technical level only). In this case, the risks are high that the results of the planning process are not sufficiently incorporated by local/regional government in the local policies, laws, budgets and programmes, which will limit the impact of the agro-food plan.

MacRae and Donahue (2013), when reviewing municipal food policy initiatives in Canada, observe that the hybrid organizational model with direct participation of civil society organizations *and* local government departments and created with formal municipal endorsement have better results (effectivity and continuity) due to the blending of local government interests, expertise, procedures and the interests and expertise of private and civil society actors, better access to financing and supportive staff during diagnosis and planning (allowing a more systemic and integrative approach) as well as for the implementation.

Policy framework versus direct actions

A dilemma closely related to the former is whether the emphasis in the planning process should be on identification and implementation of actions to tackle certain key problems and that can be implemented in the short term and within the actual institutional and financial conditions, or whether the emphasis should be on the development of a longer-term strategy to transform the agro-food system in the city region that may require new policies, new laws and regulations, new institutional arrangements and acquisition of additional resources, and thus take more time to result in concrete actions.

In the practice of the RUAF-CFF programme we learned that the emphasis should be on strategic mid-term planning and careful embedding of the strategic agro-food plan in the actual policies, budgets and programmes *combined with* early implementation of priority actions at the local level while the diagnosis and strategic planning process is still ongoing (Dubbeling et al. 2011). Also Scherb et al. (2012), when reviewing local food planning initiatives in the USA, conclude that successful food policy initiatives (surviving for three years or longer) had undertaken early actions that provided a solution to a pressing problem that might not have been addressed otherwise.

Mainstream versus alternative

Also closely related is the potential conflict of interest between certain stakeholders, e.g., between those that defend vested interests in the urban agro-food system and actors that want to transform that system and seek to reduce the power of certain dominant actors in the food system, or seek to force them to accept new norms and adapt their practices, or that are building up "alternative" food chains and undermine the market position of the dominant actors.

The basic principle of multi-stakeholder planning is that the various stakeholders in the agro-food system enter into exchange and dialogue, develop a better understanding of each other's viewpoints, practices and needs, and identify joint strategies to strengthen the local agro-food system. However, in practice it may be difficult to make the voice of the less-powerful stakeholders heard, to harmonize the various viewpoints and to come to a shared view on the policies to be applied. Those who manage the multi-stakeholder planning process should be aware of the differences in policy influencing and market power of the various stakeholders in the food system, detect potential conflict areas and have the ability to manage (potential) conflicts. Multi-stakeholder planning is often (also) a negotiating process between the various actors and it is an advantage when the facilitators of the process understand that and have experience in managing such a negotiating process.

In our view it is important to keep both "mainstream" actors, "informal" and "alternative" food chain actors involved in the planning process. The resulting plan to strengthen the urban agro-food system might contain measures to adapt and improve the mainstream food chains (e.g., reduce the ecological footprint of the local food system, improve access to food by the urban poor, enhance product nutritive quality) as well as to support the development and sustainability (especially economic) of "alternative" producers-to-consumers local food chains and link mainstream and alternative systems whenever possible and meaningful.

MacRae and Donahue (2013) observe that in Canada conventional mainstream food chain actors (e.g., food processing firms, larger traders, supermarket chains, agricultural input providers) are far under-represented in most food policy councils and other local/city-region food-planning initiatives, which may result in a low impact of the local/regional food-planning efforts on changing the local/regional food system.

The process of planning the local or city-region food system

Introduction

Non-linear process; flexible work planning/approach

Although the planning process is described below in a linear stepwise way, in practice the process will be (and even must be) more "chaotic," with certain steps advancing already while earlier steps are still developing, will need to repeat certain activities from earlier steps during later steps (e.g., awareness-raising, collecting additional data, sharing viewpoints on the desired development of the agro-food system, etc.) or change the order of certain steps (e.g., the moment to create the broader forum for dialogue and joint planning). There are many (hampering and facilitating) factors that influence the planning process and that cannot be known in advance. Therefore, it is important that the organizers of the planning process periodically adapt their work planning and approach in order to adapt to emerging new insights/demands and changing conditions during the process.

Adaptation to local conditions and priorities

Although we will describe below the planning process in the form of "a best practice," a main lesson learned in the RUAF-CFF programme and in other urban agro-food planning initiatives is that no two cities are alike and in each city region those who lead the planning process have to develop their own approach that fits best local conditions, needs and political priorities.

TABLE 3.1 Overview of the multi-stakeholder agro-food planning process

	Phase	*Main actions*
1	Getting started	The initiative
		Stakeholder inventory; raising awareness
		Inter-institutional cooperation agreement; establishment of working group
2	Assessment of the current agro-food system in the city region	The vertical dimension
		The horizontal dimension
		The policy and institutional dimension
3	Multi-stakeholder dialogue and strategic planning	Stakeholder consultations
		Establishment of a Multi-stakeholder Forum on Urban Food and Agriculture
		Identification of key issues (problems and potentials) to be attended
		Joint visioning; objective setting
		Identification of policies to be applied to transform the agro-food system in the city region
		Drafting the strategic agro-food plan

(Continued)

TABLE 3.1 (Continued)

	Phase	*Main actions*
4	Formalization, operationalization and institutionalization of the proposed food and agriculture policies	Formalization of the strategic plan Operationalization Creating an institutional home for urban food and agriculture
5	Implementation, monitoring and renewal of the strategic agro-food plan in the city region	Implementation; monitoring progress and impacts; renewal of the strategic plan (start at 1)

Source: authors.

Phase 1: Getting started

The initiative

The initiative for the urban food planning process may be taken by civil society actors, commercial actors in the food chains or a local or regional governmental organization. It is important that those who take the initiative have a good capacity to establish linkages with a variety of stakeholders in the agro-food system and to cross existing gaps and barriers between those stakeholders, especially between government-civil society actors and private commercial actors, and the capacity to initiate and facilitate a multi-stakeholder strategic action planning process (Amerasinghe et al. 2013).

Stakeholder inventory; raising awareness

A good starting point is to make a quick review of the main actors involved in each of the components of the food system in the city region (production/farmer types, transport/storage, processing, distribution, consumer categories, and support services).

Such an inventory normally involves telephone calls and visits to the various institutions and organizations, a review of recent publications (research and project reports, articles in the local media) and chamber of commerce registry, in order to identify the policy and public actors, businesses and civil society organizations that should be approached in order to motivate them to participate in the intended process of joint planning and realization of the necessary changes in the food system. When making this inventory also try to find out what may facilitate or hamper the engagement of certain categories of actors in the planning process so that such barriers may be taken into account when planning the next steps in the process.

Once the main stakeholders have been identified, a series of actions have to be organized to enhance the awareness of the stakeholders of the importance of building a resilient and equitable food system in the city region and to obtain their active participation. Various strategies may be applied: visits to key persons in the various institutions and organizations, or preparation and distribution of short memos on some key issues in the local food system to local decision makers, journalists, networks of local retailers, agro-businesses and farmers, consumer organizations and other civil society organizations. Also organizing public debates in face-to-face seminars and/or electronic discussion platforms, food festivals, awards for innovative ideas for food activities, visits to other cities or local successful initiatives, and other events rousing interest and debate are helpful to raise interest and involvement.

Establishing an inter-institutional cooperation agreement and working group

Once the key actors in shaping the regional agro-food system have been identified and motivated to participate, these actors are brought together in order to agree to undertake a process of joint analysis, action planning and implementation to transform the local food system.

In RUAF's experience, it was important for a successful start of the planning process that:

- A working group is established comprising a core group of committed key actors including minimally one or more municipal departments (e.g., city planning, health, parks/agriculture, . . .), one or more local universities, one or more non-government organizations (NGOs) or other civil society organization active in the field of urban food and agriculture, and representatives of main food-chain actors: urban farmers, organizations of local retailers and agro-businesses, and consumers groups.
- The partners in the core group sign a formal cooperation agreement. The agreement makes the cooperation less informal, clarifies the intended contributions by each of the partners to the joint process (e.g., provision of staff time, transport, office space, supply of data and research support) and the arrangements for work planning, coordination and progress monitoring) during the first stages of the process. Formalizing agreements to work together through carefully structured work plans stimulates concrete results, and generally results in a good buy-in from the stakeholders. However, compliance may, in part, be jeopardized, for example, due to rapid staff turnover or conflicts with government directives (Amerasinghe et al. 2013).
- The chair of the core group is occupied by a person with strong organizational and facilitation skills and made available by an organization with sufficient

invitation and coordination power, in most cases the mayor's office, the city planning department or a municipal department that was given a coordinating role in this field.

- The strategic planning is organized as an interchange of preparations by the working group (where the work might be divided between several task groups) and consultations of the various stakeholders and regular meetings of the Multi-stakeholder Forum (see below) to discuss proposals and arrive at conclusions.
- There is an application of a systematic, stepwise approach, maintaining sufficient intensity and speed of the process and to further build up institutional commitments during the process. In each phase of the process a matrix may be used to provide all partners with an overview of all activities agreed upon, the agreed timeline for implementation, the expected outputs, the responsible actor(s) and related commitment of resources, and to enable joint monitoring of the realization of the commitments.
- Concrete development actions are implemented during the planning process with means available in the participating organizations. Early implementation of activities on the ground with high visibility of tangible results is very important to maintain the motivation and active participation of urban farmers, community groups and other civil society actors during the often lengthy process of assessment, planning and formal approval of the strategic plan, and acquiring the required resources for its implementation. Experiences gained in these small projects were reported to the Multi-stakeholder Forum (see below) to stimulate inter-institutional learning among the participating organizations and presented in the media to gain wider public support and stimulate similar actions by other local actors.

Phase 2. Assessment of the current agro-food system in the city region

Transforming the urban agro-food system should start with a thorough assessment of the agro-food system in the city region and ongoing trends. The assessment will provide appropriate information to the various stakeholders to enter into dialogue, facilitate joint goal setting and strategic action planning and establish baseline data and indicators for monitoring and evaluation.

Assessments of the agro-food system are undertaken in various ways (e.g., rapid mainly qualitative appraisal versus more systematic data gathering including statistically representative quantitative data), using a variety of methods (e.g., review of available research data and available statistics, GIS [Geographic Information Systems] mapping, key informants, focus group interviews, community food mapping, *sondeos* [short focused surveys], and more extensive surveys; see also the next paragraph on tools) and with varying focus (e.g., focusing on food security of the urban poor and disadvantaged groups, or just on the environmental sustainability of the local agro-food system) and width (narrower or more comprehensive/ systemic).

FIGURE 3.2 Cover of the Bristol food system assessment
Source: Bristol City Council.

According to Moragues et al. (2013), the assessment should be methodologically rigorous, consult a variety of stakeholders and look at a diversity of food system issues, considering vertical (stages of the food chains), horizontal (action fields) and institutional dimensions of the agro-food system. They listed the following elements that may be included in the assessment (which we further elaborated based on the experiences gained in RUAF programmes):

Assessing the vertical dimension of the food agro-system

This refers to the collection of data and the application of a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis on each main component of the regional food system (using economical, ecological, food security/nutrition/health and sociocultural lenses):

- ***Food production:*** What food is produced in the city region, by whom, where and under what working conditions, and using which production techniques? What types of inputs are used and by whom are these produced and delivered? Which are the main types of producers in the city region, their characteristics, the main constraints encountered by each type of producers, their potential for development and related support needs? Where is agricultural land use threatened by city extension? Where is suitable space available in the city, with which agro-ecological characteristics, and what obstacles hamper their use for food production? How do the different types of producers market their products? What innovative marketing initiatives exist in the city region? What are the main critical issues related to food production and marketing for the development of a sustainable agro-food system in the city region? What per cent of urban food consumption (of total nutrients/calories consumed and for specific food groups) is actually covered by production in the city region? What are the main current food deficiencies? What could be potentially grown locally, e.g., to replace products with high food miles and enhance urban food resilience?

- ***Processing:*** Which processing companies and other food processors (e.g., informal) operate in the city region? How do their input and output relate to the local economy and society? What is the nutritive quality of their products? What are the related GHG emissions? What are the new initiatives by existing companies and other actors? What are the main constraints encountered by the various types of food processors and what is the development potential of each type in the city region and related support needs? What are the main critical issues related to food processing for the development of a sustainable agro-food system in the city region?
- ***Distribution and storage:*** How is food distribution organized in the city region: the retail and other food distribution structures (conventional, alternative, informal); location of food distribution points (food hubs, open markets, supermarkets, small retail shops, street/mobile vending, etc.)? Where do the main access problems occur (especially of poor and vulnerable people to fresh and nutritious food) and what are the main causing factors? What is the actual role and importance of short food supply chains within the agro-food system in the city region?
- ***Consumption:*** Who is consuming what kinds of food, in what context and in what amounts? How is the affordability of food for various socioeconomic classes? Which groups are already at risk of food insecurity and where are they located? What is the impact of actual food consumption habits and trends on health-related issues, such as obesity? What is the effectivity of actual food and nutrition programmes?
- ***Wastes/nutrients management:*** What are the sources and volumes of urban organic wastes and wastewater and their actual disposal/recycling routes? What are the food wastes, energy use and GHG emissions in all components of the current agro-food system? What are the main options and constraints for resource recovery and productive reuse of organic wastes and wastewater (and related nutrients) and reduction of food wastes in various parts of the agro-food system?

Assessing the horizontal dimension of the agro-food system

This refers to bringing the results of the analysis of the various elements of the food system (the vertical dimension) together around certain areas of concern and themes related to the objectives of such a policy or strategy. In other words: the desired changes in the local agro-food system one wants to realize:

- ***Public health:*** Critical health issues related to the actual agro-food system; food safety regulating bodies and laws, labelling practices; presence or lack of promotion and support of healthy lifestyles and nutrition; and assessment and management of health risks associated with urban agriculture.
- ***Social justice/food security:*** Access to healthy food/main food-insecure and vulnerable households, flaws in actual retail system (e.g., underserved categories of the population and/or areas of the city); presence or lack of assistance measures for food-insecure and vulnerable households; role of urban agriculture in urban poverty alleviation, social inclusion and neighbourhood renovation and in enhancing the resilience of the urban food system.
- ***Environment:*** Food miles; GHG emissions related to food production, processing, packaging, distribution, and waste management practices; actual and potential GHG reduction through short(ening) supply chains; contributions of local agriculture to disaster prevention, urban climate management (heat, dust, storm water management, CO_2); actual and potential productive reuse of urban wastes and wastewater in urban agriculture.
- ***Economic:*** Impact on the regional economy and local livelihoods (income and jobs) implicated in all stages of the urban agro-food system; emergence of new business models in the area of local food economies.
- ***Sociocultural:*** Food-related social and cultural meanings, diversity of foods and cuisines consumed in the city region, food preferences of immigrants and minority groups, valorization of traditional foods and practices including local breeds, varieties and farming systems.

As indicated earlier, the planning process might be more comprehensive/systemic or focused on one or two of the above-mentioned elements (e.g., on the food security/health/social inclusion elements, or on the environmental/resilience element). This means that when preparing the assessment of the local or regional agro-food system, one already has to make conscious choices regarding the main objectives of the diagnosis and the – to be formulated – urban food plan or strategy. A more comprehensive assessment is preferable since the various elements are strongly interlinked and understanding the food system in a systemic way helps to arrive at effective intervention strategies. However, this will also be more complex, time-consuming and costly.

In cities where the awareness of the importance of the urban agro-food system is still rather low, or where available means for the assessment are rather low, in RUAF's experience it is recommendable to focus the diagnosis initially on those elements of the system that actually attract most attention from the policy makers and that seem to mobilize the stakeholders best. In most cases, during the process (or later, when preparing an update of the plan) the interest in other elements of the agro-food system will grow and new resources may become available to broaden/deepen the assessment.

Assessing the policy and institutional dimension of the agro-food system in the city region

This refers to a further exploration of the policy and institutional context:

- ***Policies, instruments and programmes*** at city, regional and national levels that influence the agro-food system in the city region (agricultural policies, health regulations, land use norms and zoning, environmental policies, city development plans, poverty alleviation strategies, food security schemes, nutrition education and food supply programmes, economic development and marketing policies, etc.).
- ***Institutions:*** Mandates and values that influence their views on urban food and agriculture and their related actions and regulations; community and civic values related to food system functioning and management; relevant bodies implicated in agro-food system policy and management. Current integration of agro-food system issues in municipal programmes, plans and budgets.
- ***Participation structures:*** Approaches and norms that encourage or limit stakeholder participation; existing and potential opportunities for civil society to participate in defining, planning and implementing food policies and interventions; existing levels of participation by various stakeholders; measures taken to ensure involvement of various stakeholders.
- ***Knowledge, learning and empowerment opportunities and practices*** that might be valorized and developed further (e.g., ongoing food community projects; sustainable production and processing pioneers and innovators; short chain initiatives; good food ambassadors; and sustainable and healthy food consumption educational programmes).

It is crucial that the core group develops a clear work plan for the assessment, indicating clearly what kinds of information will be collected and how, what will be the role and contributions of each of the partners in the core group and other actors to be involved, and what are the timeline and coordination mechanisms. In RUAF's experience best results are obtained when one organization experienced in this field (e.g., a local university or research institute) is assigned to coordinate the assessment, with clear supporting roles of each of the partners regarding specific sets of data/themes/research or support activities like provision of staff, transport or funding (Dubbeling et al. 2011). Needless to say, sufficient financial means need to be secured timely for the realization of the assessment according to plan. Especially when larger amounts are needed to assign a substantial part of the assessment to a university or consultancy organization, acquiring these funds (from the municipality and/or other sources) may be a lengthy process, which needs to be started early and pursued with sufficient energy and mobilization of support.

In a later section of this chapter we will discuss a number of assessment methods (each with a different focus) that may be applied in assessments of the agro-food system at local or city regional level.

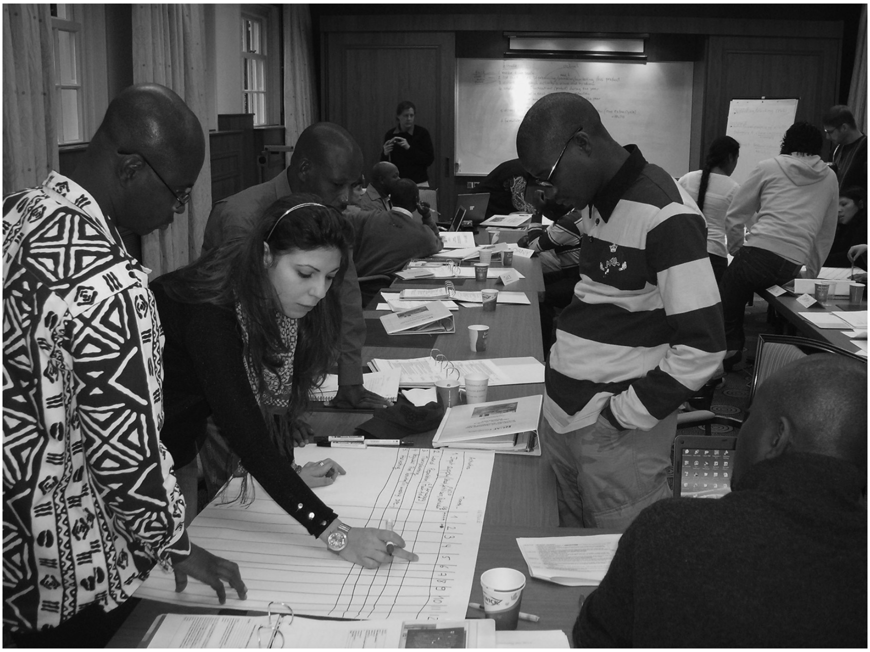

FIGURE 3.3 RUAF-CFF city teams preparing for the planning process
Source: RUAF Foundation.

Phase 3. Multi-stakeholder dialogue and strategic planning

Stakeholder consultations

The various actors that shape the agro-food system in the city region have different positions and interests. It is important to clarify and understand the differences in motivations, interests and goals of the various categories of stakeholders in the city agro-food system and related views on the actual problems and visions on the desired development of the agro-food system in an early stage of the joint planning process. Some stakeholders are well organized and have well-established linkages with policy circles and can influence the political decision making in the city, while others are hardly organized (e.g., small farmers and gardeners in the city region, concerned consumer groups, urban poor and disadvantaged) and their voice may be rarely heard at policy levels.

The interests and views of the stronger stakeholders may be obtained through interviews with senior staff in the various institutions and organizations as well as by analysis of their reports and statements in the media. It is of value to collect information on their institutional mandate and priorities; past, ongoing and planned activities in the field of urban food and agriculture; available resources for such activities, their linkages with other key actors, their views on the actual situation and the desired changes in the actual agro-food system and what should be done to realize these changes.

The views of the weaker stakeholder categories can be obtained through consultations/focus group interviews (often as part of the assessment of the agro-food system) with one or a few groups of people considered representative for this stakeholder category (e.g., different types of local farmers and gardeners, consumers, retailers) seeking to understand their present position in the agro-food system, problems encountered, their views on how these problems could be resolved and the direction to which the agro-food should be transformed.

Although presented here as a separate "step" in the process, in practice these consultations will be organized mainly together with, and as part of, the assessment of the local agro-food system. These consultations also have an important role in (further) raising the awareness and involvement of the various stakeholders. Where practically possible and scientifically sound, the involvement of stakeholders in the data-gathering process may go beyond consultations, e.g., involvement of community organizations in mapping the retail system and food insecurity/vulnerability in their neighbourhood, or the involvement of local agro-industry in collecting data on the water, energy and inputs use in their processing activities and related GHG emissions. In other cases, such direct involvement will be minimal (e.g., mapping actual agricultural land use and available open spaces in the city with the help of GIS by a municipal department).

Establishment of a multi-stakeholder forum on urban food and agriculture

Once the local stakeholders show a strong interest to engage in a joint planning process and the basic information is on the table, the time is ripe to establish a Multi-stakeholder Forum on Food and Agriculture in the city region or a Municipal (or City-region) Food Policy Council or similar platform where the various stakeholders can meet, engage in dialogue and joint planning with other stakeholders in the urban agro-food system and, in a later stage, coordinate the implementation and monitoring of concerted policies to transform the agro-food system in the city region and stimulate their institutionalization (e.g., inclusion in municipal and institutional policies, budgets, establishment of a coordinating urban agricultural office or department, etc.).

In the RUAF-CFF programme the composition of the Multi-stakeholder Forum varied from city to city. In most cases, the partners in the core team were complemented by representatives of 15 to 50 other organizations (farmers groups, community organizations, NGOs, agro-enterprises, food retailers, educational centres, health programmes, media, etc.).

Special efforts may have to be taken to engage informal and less-organized stakeholder groups, as, for example, the many small-scale producers in and around cities in developing countries. It may take time to build relationships of trust and find effective ways to include their voice in the Multi-stakeholder Forum.

In developing countries, to obtain the active involvement of certain stakeholders (especially governmental organizations) often requires not only the official commitment to engage in the process but also some incentives for the persons who represent their organization like remuneration, training or travel opportunities (Amerasinghe et al. 2013).

In the RUAF-CFF experience it turned out to be of great importance that the Multi-stakeholder Forum has close links with local government, is recognized as the main advisory body in the field of urban food and agricultural issues and that municipal departments participate in and support the Forum. The Forum, however, should have an independent position and should not be dominated by local political parties or depend on municipal funding only. The Multi-stakeholder Forum should also develop strategies that enable to continue functioning after elections and related changes in political priorities.

Discussion of the draft report on the situation analysis; identification of key issues (problems and potentials) to be attended

In order to initiate and feed the dialogue in the Multi-stakeholder Forum, the results of the assessment of the actual agro-food system have to be made available to all stakeholders in a concise and clear way. The report should present key facts and trends on the urban food and agriculture situation, the views of the various stakeholders on the actual situation and the remedial or development actions proposed by them.

In the RUAF-CFF programme this discussion document was distributed to councillors, senior staff of several city departments, NGOs, universities, farmer groups, local agro-food businesses and other relevant local actors identified in the stakeholder analysis in order to enhance their understanding of the present situation of the agro-food system and its effects on urban food security and social inclusion, local economy and the urban environment, and in the preparation of the dialogue with other stakeholders about this situation.

The core group will prepare the draft report and present it for discussion in the Multi-stakeholder Forum. The main elements of the assessment presented above can be used as the structure for this presentation and related discussions.

In this step and the following ones, there is an interchange between the preparatory and follow-up activities by the core group and the sharing, dialogue and decision making in the Multi-stakeholder Forum meetings.

All members of the Forum are informed before the Forum meeting about the preparatory activities implemented by the core group and the issues to be discussed in the Platform, allowing them to consult their peers before the meeting if desired. Also important is to inform all members on the results of the Forum meeting and the follow-up given by the core group.

Joint visioning; objective setting

The discussions on the actual situation and related key issues will be followed by the development of a joint vision on the desired development of the agro-food system in the city region: How should the agro-food system in the city region look like in five or ten years from now? What role(s) should it fulfil in sustainable and equitable city development? What changes in the actual agro-food system in the city region would that imply? Which indicators should we use to measure such changes and what is our aspiration level for each indicator (e.g., reduction in the number of food-insecure households and/or obese people in the city; reduction in GHG emissions or food miles related to urban food consumption; increase in per cent of urban organic wastes and wastewater that are reused in agriculture in the city region or reduction in the amount of urban organic wastes that end up in the landfill; number of farmers in the city region that apply ecological farming practices, etc.)?

This is a very crucial phase in the strategic planning process and sufficient time should be taken to arrive at a coherent joint vision on the desirable development of the agro-food system in the city region and seeking win-win solutions to existing conflicts of interests. Assistance of an experienced facilitator of negotiations might be needed. The development of the vision and associated goals constitute a negotiation and learning process: actors have different interests but the process also allows the different actors to learn from each other's knowledge and experience, building a common cause. Different knowledge brokerage activities and facilitation techniques can be applied that help in advancing the process of joint vision building and related goal setting.

It is often debated what comes first: the assessment of the actual situation of the agro-food system or the joint vision building and objective setting in the Multi-stakeholder Forum. In RUAF's experience, the vision building should build on a well-informed dialogue on the problems (and assets/potentials) in the actual situation. That is why we prefer that the assessment is implemented first (the core group could select some preliminary broad objectives to focus the assessment).

Eventually, after the joint vision and development objectives have been defined by the Multi-stakeholder Forum, some additional data-gathering might be needed to fill some information gaps identified during that process.

Identification of policies to be applied to transform the agro-food system in the city region

For each of the key issues identified, the policies are selected that may be applied to realize the required changes regarding this issue. The joint vision and related objectives will orient the identification of alternative policies. Each of the alternative policies identified will be jointly analyzed, especially the related costs/benefits (how effective and efficient is this policy in realizing the desired changes?) and the applicability of this policy (how likely is it that we will have the means and tools to apply this policy with success? Will policy circles and stakeholders support this strategy sufficiently?). Evaluation of the alternative policies will lead to selection of the preferred policies to tackle the key issues and bring about the desired changes in the agro-food system. An overview of policies that are frequently applied in city agriculture and food policies is provided in Chapter 2 of this book.

Drafting the strategic agro-food plan

The selected policies will be included in a (draft) city food and agriculture strategy or plan that should preferably include:

- A concise description of the actual situation of the agro-food system in the city region, its main elements and actors and the key issues identified (problems, potentials; threads, opportunities).
- The joint vision on the desired transformation of the agro-food system and the changes to be realized and related indicators and time horizons.
- The policies to be undertaken to tackle each of the main issues identified and realize the desired changes indicated by the joint vision, including:

FIGURE 3.4 Cover of the Seattle Food Action Plan

Source: Neighborhood Farmers Market Alliance.

  - The actions to be implemented under each policy included in the plan and related implementation targets, the priority of each of these actions and the ease of implementation of each action.
  - The main actors that will/should be involved in the implementation of each of the strategies.
  - The resources required for each of the strategies, the resources that can be contributed by the implementing partners themselves and potential sources of additional resources.
- Proposals regarding the institutional arrangements needed for the implementation of the strategic plan.

Phase 4. Formalization, operationalization and institutionalization of the proposed food and agriculture policies

Once the strategic plan for the transformation of the agro-food system in the city region has been finalized by the Multi-stakeholder Forum, a process starts to get this strategic plan accepted by the local policy makers and included in municipal and/or regional policies and laws, in city spatial and development plans, in the municipal budget and in the budgets and programmes of relevant institutions and organizations. However, to be successful this process of linking up with and influencing decision makers should start right from the very beginning (during stakeholder identification and awareness raising) and is continued throughout the diagnosis and planning stages, but is intensified and is the main challenge during this stage.

In this process, actions like the following may be helpful:

- ***Preparation of a policy brief*** that briefly describes the actual situation of the agro-food system in the city region and the reasons why the urban food system should be transformed, the vision of the multi-stakeholder forum on the desired changes and a summary of the proposed policies to realize these changes.
- ***Organization of a policy seminar*** for councillors and their advisors/senior local government officers, where the strategic plan is presented and discussed.
- ***Presentation of the food and agriculture strategic plan to the most relevant council committee*** for discussion and approval (eventually after making changes and/or further elaboration) and subsequent forwarding of the strategic plan to the Municipal Council for its formal approval.
- ***Dissemination*** of the strategic plan and media outreach.

In the formalization and institutionalization process attention needs to be given to:

- ***Formalization:*** Translation of the strategic food and agriculture plan into city development (master) plans and land use plans, in municipal by-laws, standards and regulations, and inclusion in municipal budgets. The American Planning

Association (Raja et al. 2007) stresses in its "policy guideline" that local and regional food planning includes much more than the assessment and drafting of the food plan or strategy, and that ample attention should be given to creating standards and guidelines, regulating and codifying, targeting public investments, etc.

This is often a lengthy process that is largely done within the various local and/or regional government departments. This uptake of these tasks in most cases is faster and substantive when local government actors (sector specialists, legal advisors, urban planners, councillors, etc.) have been involved actively in the planning stage.

It is very important that the Multi-stakeholder Forum closely monitors the progress of this process, enables inputs by non-government actors and – whenever needed – puts pressure on local government to perform these activities with more urgency.

- ***Operationalization of the strategic plan:*** In order to be able to implement the strategic plan, the various stakeholders have to include the actions in which they will be involved in their own (multi-) annual plans and budgets and programmes and to work out operational plans for the implementation of their own contributions to certain components of the strategic plan (what to do, when, how, by whom, with what means/tools, expected results, how to monitor). Too often, commitments made in the strategic planning phase by certain actors are not realized in the implementation phase (or only in a very late stage) due to lack of timely operationalization of the promised contributions and inclusion in institutional work plans and budgets.

  Also here, the Multi-stakeholder Forum has an important encouraging and monitoring role. Kingdon (2010) observes that if local food planning initiatives and the opening of a new policy window (problem recognition, policy formulation) is not followed by legislation, funding and implementation, the opportunity passes and politicians will move on to another issue (or are replaced by others after elections with other priorities) and the momentum is lost.

- ***Creating an institutional home for urban food and agriculture:*** If not yet existing, the establishment of an interdepartmental committee on urban food and agriculture and providing one department with the mandate and staff to coordinate the operationalization, implementation and monitoring of the city food and agriculture strategy is of great importance for the continuity and implementation. Also, formal recognition of the Multi-stakeholder Forum on Food and Agriculture (or City Food Policy Council or similar platform) as a policy advisory body and main mechanism for the coordination and monitoring of the implementation of the city strategic plan on food and agriculture is of strategic importance. The Multi-stakeholder Forum creates a balance between top-down and bottom-up elements and increases the resilience against short-term political changes and slowing down of public or civil engagement.

Phase 5. Implementation, monitoring and renewal of the strategic agro-food plan in the city region

As indicated above, it is of crucial importance that the Multi-stakeholder Forum continues to function after the initial planning process. First to monitor and support the formalization, institutionalization and operationalization of the strategic food and agriculture plan and thereafter to function as the platform to coordinate public-private-civic cooperation during implementation, to facilitate exchange and learning of experiences gained and to monitor progress and impacts.

The above is more complicated than it looks at first sight. Most of the actors are not used to reporting to other stakeholders on their activities and results obtained, and when they do they are tempted to stress the positive results and leave out the disappointments and failures or use their institutional templates to report to the Multi-stakeholder Forum, which might not be suited to monitor the impact of their actions on the realization of the desired changes indicated in the joint vision. It requires continuous attention by the core group to motivate the partners in the Multi-stakeholder Forum to share their experiences in a meaningful way in order to facilitate joint learning and to enable the evaluation and future adaptation of the policies of the strategic plan.

The monitoring should relate to the implementation process (approach/methods applied, inter-institutional cooperation, civic participation, etc.), progress (activities implemented and outputs realized), as well as the impacts obtained: the degree of realization of the desired changes in the regional agro-food system as a result of the interventions, as well as unintended impacts. Since this is a complex task (e.g., How to filter out other influences on the regional agro-food system?) and to get a more objective view on the effects of the actions undertaken in the context of the implementation of the strategic food and agriculture plan, it may be necessary to ask an independent research institute to periodically assess the changes in the regional agro-food system applying the indicators established in the strategic plan.

Reflection on the experiences gained and the monitoring results can be used by the individual partners to improve their programmes and by the core group to prepare periodic upgrades of the strategic food and agriculture plan (every three to five years) for discussion in the Multi-stakeholder Forum followed by formal political approval.

Moreover, local/regional food planning should not be undertaken as a one-time exercise but promoted as an area of continuous attention of urban planners/planning departments built into the urban planning processes.

FIGURE 3.5 Cover of the Melbourne Food Policy

Source: City of Melbourne.

Methods for the assessment of the local or city regional agro-food system

Introduction

As Freedgood et al. (2011) indicated, the development of local/regional food assessment and planning methods is quite recent and there have been few systematic efforts to classify the various methods applied, their main differences and similarities and their results and effectivity. Moreover, methods that are quite similar may have been given different names, while methods that yield quite different results may have been given similar names: local food system assessment, community food security assessment, community food mapping, foodshed analysis, etc.

Rather than reviewing all these concepts/methods one by one and seeking to explain the differences/overlaps between these methods, we will briefly list and discuss below some methods that analyze the food system with a specific focus and yield specific results. Depending on the local conditions and priorities in each city, certain methods will be selected and combined in a locally specific approach for the assessment of the local or city regional agro-food system.

The selection of methods has to be done very carefully since this has a strong influence on both the development of the process and its results. When selecting the methods/tools to be used one has to consider the following:

- The main objectives of the food system planning exercise and its focus (more integrated/systemic assessment and planning, or focused on one or two main dimensions of that system, e.g., its food security/nutrition or environmental dimension).
- The planning level (metropolitan area, city/district, neighbourhood).
- Financial means available.
- The available human resources/areas of expertise.
- The intended time frame.
- Sources and types of information that are already available and main gaps in the actual information base.
- The types of stakeholders one wants to involve in the process and the forms and degree of participation in data gathering and/or planning one has in mind.

Food asset-mapping

Food asset-mapping (as, for example, applied in the Greater Philadelphia Food System Assessment Study: DVRPC 2010) is one specific type of assessment that identifies and maps the main stakeholders in the local or regional food system, their locations and related assets (access to land, water, staff, infrastructure, etc.): agricultural producers by type, providers of agricultural inputs, food processors, wholesale traders, transportation and warehousing, sites of food access (formal and informal food retailers and markets), actors in waste and nutrients management, and related infrastructure, support actors (technical assistance, quality control, licenses, financial assistance, assistance to food-insecure households, etc., by governmental institutions, private commercial and civil-society organizations).

The stakeholder/assets inventory is preferably combined with an inventory of the views/needs of each key stakeholder category in the food system on the actual problems and opportunities for the development of a sustainable, fair and safe food system in the city region.

Food asset maps can inform the planning process about the actors to be involved in the diagnosis and planning of the local/regional food system, the available human and other resources that may be mobilized to transform the local/regional food system and the views of the various stakeholders on the needed transformation of the food system.

Mapping actual and potential agricultural land use in the city region

In this approach the following activities are undertaken:

- Inventories of *land currently used for agricultural production* in the city region (by type and scale; formal and informal, commercial and non-commercial).
- Identification of available *vacant or underused open spaces* (publicly and privately held) in the city region (and other spaces like rooftops) that can be potentially used for food production in the city region (e.g., Mendes et al. 2008).

The available land inventory is usually combined with the following:

- An assessment of the production capacity ("local foodshed carrying capacity") of the potentially available spaces for (intra- and peri-) urban agriculture, taking into account factors like location, size of the plots, soil quality, access to irrigation water, accessibility of the plots and other limiting factors; see, e.g., Peters et al. (2009, 2013) and Kremer and DeLiberty (2011). Hu et al. (2012) used a systems optimization modelling approach to assess how alternative policy measures would affect the foodshed carrying capacity in Iowa. A key problem in this kind of calculations is often the definition of the border of the "foodshed" (municipal borders, city region up to 50, 100, 150 km?), which strongly influences the results.
- An analysis of barriers and opportunities for transitioning vacant or underused land into cultivated spaces and how the available potential production capacity can be fully developed in practice.

Land-use mapping exercises provide – amongst others – a basis for policies that enable access to land for agricultural production and more secure lease agreements, the integration of intra- and peri-urban agriculture in urban land-use planning and zoning and to determine the extent to which local/regional food production may cover the total urban food needs.

Community food assessment

Community food assessments (see, e.g., Zahilay 2010 for Bedford-Stuyvesant and Isles Inc. 2005 for Trenton) focus on engaging community members and other local stakeholders in assessing the local food system – with an emphasis on local food distribution and access to (nutritious) food, especially of urban poor and disadvantaged households – and framing action initiatives. The needs assessment compiles information on maps on a cross-section of issues in the local food situation – including who/where the food-insecure householders are, their access to food, food availability/prices/quality in the community; spatial distribution of retail shops; eating and shopping habits, diet-related health trends; local food production and processing activities and trends – by interviewing food purveyors, conducting focus group interviews with residents, local school students keeping diaries on the quality and quantity of food, etc., making inventories and price comparisons at food stores, mapping locations of retail shops and markets, etc.

The collected information can be used to identify locations in a given community where residents have limited access to healthy food sources ("food deserts"), as a basis for policy advocacy (showing the problems encountered by the urban poor to access healthy food at affordable prices in their communities) and to identify policy measures that may improve the local food situation. The participatory process also mobilizes local food initiatives and enhances community building and empowerment. Several guides for local community food assessments have been developed and are widely applied nowadays (Hugh 1997; Cohen 2002; Siedenberg and Pothukuchi 2002).

SWOT analysis of different types of intra- and peri-urban farming

While local community food system assessments mainly focus on the consumer side (analysis of access of urban producers to healthy food and food distribution issues), the urban agriculture assessments undertaken in the context of the RUAF-CFF sought to understand the actual constraints and development opportunities for different types of intra- and peri-urban agriculture. The interests and production conditions of the various types of intra- and peri-urban producers vary with their main aims (for subsistence, commercial, social), scale/technology, main products (horticulture, livestock, aquaculture, etc.,), organizational form (family based, cooperative, SME [small or medium enterprise], larger enterprise), location, etc. In order to be able to strengthen food production in the city region, it is important to understand the specific interests, constraints and development opportunities of each of these types of producers in the city region.

In the RUAF-CFF and RUAF-FStT programmes, first an inventory and classification were made of the main types of (intra- and peri-) urban agriculture present in the city region. Subsequently, focus group workshops were held with representatives of each main type to jointly make an analysis of their main strengths and weaknesses, opportunities and threats (de Zeeuw et al. 2011).

The results of the differentiated SWOT analysis of the intra- and peri-urban producers provide valuable information for urban planners and decision makers and local agricultural support institutions regarding main development constraints and perspectives for different types of urban producers and related support needs/opportunities.

Food chain analysis

This type of analysis focuses on the analysis of the relations between the various actors in a specific food chain (either a mainstream conventional food chain or an "alternative" short food chain) with the aim to analyze key problems in the functioning of this food chain (e.g., for fresh green vegetables) and to identify opportunities to improve its functioning by concerted actions of the stakeholders involved.

The chain analysis includes the tracing of the flow of a certain (type of) food product(s) from its origin on a farm to its ultimate point of consumption and the mapping of all flows related to this specific food chain: flows of inputs (manure, water, seeds, fodder, etc.) and services (finance, advice, quality control, etc.), raw and processed food products and related wastes (water, excrements, refuse and the nutrients and pollutants these contain) and to measure different costs of producing and transporting these products through the chain and the value added at each stage in the food chain.

CIAT developed a guide for participatory analysis of, and intervention in, rural–urban food chains with a focus on Latin America (Lundy et al. 2007). Folke et al. (2010) present various cases of food chain analyses and interventions in Asia.

The chain/flows analysis helps to understand the economic, ecological, socio-cultural and health impacts of certain food chains and to identify building blocks for the development of a more sustainable, effective and fair food chain. When a participatory approach is applied, it also mobilizes the chain actors and creates mechanisms to plan and implement concerted actions to improve the functioning of this specific food chain.

Ecological food footprint analysis

Food(t)print analysis refers to the quantification of the energy use and greenhouse gas (GHG) emissions of the food consumed by the population in a particular city region.

Food print analysis builds on the chain/flows analysis for specific food products but the following are added:

a. The quantification of the energy use and GHG emissions involved in the production/transport/processing/distribution/consumption/waste management of each main food product. See, e.g., Denny (2012) who provides a lifecycle analysis of tomato production and consumption in the UK.
b. Combining the data on individual products (often food products that are representative of certain food groups are selected) in an analysis of the actual energy use and GHG emissions of the total food consumed in that city region.
c. The analysis of the options to reduce the urban food footprint (total energy use/GHG emissions related to food consumption in the city region): changing production and/or processing practices (e.g., reduced use of industrial agro-chemicals and reuse of urban organic wastes and wastewater), change in production location (close to the city rather than imported into the city region), changes in food consumption patterns (e.g., more fresh, unprocessed or packaged food).

For an example of activities b and c mentioned above see, e.g., Jansma et al. (2012), who calculated the GHG emission reduction due to (two scenarios for) integrating agriculture (horticulture and livestock) in a planned residential area.

Such an analysis is valuable for determining the vulnerability of populations to disruptions in their food supplies, to estimate the capacity for population centres to supply more of their food from local sources, to plan policy measures that can reduce the energy use and GHG emissions related to the city region food system and to reduce dependence on fossil energy.

Economic assessment of local food systems

In various cities, especially in the USA, studies (often local or city regional inputs/outputs modelling) have been undertaken to assess the economic impacts of enhancing local/regional food production for the urban markets in the city region (e.g., Conner et al. 2008; Enshayan 2008; Swenson 2009): to assess new (additional) labour income and jobs (that may be expected to be) generated as a result of different scenarios for enhanced production of certain food products (e.g., vegetables and fruits, meat products) and their processing/distribution through alternative marketing channels (conventional vs alternative).

Such studies help planners to identify ways in which the local food economy can be strengthened most effectively (e.g., establishment of supporting infrastructure like food hubs, farmers' markets, preferential government food procurement, etc.) and provide policy makers with information on the potential impacts of certain plans or policy measures on the local/regional economy (enabling decisions on related investments).

A quick but much more restricted approach is to calculate the fiscal contribution (revenues/costs ratios) of different types of intra- and peri-urban agriculture and forestry farms, urban forests, and other green, open urban spaces in comparison to alternative uses such as residential or commercial use (see, e.g., the studies implemented by the American Farmland Trust, the Brandywine Conservancy and the Heritage Conservancy in the Delaware region; cited in DVRPC 2010).

Gómez-Baggethun and Barton (2013) provide an overview of valuation methods that can be applied to assess the economic value of eco-services provided by agriculture and forestry in the city region, including the "avoided expenditures" method (what would be the costs if urban agriculture and forestry would not provide these eco-services, e.g., more energy use due to increasing food miles and higher temperatures, more damage due to floods and landslides, etc.?), the "replacement costs" method (what would it cost to provide similar eco-services in another way?) and contingency valuation (e.g., hedonic pricing, stated preferences, willingness to pay).

Such methods make the economic value of productive green open (intra- and peri-) urban spaces visible, which is very important for awareness-making among urban planners and decision makers, to include "green infrastructure" in municipal budgets/asset accounting, decision making on the location of new residential, industrial and office areas, and the forward urban development and land use planning.

Such methods may also be applied to assess the economic value of other potential impacts of enhanced local/regional food production (e.g., social benefits, health benefits).

Comprehensive agro-food system assessments

Comprehensive agro-food system assessments combine most of the above and other methods in an integrated approach (including system modelling) to evaluate the performance of the local or regional agro-food system in a systemic way, including the complex interactions between the various components of the agro-food system: to determine the actual performance of the agro-food system with the help of a number of selected indicators (social, economic, ecological) and to assess the expected changes in such indicators as a consequence of certain proposed policies and plans in relation to the local/regional agro-food system. Often, metropolitan or regional planning authorities take a leading role in such exercises.

Examples of more comprehensive city region agro-food assessments are Bristol, UK (Carey 2013) and Vermont, USA (Koliba et al. 2011).

Conclusions and the way forward

We have shown that choices made in the initial phases of the planning process will strongly influence the scope of the exercise and the type of results that may be achieved:

a. Choice for a specific geographical scope: Is the focus on neighbourhood, city or city-region level? Each level is bringing its own demands (and limitations) for information, policy orientation, stakeholder involvement, etc.
b. Choice for a specific focus: Is the attention mainly at improving health/nutrition, enhancing food security and access to food of the urban poor, strengthening the local economy and resilience of the agro-food system in the city region, on reduction of the urban food(t)print, on improving the urban green infrastructure with recreational and eco-services next to food production, or a combination thereof? Such choice will – amongst others – lead to other data requirements, stakeholders and selection of other assessment methods, and finally to identification of a different set of priority food strategies.
c. Choice for a specific approach: Is the process mainly focused on mobilizing and supporting innovative and alternative local initiatives in the field of food and agriculture (e.g., Amsterdam: Vermeulen 2010), or rather on the realization of a systematic assessment and planning of the local or city regional agro-food system as, e.g., in Bristol (Carey 2013).
d. Choice of the position viz. local authorities: Is the process managed by local or regional authorities or by a group of concerned civil society actors, or

characterized by an intermediate position (independent from government but with more- or less-developed linkages). This strongly influences policy uptake, access to financing and sustainability (also amidst political and institutional changes). Also the degree of awareness among urban planners and decision makers strongly influences the planning process (crucial role of "champions" in the process, more time and efforts needed for awareness-raising and engagement and search for funds to implement the process).

The review of the assessment and planning methods applied in urban agro-food planning indicates a number of challenges for the practitioners and scientists involved in such exercises:

- There is a strong need for comparative assessments of the efficacy of different approaches to local/regional food system planning: Which approaches have more effects on local policies and planning, lead to better participation of the less powerful actors in the local food system, lead to a better systemic understanding of the functioning of the food system and are more effective in leading to concrete changes in the urban food system (in terms of access to food, nutritive quality of food, ecological footprint of urban food consumption, resilience of the urban food system, etc.)?
- In that perspective, there is a need to include in reports on local/regional food system assessment and planning studies detailed information on the methods used and their implementation (process applied, participating actors/how/in what, hampering and facilitating factors, lessons learned) and related costs (financial means, human resources) and time horizon. Especially the resources used in urban food planning processes so far are hardly documented and analyzed.
- There is a need for stronger integration of the more participatory community-based local food system approaches and the more planning-led comprehensive city region food system planning approaches.
- Also the adaptation of the methodology for less endowed cities (in terms of available data and information management systems, staff, financial means), e.g., medium and smaller size cities, especially in developing countries.
- The development of a (minimum) package of indicators to monitor the functioning and development of the city region agro-food systems is much needed.

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4

AGRICULTURE IN URBAN DESIGN AND SPATIAL PLANNING

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Introduction

This chapter will focus on particular issues, driven by increasing urbanization worldwide, that are affecting the planning for (intra- and peri-) urban agriculture in the Global North and South. The attitudes taken in the future towards the position of urban agriculture within design and planning theory and practice will have a profound effect on the spatial qualities of the urban and rural sectors. The chapter aims to draw out design and planning opportunities presented by, in the main, intra-urban agriculture referring to a repertory of state-of-the-art examples from around the world.

Planning and design

Developments regarding agriculture in urban design and planning

Since the publication of RUAF's "state of the art" in 2006 (van Veenhuizen 2006), the most significant planning document within a developed country has been the *Policy Guide on Community and Regional Food Planning* adopted nationally by the US American Planning Association (APA) in 2007. Most memorably it notes that

> Food is a sustaining and enduring necessity. Yet among the basic essentials for life – air, water, shelter, and food – only food has been absent over the years as a focus of serious professional planning interest. This is a puzzling omission because, as a discipline, planning marks its distinctiveness by being comprehensive in scope and attentive to the temporal dimensions and spatial interconnections among important facets of community life.
>
> *(APA 2007: 1)*

This policy guide followed on from the paper by Pothukuchi and Kaufman (2000) "The food system: A stranger to urban planning", as well as from other related writing, but none that dates back further than 20 or so years.

In developing countries, both at the planning and design level, important progress has also been made since 2000. On the planning side, for example in the context of the RUAF programme "Cities Farming for the Future", 17 municipalities – working with other local stakeholders – developed a *Strategic Agenda on Urban Agriculture* as a basis for local policies and programmes to include urban agriculture into local land-use plans and regulations. Such global policies and strategies have then to be translated into concrete action plans and designs at the local level, such as house, site, cluster and neighbourhood.

In cities like Colombo (Sri Lanka) and Rosario (Argentina), McGill University's School of Architecture (Canada) and the RUAF Foundation collaborated with local architects and stakeholders to elaborate lane, housing and neighbourhood designs that included urban agriculture. In Rosario, for example, local government, neighbourhood groups, local producers and invited experts jointly designed multifunctional "productive parks" in poor neighbourhoods, combining urban greening with community gardens, children's playgrounds, food-producing school gardens, and facilities to capture and store excess storm water and grey household water (see: www.ruaf.org/projects/making-edible-landscape-integrating-urban-agriculture-urban-development-and-design).

In parallel with practical action on the ground, research publications and programmes have continued since the start of the new millennium. EC-funded projects were undertaken, for example, by the *SWAPUA* programme in five Eastern European countries implemented by RUAF and ICLEI in 1999 and 2000. Programmes like PUREFOOD, FOODLINKS, COMFOOD, Eating City/Risteco, SUBURBFOOD, SUSCHAIN, RURURBAL and others followed in later years (see: http://publications.jrc.ec.europa.eu/repository). The outcomes of these programmes are directed towards high-level research and policy agendas and do not easily or quickly reach or inform practitioners in a way that addresses their day-to-day concerns. In part as a response to this, in 2009, a number of active European researchers undertaking work in this field established the Sustainable Food Planning Group under the umbrella of the Association of European Schools of Planning (AESOP). The aim of this group is to further cross-disciplinary dialogue, research and practice and to disseminate findings within schools of planning and design as well as within practice. An annual *European Sustainable Food Planning Conference* has been held since the group's inception (see: www.aesop-planning.eu/blogs/en_GB/sustainable-food-planning).

Another strand of development has occurred within the field of design, often led by architects, and resulted in several publications, exhibitions and events aimed at envisioning and visualizing how, in the main, urban agriculture could contribute to the urban realm. For example, in Europe, 2005 saw, as far as we know, the publication of the first book advocating a comprehensive design strategy for the integration of urban agriculture into cities (Viljoen 2005), and in 2007, the

Netherlands Architecture Institute in Maastricht hosted the first major exhibition on the subject, titled *De Eetbare Stad/The Edible City* (see: http://culiblog.org/2007/02/the-edible-city). A further publication with a significant public impact in the English-speaking world was Carolyn Steel's (2008) book *Hungry Cities: How Food Shapes Our Lives*. Since 2009, the *Carrot City* project, consisting of a travelling exhibition, a website (see: www.ryerson.ca/carrotcity) and a book (Gorgolewski et al. 2011), has been providing an important international overview of current urban agricultural design.

All these publicly accessible initiatives complement long-established resources like the online *City Farmer News* (see: www.cityfarmer.info) and RUAF's extensive international policy and practice-focused archive and journal (see: www.ruaf.org). The recent emergence of Food Policy Councils, especially in North America, highlights the start of a transition of the debate about urban agriculture and urban food within the wider population towards food systems planning. Figure 4.1 reflects the emergence of urban agriculture as a design subject and the increasing international attention paid to it, as evidenced by major design-related outputs (note: *this chart is not exhaustive, but reflects trends evident to the authors Bohn and Viljoen in their practice*).

Intra- and especially peri-urban agriculture has been encouraged in the Global South for a considerable period of time within the broad field of development initiatives, both as an area for practical implementation and academic investigation. Receiving ever more attention in the recent past, it has been – implicitly rather than explicitly – incorporated in urbanization studies as well as in urban planning initiatives. Von Braun (1987), for example, broached the issue of developmental potentials of urban agriculture in the late 1980s.

Comparing the world's situation in summary: Within developing nations, peri-urban agriculture remains a significant food-supplying land use, but one which is threatened by rapid urbanization and the consequent loss of land to building activities. Within developed nations, and especially evident in Europe, farms in peri-urban areas are diversifying their commercial activities towards recreation and health in order to remain financially viable (EU 2008).

Green infrastructure and multifunctional landscapes

Today, intra- and peri-urban agriculture can be theorized in relation to regional planning and the concept of multifunctional landscapes (Kasper et al. 2012). Multifunctional landscapes are often equated with the larger concept of *Green Infrastructure,* as in the case of the UK-based Landscape Institute advocating green infrastructure as a connected and multifunctional landscape (Landscape Institute 2009).

Four guides issued in 2012 by UN Habitat under the general heading *Urban Patterns for a Green Economy* are significant for explicitly linking calls for urban compaction, increased biodiversity and economic competitiveness within a context of environmental sustainability. Each guide focuses on a theme, namely i) Working

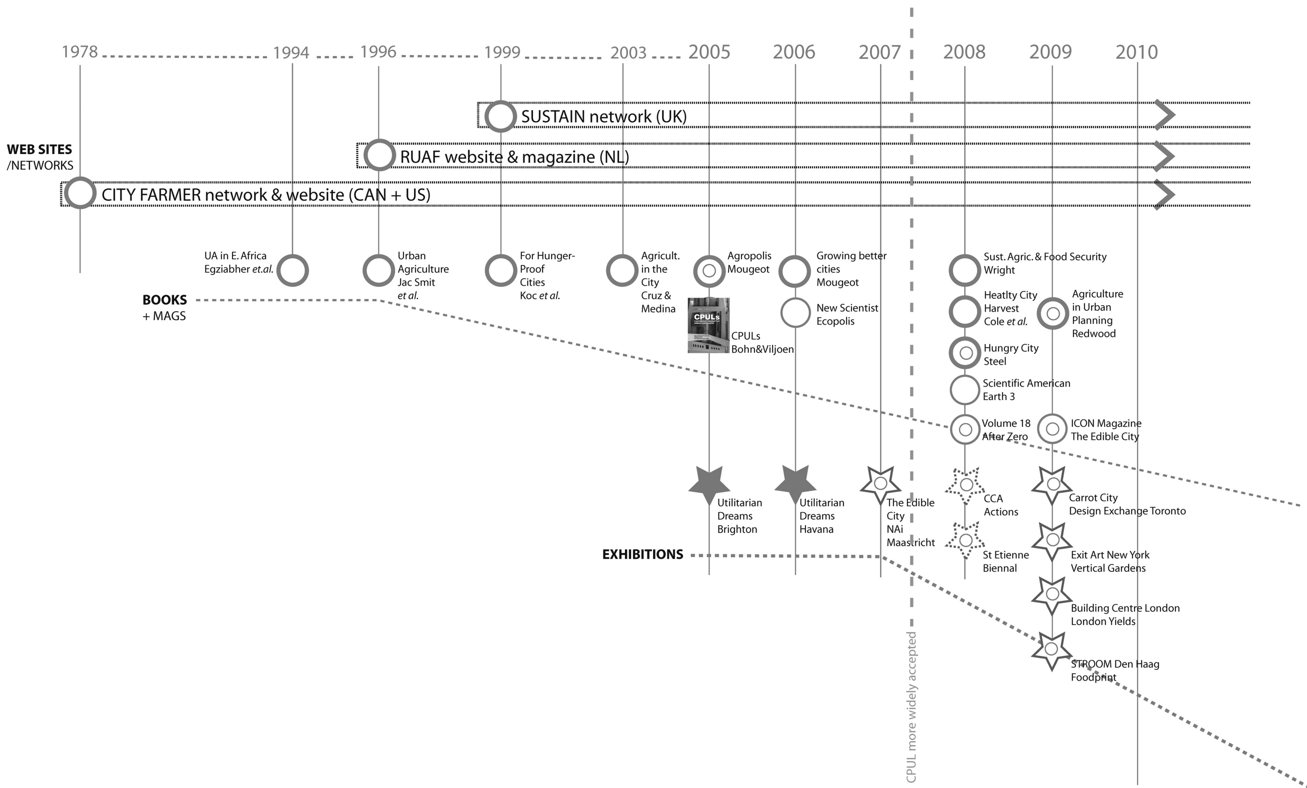

FIGURE 4.1 The emergence of urban agriculture as a design subject

Source: Bohn&Viljoen.

with Nature, ii) Levering Density, iii) Clustering for Competitiveness, and iv) Optimizing Infrastructure. Intra- and peri-urban agriculture is dealt with most explicitly in *Working with Nature* (UN Habitat 2012a) and *Optimizing Infrastructure* (UN Habitat 2012b).

Issues affecting space for urban agriculture

The high cost of urban land is common to all dynamic cities, whether in developing or developed nations, and poses very real challenges for the implementation of intra-urban agriculture, as does a general lack of policy to support it within planning documents. This is exacerbated by increasing levels of urbanization, which puts pressure on intra- and peri-urban agriculture. On the other hand, recognition of the need for enhanced urban biodiversity and access to open urban spaces for social interaction supports the importance of multifunctional landscapes including agriculture. Furthermore, agricultural production can facilitate local cradle-to-cradle systems, for example by utilizing organic waste to produce soil for growing food.

As a starting point for the rest of this discussion, we accept the rationale and desirability for thinking about intra- and peri-urban agriculture as part of an urban–rural continuum embodying multiple interdependencies, as most recently set out in the document *City Regions as Landscapes for People, Food and Nature* (Forster and Getz Escudero 2014). If this rationale is employed and if it includes urban (i.e. spatial) design – which, surprisingly, is missing from the mentioned document – then there is potential to improve qualitative and quantifiable aspects of daily life, while simultaneously creating a shift towards smaller ecological footprints and more enjoyable places to live.

Urbanization and political-administrative challenges

Actual and projected population growth and urbanization in developed and developing nations are having a major impact on the access to potential land for intra- and peri-urban agriculture. Dar es Salaam (Tanzania), for example, has quadrupled in size within just over 20 years (UN Habitat 2010; UN 2012), and Ouagadougou (Burkina Faso) show similar growth (Figure 4.2). Population growth and the respective rapid expansion of urban agglomerations – such as Lagos (Nigeria), Nairobi (Kenya) and Mumbai (India) – are the most severe challenges to urban planning institutions.

In many countries of the developing world, similar issues also arise in small and medium-sized cities. This particularly applies to smaller settlements in the vicinity of major settlements or along important rural–urban corridors, e.g. from Ouagadougou (Burkina Faso) to Accra (Ghana). Spatial growth of these cities is therefore usually understood as a threat to arable land in and around cities and to those farmers whose livelihoods depend on it.

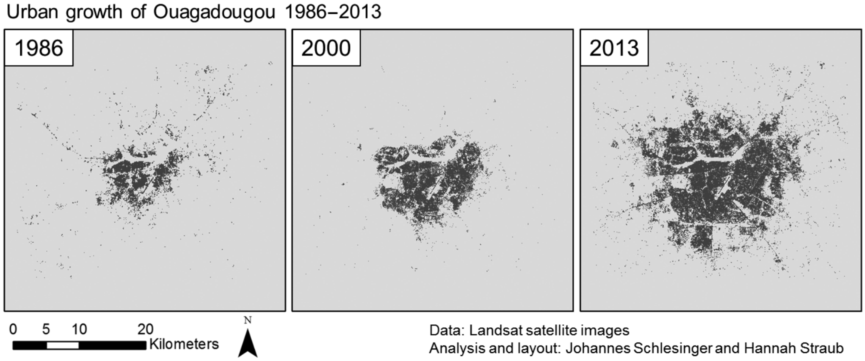

FIGURE 4.2 Rapid urban growth in the developing world – the example of Ouagadougou (Burkina Faso)

Source: Schlesinger and Straub.

As cities in the Global South grow, they can spread into territories over which the city authorities have no control, and there are manifold examples of repeated adjustments of municipal boundaries over time. The consequences for intra- and peri-urban farmers can be dramatic. As boundary changes are usually conducted following a political or administrative top-down approach without consulting the affected farming communities (Tinker 1994), they can appear arbitrary to the farmers. Peri-urban farmers are especially confronted with a lack of predictability about future development (Mougeot 2006). Sometimes without knowing about these changes, their farming activities might suddenly become illegal when territories are newly defined as urban and fall under municipal jurisdiction (van Veenhuizen and Danso 2007). As municipal by-laws tend to prohibit agricultural activities within areas classified as urban, farmers might be forced to stop their activities or shift to other areas. Additionally and regardless of its importance for many urban dwellers, agriculture is still often looked at as a traditional, old-fashioned form of securing livelihoods, which should be kept out of the administratively defined cities (Smit et al. 2001).

But there is cause for optimism too, as the UN Habitat's *Working with Nature* report shows in the following very important work that is underway in Africa: "The Sustainable Cities International Network's Africa Program is assisting the municipalities in Dar es Salaam to lobby for secure land tenure by requesting the government to allocate land for urban agriculture in the same way that land is allocated to residential developers" (UN Habitat 2012a: 35). Similarly, in its recent *State of African Cities* report, UN Habitat (2010: 20) emphasizes that "expanding the urban administrative territory is an option that should be considered by African governments and city managers, particularly in rapidly growing intermediate-size cities." If such strategies are achieved and spread more widely, they will represent a quantum leap in the progress of integrating urban agriculture into urban planning in the Global South.

Consequently, urban growth poses new challenges to planning institutions in the Global South. Planning in the Global North also deals with new challenges due to urbanization, especially as population numbers grow without cities being able to expand proportionally. Compared to developing nations, however, settlement patterns in cities of the Global North are largely consolidated, as their natural increase in population and rural-urban migration rates are rather low. To deal with population growth, city councils apply the planning tool of "secondary densification" through in-fill and redevelopment by which existing underutilized open urban space is used for construction of infrastructure and housing. Outlining long-term strategies for the (temporal) use of underutilized land still remains crucial for minimizing the city's ecological footprint through the productive use of that land.

The environmental need for (food) productive spaces

Environmentally, urban agriculture can impact on cities of the Global South and North in various ways at a micro and macro scale (Smit et al. 2001; Rakodi et al. 2002). For example, keeping green areas in the cities can cushion the impact of an increasing number of heavy precipitation events (Smit et al. 2001; Freshwater Society 2013). And by lowering average temperatures in the "urban concrete jungle", as another example, agriculturally used surfaces can improve the urban micro climate and hence the well-being of the urban population (van Veenhuizen 2006; Lovell 2010; de Zeeuw et al. 2011). However, whilst "planting" is beginning to be specified in urban planning documents as a way to mitigate climate change and reduce climate-related stress, "edible planting" is still specified much less. Furthermore, including food waste as a source of compost as, for example, advocated in the cradle-to-cradle system by Braungart and McDonough (2002), would not only reduce environmental footprints, but the quantity of compost thus generated would also provide a measure of the amount of urban agriculture that a city could support (Viljoen and Bohn 2014).

The urgency with which the loss of urban and regional biodiversity needs to be reversed to achieve environmental and economic resilience has been articulated in the UN Habitat's (2012a) publication *Urban Patterns for a Green Economy – Working with Nature*. This document makes the case for "landscape mosaic patterns" as defined by Richard Forman (2008), consisting of different-sized patches of open space connected by green corridors of small "stepping stone spaces". These are ideally suited to organic agriculture, which enables the maintenance of diverse ecosystems. In 2010, the United Nations' University Institute for Advanced Studies made an even more explicit connection to urban agriculture when they noted that "as the rule of interdependent adjacencies in urban ecology has it: the more diversity, and the more collaboration between unlikely partners, the better the chances for biodiversity, sustainability, and resilience. Linked to this idea is the concept of Continuous Productive Urban Landscapes (CPULs), which represents a powerful urban design instrument for achieving local sustainability while reducing cities' ecological footprints (Viljoen 2005)" (UNU 2010: 31–32).

With respect to planning, Bohn and Viljoen have long argued that, if land is to be provided for intra- and peri-urban agriculture, a conceptual leap is required by which it becomes considered "essential infrastructure" (Viljoen and Bohn 2005). The many-faceted arguments in favour of urban agriculture, beyond yields, allied to the recognized needs for changing consumer behaviour and enhancing urban biodiversity, are all advancing this argument. Detroit (USA), for example, which is well known as a shrinking city facing multiple challenges, has concluded in its 2012 *Strategic Framework Plan* to "utilize productive landscapes as the basis for a sustainable city" (Detroit Future City 2012).

Spatial opportunities for agriculture in and around cities

According to Mougeot, manifold types of locations can be identified "respective to residence (on-plot or off-plot), development status (built-up or open space), modality of tenure/usufruct (cession, lease, sharing, authorised or unauthorised – through personal agreement, customary law or commercial transaction) and the official land-use category of the sector where [urban agriculture] is practised (residential, industrial, institutional, etc.)" (Mougeot 2000: 7–8). This can include cultivation on private land, such as backyards and around houses, or on community and other public lands, such as parks, along roads, railways, under power lines and alongside streams, or in areas that are too steep for construction (Bryld 2003; Viljoen et al. 2004; Drescher and Gerold 2010; de Zeeuw et al. 2011).

The economic use of these sites can be increased, "since income is generated from temporarily available land and lands not suitable for building" (Bryld 2003). Thus, urban agriculture can take place in a broad range of settings, often transforming vacant or under-utilized land into productive areas (de Zeeuw et al. 2000). Accordingly, the areas where urban agriculture is conducted are as diverse as the farmers cultivating the land, and despite the increasing pressure on (intra- and peri-) urban arable land, farmers manage to find locations to pursue agricultural production. The locations where agriculture occurs are important because "this points to specific constraints and opportunities such as the degree of land access, the land tenure situation, costs and time related to travelling to and from the production site, closeness to markets and risks" (van Veenhuizen and Danso 2007).

The importance of tenure

The lack of formal land titles appears as one of the key obstacles to increasing the access to finance for urban farmers in the developing world (Drescher and Iaquinta 1999). In general terms, lack of secure tenure is a major disincentive for farmers because it restricts their access to land or becomes a barrier to financial investment. A programme developed in Freetown (Sierra Leone) provides a promising example of how to address this problem:

> The Freetown Urban and Peri-Urban Agriculture Forum, involving key political institutions, credit institutions and farmers, have designed an innovative financing mechanism in 2010. The new program relies on authorities for the permanent allocation of valleys, slopes and low lands for urban and peri-urban agricultural use. Land is allocated to registered and functioning farmers' groups for a period of 5 years for a token rent provided that they abide by the agreement regulations. The groups receive technical training and monitoring, and four credit institutions (First International Bank, Access Bank, Luma Micro Finance Trust Limited, Salone Micro Finance Trust) have agreed to accept such land agreement together with the groups' existing savings or current accounts as a collateral for two purposively designed credit products (personal comment, Marco Serena 2011). The first is a micro credit of between 100 and 400 EUR (repayment period 1 year); the second is a loan between 1,000 and 2,000 EUR (repayment period 2 years) with a yearly interest rate of 24%. The number of households who could potentially benefit from the scheme once fully established is estimated at 2,500.
>
> *(Cabannes 2011)*

If planning policies can be agreed and enforced in developing countries, as in the example above, a tremendous opportunity exists to incorporate designated spaces for urban agriculture within their cities' future urban expansion areas. By contrast, cities in developed countries, even dynamic ones like London (UK), Rotterdam (The Netherlands) and New York (USA) are seeking the evidence for supporting planning policies to retrofit or reintroduce productive spaces within their current boundaries.

Integration of agriculture into urban and city-region land-use planning

Planning tools

The most commonly used planning tools include master plans, strategic plans and structure plans (Dowall and Giles 1997). Different zoning measures are part of those plans. Experience has shown that general and master plans tend to be static, prescriptive or assume slow-growing cities. They also tend to ignore how households and the commercial sector alter their demand for land as prices change. Even when such master plans have taken substantial time and effort to make, they could be of limited relevance to real developments on the ground, unless the most powerful stakeholders are willing to adhere to them. In other words, the authority of a master plan can vary a great deal (van den Berg 2000).

A more appropriate and dynamic planning tool is "structure planning". It provides a broad framework for local decision making and involves public participation. The structure plan sets out a framework for the development of a community. Being more indicative than master plans, it requires not only projections of future demands and needs of the community, such as housing, infrastructure, employment, transport, local markets, etc., but also environmental aspects like waste management. We can see this approach being applied more formally in developing and developed countries where elected city authorities are increasingly cash-strapped and aim to facilitate development rather than lead it as was often the case during the second half of the last century. To facilitate *structure planning,* participatory processes are required as described in Chapter 3 of this volume.

The increasing use of remote sensing tools for urban land-use planning

The use of remote sensing (RS) for mapping and monitoring (intra- and peri-) urban green spaces facilitates the mapping process, but needs to be combined with actual ground data evaluation if it is to be of practical use. Although urban planning has made wide use of geographical information systems (GIS) for decades, this hardly ever included the management of open spaces. The experience of applying GIS to urban food production activities has, however, rapidly increased in recent years in many cities in the Global North and South. GIS is not only used for urban planning and open space mapping, but also for monitoring the loss of agricultural land within city boundaries, to visualize food security indicators or for measuring urban greening indicators (Idbamerica 1998; American Forests 2000; Fazal 2000). It also has the potential to foster the preparation of urban food policies and strategies by providing detailed analyses of food flows from the production sites to the different locations within cities, as exemplified by the US *Foodprints and Foodsheds* project (see: www.foodprintsandfoodsheds.org).

In a situation where cities continue to undergo rapid changes, GIS allows planners to more easily monitor changing urban food production trends by applying this tool to the entire urban food system (Dongus and Drescher 2000; Drescher et al. 2013; Schlesinger and Drescher 2013; Schlesinger 2013). Innovations in the field of "unmanned aerial vehicles" (UAV) further reduce costs for GIS data collection. The significant comparative advantages of these systems typically include: very high ground resolutions (ca. 3 cm/pixel), flexibility in terms of payload (e.g. RGB-, Infrared- or Laser-systems) and applications (e.g. crop mapping, site monitoring, digital surface models). UAVs were already successfully applied in the quantification of crop production areas in West Africa by Schlesinger (2014) (Figure 4.3).

Nevertheless, the use of RS reveals institutional difficulties in planning. Planning can only be carried out efficiently if the different data on space, infrastructure, markets, nutrition, health, soils, water, waste, socioeconomy, agriculture, etc., amassed by different departments is linked together. Furthermore, the technical equipment (data, computers, plotters, computer networks) and the skills needed in applying RS are often missing. Traditionally, GIS has been used in a rather centralized way, in that one institution takes the lead in the planning process with little or no participation from other units. GIS does not automatically facilitate the dialogue

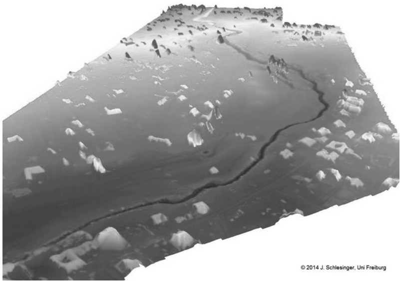

FIGURE 4.3 Digital surface model (left) and high-resolution RGB ortho image (right) of an agricultural site in Tamale (Ghana)

Source: Schlesinger.

with the decision makers, but it needs to be used innovatively. Community building is a prerequisite for enabling participatory planning, and the successful application of GIS for participatory urban planning has been demonstrated in Cagayan de Oro (The Philippines) (Holmer and Drescher 2005).

Planning and access to land

Once sites for urban agriculture have been identified, whether they are plots on the ground or building-integrated agriculture, we come back to the question of tenure, which remains critical because of the significant investments of time and infrastructure required to raise crops. As regards the protection of existing agricultural land, the lessons learnt from a radical "zero-loss policy" being applied in India will be relevant to the future of urban agriculture: "As proposed by the Indian National Planning Commission, new development activities should be carried out with zero loss of agricultural productivity; if agriculture land has to be used, innovations should be included to introduce new forms of agriculture in the same premises" (NAAS 2013).

Protecting spaces for (intra- and peri-) urban agriculture by securing tenure

Experiences from site-and-service schemes, whereby areas are designated for self-help housing and provision of basic services such as roads and water to upgraded squatter settlements, have shown that the poor tend to gradually improve their housing, provided they have land security. Similar observations are true for urban agricultural activities, as shown in South African townships (Small 2001). On the other hand, experience shows that the poor, because of high costs, often tend to sublet or sell these sites and move back to the original squatter settlement (Dowall and Giles 1997). Also, increasing population density of squatter sites reduces agricultural land in these areas. Sometimes in-town or rural-urban chain migration is the cause of this, but often the owner of the plot sublets part of the plot to strangers to make money. With respect to the public interest in the conservation of open spaces in cities, this is a strong argument to lease and not to sell urban agricultural land.

Leasehold provides a limited right to use land for a specific time and for a specific purpose often including protected tenure with rights for prolongation and of transfer (Österberg 1998). Contrary to outright landownership, leasehold (from public bodies) prevents land speculation, thus protecting public interest in open spaces. Proper leasehold is closely related to customary tenure, which, for example in Africa, often includes land use for specific purposes. Another model is community leasehold whereby land is given to a community or association to use it for specific purposes. The European allotment systems work along this line. Nevertheless, this requires the establishment of management associations, garden clubs or similar community-based groups (Drescher 2001).

Within Europe and North America, Community Land Trusts (CLTs) are emerging as a new way of providing tenure for urban producers. Urban agriculture is not usually the primary driver behind the establishment of CLTs, but they can, through cross-subsidy or because of community concern support UPA practitioners. A 2012 study by the US-based Lincoln Institute of Land Policy usefully explored this potential in greater detail:

> Community Land Trusts (CLTs) are non-profit, community-based land organizations with a place-based membership, a democratically elected board, and a charitable commitment to the use and stewardship of land on behalf of local communities. In most cases, CLTs retain permanent ownership of land, which is then leased – through a system of inheritable leases – to various users that own the improvements upon the land, such as residential homes, recreational facilities or, more recently, also urban agriculture. Such ground leases have different benefits: (1) they secure occupancy rights for land users; (2) they preserve affordability by restricting the resale price of improvements; (3) they prevent undesirable uses and improvements of the land; (4) they prohibit predatory lending and reduce foreclosures; and (5) they create a source of income through monthly lease fees to support CLT activities.
>
> *(Rosenberg and Yeun 2012)*

Planning and practical action

Municipalities, professional bodies and enterprising individuals still have the power to make forward-looking interventions and are increasingly doing so. However, the picture is uneven, for example in former British colonies the category of farming or agriculture did not exist in urban master plans and this has still not changed in many of these countries (personal communication, Pay Drechsel 2014). Furthermore, local authorities are often overwhelmed by the dimension of urban development. In the few cases where the planning institutions are willing to support urban agricultural schemes, it is often the sheer lack of human resources in the respective administrative bodies that hinders locally adjusted urban development measures that take into account the importance of urban agriculture. As pointed out by Allen et al. (2014) for the example of Accra (Ghana), unsolved land tenure conflicts and increasing land speculation – especially in the peri-urban areas – often hamper long-term planning for agricultural activities in African cities. Even proper institutionalization of urban vegetable farming was, in the case in Accra, not leading to long-term sustainability. For example, the revision of Accra's bylaws lost its dynamic when external funding expired (Drechsel et al. 2014).

In India, by contrast, the role of urban food production is increasingly recognized not only by the scientific community but also by policy makers and urban planners. The Indian government developed a vegetable production scheme, and the Planning Commission for the *12th Five Year Plan* (2012–2017) has emphasized the potential of urban agriculture with regard to environmental services and health care (NAAS 2013). Similar trends can be observed in some cities in Latin America. In Rosario (Argentina), for example, urban planners start recognizing the importance of including the local population in urban design and development measures, to enhance the local food production (Dubbeling et al. 2009). The support by the municipal Urban Agriculture Office led to the development of more than 700 community gardens as well as four large parks located in the vicinity of marginalized communities (POLIS 2010).

Looking to North America and Europe, we can identify concrete initiatives in support of urban food planning. In 2011, for example, the American Planning Association followed up their *Policy Guide on Community and Regional Food Planning* (APA 2007) with a substantial advisory report specifically addressing urban agriculture (Hodgson et al. 2011).

Although policy in support of urban agriculture within municipal legislation is still by no means the norm, it is beginning to appear, and precedents continue to be set since about the last ten years. In addition to those cases described above, notable examples at the municipal level include Brighton & Hove (UK) Council's adoption, in 2011, of a non-binding planning advisory document titled *Food Growing and Development,* advocating the integration of food-growing spaces within urban development proposals. This advisory notice, the first of its kind in the UK, has resulted in a measurable increase in the integration of food-growing spaces within subsequent planning applications. Similarly, US cities like New York City have relaxed restrictions on the construction of rooftop greenhouses to remove barriers to the implementation of rooftop gardens as well as greenhouses. Furthermore, cities are beginning to promote productive urban landscapes within development plans, e.g. Berlin (Germany) (SenStadt 2012) and, as already mentioned, Detroit (USA) (Detroit Future City 2012).

Designing urban spaces for and with agriculture

Urban design and agriculture

Due to its relatively large and visible presence, urban agriculture has a very significant impact on urban space. It is apparent that these spaces have the potential not only to be unique spaces, but also to contribute to a new evolution within thinking about urban space. An early design study titled *Cuba Laboratory for Urban Agriculture* (Viljoen and Howe 2005) took the approach that the pragmatic positioning of extensive "organoponicos" (commercial urban market gardens applying large amounts of organic materials in raised beds and eventually established on paved and concreted areas) in Cuba provided an opportunity to speculate on their design potential. The fact that "organoponicos" had been positioned using a set of clearly defined horticultural criteria, but had not consciously been planned as part of an urban design strategy, meant that these provided an ideal vehicle for examining how they could be designed to contribute beneficially to their surrounding environment. This study, published in 2005, was so far as we know the first attempt to apply design criteria to agricultural sites. From this a set of principles were proposed related, for example, to the design of edges, paths, topography and uses in addition to food growing. The subsequent expansion of urban agriculture has reinforced these and we refer readers to the original document for further elaboration. Another major ongoing and accessible resource, making the case for understanding the design potential of urban agriculture and documenting international projects, is the *Carrot City* (2009) repository that has been referred to at the start of this chapter.

Other significant and recent pieces of work led by architects and landscape architects are the *Edible Rotterdam* project (Graaf 2012) and the Swiss research programme titled *Food Urbanism Initiative* (see: www.Foodurbanism.org). The former develops design strategies based on spatial opportunities identified within Rotterdam (The Netherlands), whilst the latter produced an online definition of particular *Food Urbanism* typologies of use to planners and designers and categorized under the headings *"Site"*, *"Cultivators"*, *"Motivation"* and *"Production Entity"*.

From the body of work that the above examples belong to, we can extract a number of key ideas with which a designer can work, which will be briefly discussed in the next section.

Key design ideas

Programme and place

It is when additional programmes of use are added to food production that spaces require the most design input. And where intra-urban agriculture is not self-evidently required on conventional economic grounds (e.g. in much of Europe), it is often the multiprogramming of space that makes agriculture economically viable by providing opportunities to meet social needs. A number of ambitious projects like this are underway in Europe.

For example: R-Urban is a neighbourhood project in the Paris suburb of Colombes (France) led by Atelier d'Architecture Autogérée (AAA), which includes agriculture as a major spatial and social component using co-design principles (Figure 4.4). Edible Landscape projects are being integrated in the Dutch neighbourhoods of Rotterdam, Den Haag and Amsterdam by Urbaniahoeve's Social Design Laboratory for Urban Agriculture, using arts-based practice as a way of engaging in dialogues with city authorities and local stakeholders (Figure 4.5). Multifunctional communal food gardens have been developed by the Department of City and Nutrition within the Technical University of Berlin's Landscape Architecture programme for the Berlin suburb of Marzahn (Germany) (Figure 4.6). As well as food production, they have various functions for different age groups, such as children's playground, environmental and food education, and recreation for the elderly.

FIGURE 4.4 Agrocité: the agricultural site designed by the R-Urban neighbourhood project in Colombes near Paris (France)

Source: Bohn&Viljoen.

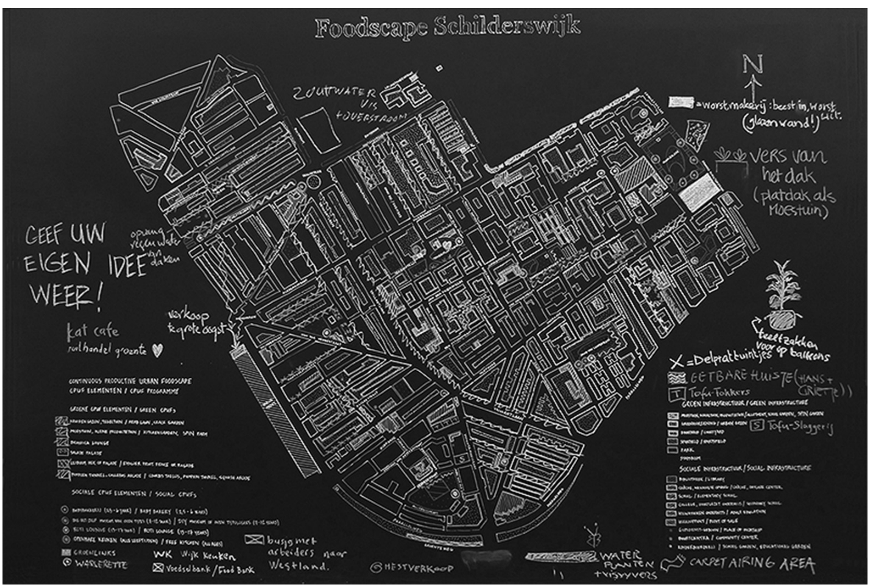

FIGURE 4.5 The borough Schilderswijk in The Hague (The Netherlands) designed as a Continuous Productive Urban Foodscape by Urbaniahoeve

Source: Urbaniahoeve.

FIGURE 4.6 View of the Marzahn multifunctional community garden project in Berlin (Germany)

Source: Bohn&Viljoen.

Importance of scale – urban or architectural scale

Intra-urban agriculture spaces can be thought of as "urban rooms", "floors" or "corridors" within the city. Without understanding that these spaces can be made part of a wider network, they will remain disconnected from the wider urban structure even if by themselves they create attractive individual spaces. Concepts like *CPUL City* or *Food Urbanism* aim to offer design solutions for knitting agriculture into the urban fabric.

Recent strategic city-scale urban designs from Bobo Dioulasso (Burkina Faso) and Detroit (USA) provide good examples for this approach. As part of an overall climate change adaptation strategy, the city of Bobo Dioulasso, with a population of 800,000, plans to implement a series of productive and "climate smart" land-use strategies within green corridors (Figure 4.7). A demonstration project has been constructed along a 1.65 km long, 50 m wide green corridor which previously existed as a long dusty void in the city. In design terms, this project exemplifies the multifunctional planning and design of open urban

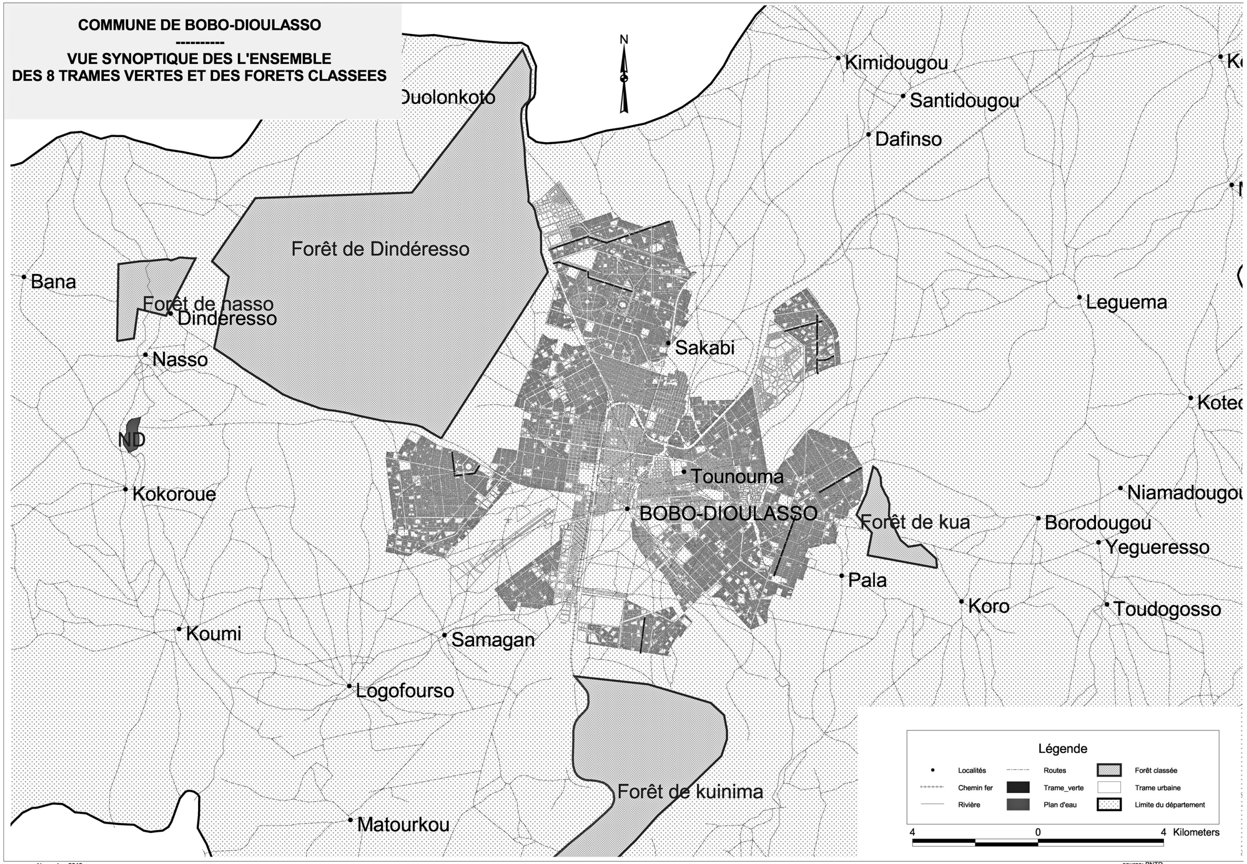

FIGURE 4.7 Mulifunctional greenways (Trames vertes) in Bobo Dioulasso, Burkina Faso.

Source: Sy.

space. The site has been divided up into a sequence of four zones, dealing respectively with forestry, food growing, recreation and education. This intelligent mix of uses creates a place with different attractions for different groups, and, by facilitating these uses, has transformed a void from a space into a place. The material means by which this transformation has occurred are minimal: paths, planting beds and fields are demarcated by small changes in level and surface texture (in this case due to compaction or the breaking open of soil) (Sy et al. 2014).

In certain respects, the ambition and scale of Bobo Dioulasso's productive landscapes echo one of the earliest and most ambitious examples of a "place making" productive landscape, namely that developed in conjunction with RUAF by residents of Rosario (Argentina) (Dubbeling et al. 2009).

In a very different climatic and demographic context, Detroit (USA), well known for its severe financial problems and loss of population, has used a comprehensive multi-stakeholder planning methodology to develop a strategic framework plan titled *Detroit Future City* to guide future development. The plan includes the intention to "utilize productive landscapes as the basis for a sustainable city" (Detroit Future City 2012). It specifically defines "innovative productive" as a new land-use category, including food growing, greenhouses, fields of flowers, aquaponics and ecological services. Detroit has so much partially occupied former suburban territory that its condition is not such that agricultural space is under obvious pressure from urbanization. Rather it has developed a scenario for intensively cultivated modern smallholdings alternating with large-scale horticultural production, resulting in an extensive mosaic of differently sized productive territories around and between which inhabited areas occur and between which inhabited areas occur (Figure 4.8). The productive territories are analogous to lakes in a landscape, and in many respects offer citizens similar benefits as a health-improving recreational landscape, without detracting from the critical densities required to create a vibrant and desirable urban culture. So-called carbon forests have been designed to run as long avenues leading towards the city center from the periphery, demarcating territory while also giving directionality and presence to ecological and personal corridors. Detroit's strategic framework plan demonstrates how essential infrastructure can create desirable territorial identity as well as climate-sensitive landscapes. The scale and process by which Detroit has developed its framework plan provides a working model for large expanding cites, such as those found in China or Africa, where, despite many challenges, the current and future prospects, including human capital, are far more optimistic than for Detroit.

Programme, place, architectural and urban scale operate at a strategic level. The following section aims to extract more site-specific ideas which help to determine particular components of a design.

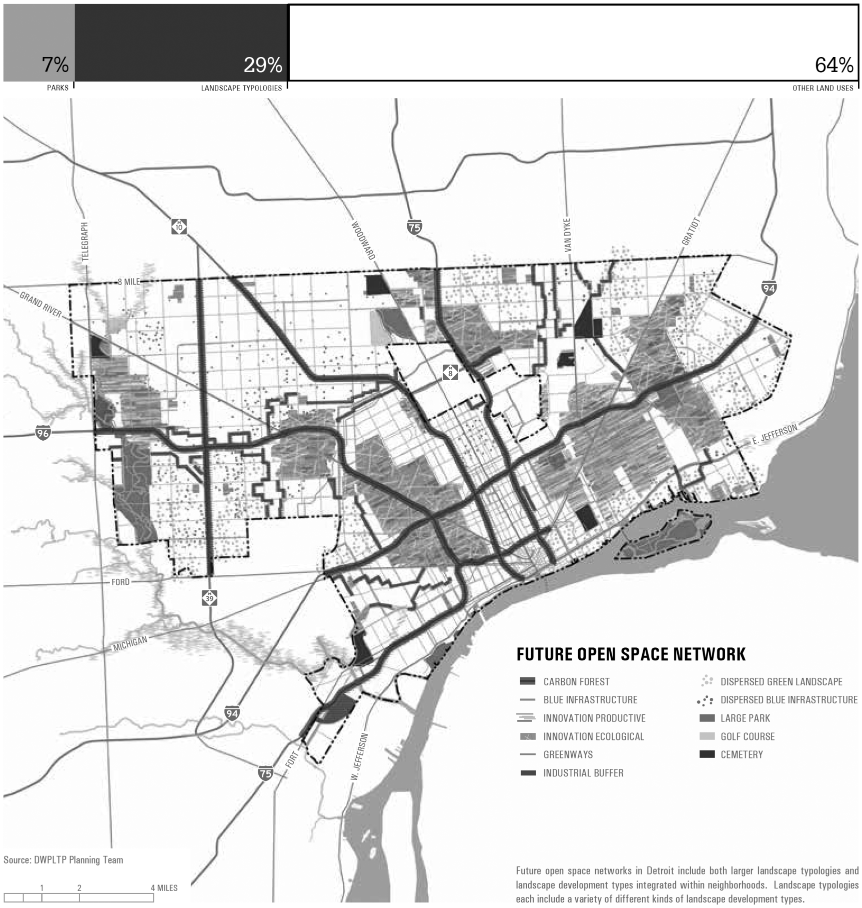

FIGURE 4.8 A leading spatial design from the *Detroit Future City* framework plan including various types of urban agriculture

Source: Detroit Future City.

Site-specific ideas and components

Strongly demarcated horizontal or vertical surfaces

Horizontal topographies tend to create a sense of openness and public conviviality in dense cities. Within horizontal territories small-level changes can create powerful demarcations of space. Vertical surfaces for agriculture are usually created by vegetation, either by means of traditional planting or technologically intensive systems such as hydroponics or aquaponics. The vertical surfaces so created are usually screen-like and visually permeable and well suited to subdividing space to create more private areas for small groups of people.

Public, open-air rooftop gardening, which has become increasingly prevalent within the USA in recent years, as for example in New York's well-publicized *Eagle Street Rooftop Farm* (Figure 4.9), accentuates many of the qualities associated with horizontality. Rooftop farms also have an additional and enormously powerful characteristic conferred by being isolated and elevated. Jerry Caldari, architect for New York's *Brooklyn Grange Farm,* particularly commented on the "universal, childlike amazement of everyone who come to see it, whoever these people are" (personal communication, Aug 2011).

A more subtle form of building-integrated urban agriculture, including vertical elements, is evident in projects where intensive, but low technology and low-cost techniques are used to improve low-income informal housing areas as for example applied in Wanathamulla, Colombo (Sri Lanka), where improvement of the sanitation was combined with mainly vertical greening turning a rundown alleyway into an attractive space (Figure 4.10).

FIGURE 4.9 Eagle Street Rooftop Farm, Queens, New York (USA): one of several rooftop farming initiatives in North America

Source: Bohn&Viljoen.

FIGURE 4.10 Wanathamulla, Colombo (Sri Lanka): lane improvement incorporating vertical greening

Source: Dubbeling.

A more high-tech version of this, but in design terms using a conceptually similar approach, is evident in the designs for prototype *Growing Balconies* proposed for use in high-density dwellings in London (Figure 4.11).

FIGURE 4.11 *Growing Balconies*: prototype developed by Bohn&Viljoen in 2009 as part of an exhibition in London

Source: Bohn&Viljoen.

Inclined planes/slopes

In addition to solar aspect and opportunities for some forms of irrigation, inclined surfaces enable agricultural sites to be seen from below, and in so doing they provide for a visual connection with a large number of inhabitants, for whom, if located in dense urban environments, this can offer an essential connection with the natural seasonal cycles. To exploit effects like this, alignments with streets, the disposition of tall buildings and distance are all important design considerations. An interesting example exists in Villa Maria del Triunfo in Lima (Peru) (Figure 4.12), where a sloped site over which power cables run has been used to establish a highly productive site. Because the site is on a slope it is visible from buildings within the valley, providing a register of seasonal change for residents. The bottom of the sloped field, where it meets the settlement, provides a great opportunity for establishing a market, much in the same way as at the new Parc Agro Urbain de Bernex et Confignon (Switzerland), referred to below.

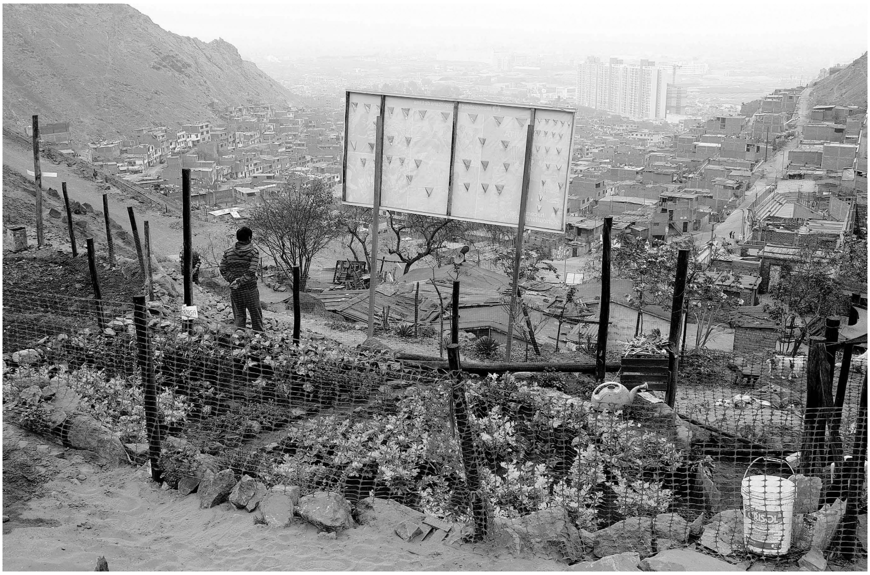

FIGURE 4.12 Small garden (on steep hill, in dune sand) in Villa Maria del Triunfo (Lima, Peru)

Source: IPES.

Paths and bridging elements

Paths are extremely significant within the design of agricultural spaces. Their requirement for cultivation is self-evident, but it is in their use as access routes to sites for the public where much design occurs. The interface/edge between cultivation areas and the public, where a formal separation will often be required, is significant in design terms, even if this is in practice mainly to provide a symbolic measure of security. Level changes, fences, streams and planting are all typical tools for achieving this. Often public paths will be structured so as to provide a fast route (following a so-called desire line), off which a series of branching or forking paths are set, configured to minimize disruption to the sites of cultivation. The integration of well-used existing public paths as spatial dividers that also enable views of crops under cultivation is a particular feature of the Marzahn project in Berlin (Germany) (Figure 4.6). Here paths also define a space for gathering in what would otherwise be a space used only for circulation (Figure 4.13).

In Switzerland on the outskirts of Geneva, a new nine-hectare "agro park" (Figure 4.14) designed by Verzone Woods Architects is, at the time of writing, scheduled to go on site, having been selected following an architectural competition. This park, named Parc Agro Urbain de Bernex et Confignon, is of note for several reasons: strategically, the city authorities have been far-sighted in deciding to implement this project on a site that is currently on the edge of the city, but that will shortly become a "green finger" due to planned development beyond the existing municipal boundary. The site will be one of Europe's first productive

FIGURE 4.13 Marzahn community garden, Berlin (Germany): raised beds for food growing intersect with footpaths and spaces for public gathering, sightseeing and playing

Source: Bohn&Viljoen.

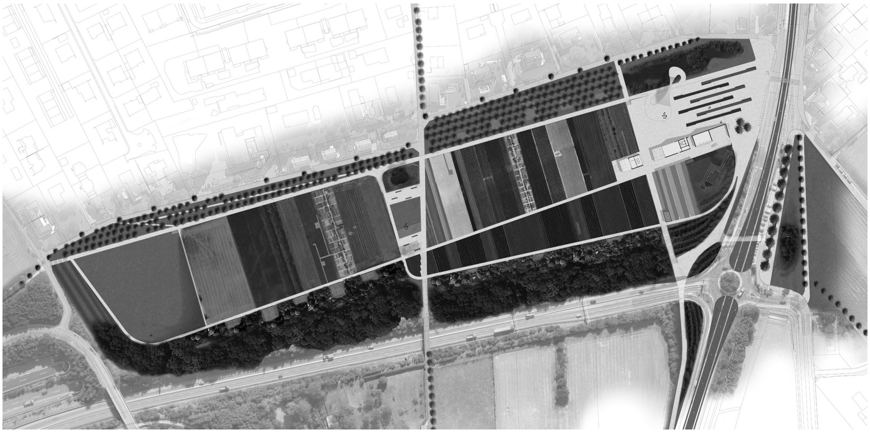

FIGURE 4.14 The Parc Agro Urbain de Bernex et Confignon, Geneva (Switzerland)

Source: Verzone Woods Architects.

parks and will integrate crop fields, a market space and leisure space. The design accommodates several different users and has adopted a highly refined and controlled system of paths that give structure to the site and define territories for sport, gatherings, a market, picnics and walking, in addition to growing food.

In many cases, entire linear agricultural sites operate as urban bridges, connecting otherwise separated parts of a city or settlement; this is a powerful element of urban design, supporting biodiversity and ourselves as residents. This bridging could possibility be explored at the Villa Maria del Triunfo site by, for example, connecting different parts of the city, or by directing people to viewing platforms as a destination for walkers or families. Here, developing a path with stopping-off points along the way, combined with a footpath and cycle way, would add a whole new layer of significance to this site.

Edges – thick, thin and topographical

Edges can have a thickness and support particular uses, such as markets, restaurants, sports areas, and sitting, picnicking and viewing spaces. The material and architectural language of the structures required by these uses will have a major impact on how they are perceived and valued, as evidenced by New York's *High Line* (USA) (Figure 4.15), which, although not an urban agricultural project, embodies many of the design considerations referred to here. Vantage points along this regenerated former

FIGURE 4.15 The High Line, New York (USA)

Source: Beyond My Ken, http://en.wikipedia.org/wiki/File:High_Line_20th_Street_looking_downtown.jpg.

railway line provide spaces accommodating individuals and groups, allowing for sitting and lying, looking out and beyond, over and into planted areas. The popularity of New York's High Line demonstrates the desire for coherently designed urban landscapes combining paths, planting and spaces for stopping.

Materiality

The choice of materials for use in a design has a huge impact on its appearance, durability and public acceptability, but until (intra- and peri-) urban agriculture is recognized as having an important contribution to make to wider concerns about the city and public well-being, cost will have a large bearing on what is available and accessible. In some instances the temporary nature of a project can be its strength, allowing for changeable and responsive solutions that are capable of accommodating a multitude of programmes in addition to food growing. Berlin's Prinzessinnengärten (Figure 4.16) is an exemplary case for the extremely successful and popular transformation of an abandoned urban space through the development of a "nomadic food garden".

FIGURE 4.16 Prinzessinnengärten, Berlin (Germany): a food garden on derelict urban space
Source: Bohn&Viljoen 2011.

Building-integrated agriculture

Although rooftop urban agriculture has been practised at a domestic scale for a number of years within developing countries, a quantum leap has occurred with respect to scale and publicity of this new type. In design terms the questions and opportunities they raise depend very much on the degree to which they are enclosed by a glass house and are typically private working concerns, or if they are open fields, typically operating with a number of sub-programmes in addition to growing food. Enclosed rooftop greenhouses do act as markers for developments, as for example, in the case of *Arbor House* New York City (USA); here a municipal housing project including a commercial rooftop greenhouse is expected to yield 80,000 to 100,000 pounds of fresh produce per year (Figure 4.17). Furthermore, rooftop greenhouses have the potential to be integrated into the building's heating and cooling system as thermal buffer zones, by means of utilizing heat pumps to transfer heat from one part of a building to another.

FIGURE 4.17 Arbor House, New York City (USA) with green houses on top
Source: Bernstein Associated.

The concept of vertical city farming, developed by Dickson Despommier, who proposes multistorey food-producing buildings (Despommier 2010), has generated a great deal of interest within the popular press and resulted in a number of dramatic and speculative proposals by architects and designers. With more design work aimed at facilitating multi-use strategies and the optimization of natural energy systems, such as designing vertical thermal buffer spaces operating symbiotically between spaces for people and for planting, it is likely that the future will see the emergence of vertical farms as one of a diverse set of urban agriculture types.

That rooftop gardening can also take place at small scale and at low cost is shown by the rooftop gardens in Kathmandu (Nepal) (Figure 4.18) established by the project *Monitoring the impacts of urban agriculture on climate change adaptation*

FIGURE 4.18 Rooftop garden in Kathmandu (Nepal)
Source: ENPHO.

and mitigation implemented by the NGO ENPHO and the Kathmandu Metropolitan City Authority with support from CDKN (UK) and the RUAF Foundation (The Netherlands) (Dubbeling and Massonneau 2014).

Layered-growing for small spaces

Techniques for maximizing the growing capacity and yield of urban agriculture, either by physically stacking planting containers, or by using hybrid systems such as aquaponics that combine hydroponic and fish farming techniques, are closely related to building integrated urban agriculture. The relationship comes about because these systems require structures for support, are frequently enclosed by a protecting structure for climatic control, and due to their three-dimensional forms are inherently architectural. This space-making potential has yet to be fully realized, and prototypes that exist tend to be experimental, as found in Skygreen's prototype constructed in Singapore, or they are more modest but probably more resilient, as found for example in El Alto (La Paz, Bolivia) (Figure 4.19).

Incremental architecture and urbanism

Perhaps the most important strategy for designers and planners to adopt is one that accommodates an incremental approach to implementing urban agriculture. Planning and design strategies should accommodate the potential for the incremental development of local food projects (like the many community gardens in Cape

FIGURE 4.19 Low-space, low-cost horticulture using tables and racks in El Alto (La Paz, Bolivia)
Source: IPES.

FIGURE 4.20 A community food garden in Cape Town (South Africa)
Source: Abalimi Bezekhaya.

Town, South Africa), enabling growth and refinement as the community itself develops, and would enable the demarcation of space for future use (Figure 4.20).

Community food gardens are often established with the minimum of resources, either driven by the needs of food security or community cohesion; but as the communities become more stable and prosperous, the site's potential with respect to the wider use and design potential can be realized. Without a long-term plan, it is all too easy for sites to be built on, at precisely the time when, due to densification and urbanization, open space needs to be protected.

Conclusions

During the past ten years, intra- and peri-urban agriculture has moved from a peripheral position on planning and design agendas to one that is now being taken seriously in developed and developing nations. A rich and mutually beneficial dialogue and knowledge-sharing is emerging between practitioners and academics in developed and developing countries.

Urban agriculture is beginning to be understood as part of wider urban and ecological planning and design strategies, operating at a regional scale. Typologies and design strategies are beginning to be defined. For example, spatial network concepts, such as Green Infrastructure, support design strategies that specifically include intra- and peri-urban agriculture, such as *Food Urbanism* or the *CPUL City* concept. Cradle-to-cradle strategies can also enable multiple benefits. Design research and knowledge transfer, such as exemplified in the *Carrot City* project, help build new online design-based repositories of best practice that are of value to designers and planners.

The increasing density of building in cities and unprecedented levels of urbanization, especially in developing countries, pose great challenges for the coherent planning of urban agriculture.

Planning methods therefore need to be adaptive and include participation by active and relevant stakeholders. Emerging Food Policy Councils are likely to help shift thinking towards a food systems approach capable of integrating intra- and peri-urban agriculture into the wider urban food system (see Chapter 2). Technological inventions, such as GIS systems, utilizing remote sensing and data from direct observation on the ground can, if dynamic and current, offer a powerful tool to aid decision making.

The rural–urban relationship in the future is likely to be seen as a continuum, rather than as a relationship between discreet entities. Equally, future farming practices will most likely happen on a spectrum, combining social and economic benefits and utilizing a range of technological approaches.

Regardless of the type and location of farming, it is evident that appropriate tenure agreements for farmers will be critical for long-term success, especially when involving livelihoods. Where food security is not a major driver, specific ways of adding value to intra- and peri-urban enterprises are required, especially where land is scarce and expensive.

Urban policy is being developed by some cities to support and remove barriers to the implementation of intra- and peri-urban agriculture. But the speed at which intra-urban projects are being established, for example in Europe and North America, or peri-urban agriculture is being lost, for example due to urban expansion in Africa, is outstripping the speed at which supportive policy is being developed. Successful pathways to policy need to be found urgently. If this shift is to be consolidated, then the next step is to collect and disseminate metrics to encourage its further integration into intra- and peri-urban design.

Summing up: During the last decade a lot has happened enabling and supporting the integration of urban agriculture into cities in the Global South and North, but a conceptual shift is still required, if agriculture is to become and remain valued as an essential element of urban infrastructure.

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5

URBAN AGRICULTURE AND SHORT CHAIN FOOD MARKETING IN DEVELOPING COUNTRIES

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Introduction

In this chapter, we focus on the specific role of urban agriculture and short marketing chains in urban food supply and distribution, with an emphasis on developing countries. Markets in the context of urban agriculture are often characterised by short supply chains and social relations based on proximity in which we may distinguish the traditional, mainly informal forms of short marketing chains and innovative new forms of more direct producer-to-consumer food supply that are developing more recently.

To sketch the context, we will first briefly discuss presence and economic performance of urban agriculture in cities of the Global South and subsequently discuss the specific and complementary role of urban agriculture in total food supply and related ways of marketing locally produced food. In the following section a number of innovative types of short chain food supply and distribution are discussed. We will conclude with listing a number of consequences for policy development on urban food supply and distribution and some challenges for research.

Presence and economic performance of urban agriculture in developing countries

Presence

Numbers on involvement of urban residents in agriculture in countries in developing countries are substantial, although the percentage of participation in urban agriculture is highly variable from one city to another. A recent study of the FAO confirms that in Latin America and the Caribbean the practices of (intra- and peri-) urban agriculture are widespread. Urban agriculture activities include a wide range of activities, varying from backyard and school gardening, to intensive production of flowers and small animals. It is practised, for example, by 40% of households in Cuba, and 20% in Guatemala and Saint Lucia. In Bolivia's main cities and municipalities, 50,000 families are (also) food producers. In Bogotá, 8,500 households produce food for home consumption. In Haiti, 260 hectares of land in and around Port-au-Prince and other towns are cultivated by 25,500 families (FAO 2014).

Similarly, for Africa another FAO study (FAO 2012) estimates that 40% of households in sub-Saharan cities are involved in intra- and peri-urban horticulture, either in "grow-your-own" schemes or as in market-oriented gardening. Ten countries provided estimates of the extent of horticulture practised in their principal cities and towns. The data indicate that horticulture was practised by almost half of urban households in Cameroon, one-third in Malawi, one-quarter in Ghana, and one in ten in Nigeria. In others – Botswana, Cape Verde, Gabon, The Gambia, Namibia and Senegal – participation was less than 10%. For capital cities, highest shares were reported for Lilongwe and Yaoundé, with 35% of households engaged in horticulture, followed by Nairobi (36%) and Accra (25%).

In a survey conducted in 2008–2009 in 11 Southern African countries, representing a total of 6,453 households in poor urban neighbourhoods, the authors concluded that 22% of them grow some food (Crush et al. 2011). The percentages are the highest (between 30 and 64%) in four cities with a high level of food insecurity and a local government with a positive or neutral attitude towards agriculture (Harare, Blantyre, Maseru, and Misunduzi). However poorer areas in some other cities were well below the average such as Johannesburg (9%), Gaborone and Cape Town (5%), and Windhoek and Lusaka (3%). This implies that poverty per se does not adequately explain the resort to household production as a source of food. On the other hand, the extremely low rates of participation by poor households in some neighbourhoods of Cape Town and Johannesburg may not be typical of the city or country as a whole.

While the above given figures mainly relate to participation of urban citizens in agriculture, a recent study, based on global data on croplands and urban extents using spatial overlay analysis, indicated that 60% and 35% of, respectively, all irrigated and rainfed croplands fall within a distance of 20 kilometres of a city (Thebo et al. 2014). Croplands *within* urban extents constitute a small, but not negligible portion at 67.4 million hectares (5.9%) of the sum of the maximum monthly irrigated and rainfed cropland area. A greater proportion of croplands *within* city extents are irrigated (35.0%) than their non-urban counterparts (17.7% irrigated). Urban croplands also proved to be extremely prevalent globally, with 87% of all urban extents with populations of over 50,000 people containing at least some area of irrigated urban cropland and 98% containing at least some area of rainfed urban cropland.

Economic performance

The economic performance of (intra- and peri-) urban agriculture builds on a number of complementary mechanisms that are differentiated according to specific geographical settings and types of socio-economic profiles of involved social actors. Depending on the specific combination of mechanisms, urban agriculture in different degrees may contribute to poverty alleviation and/or generating monetary income.

Subsistence-oriented urban agriculture activities enhance dietary improvement especially by including more fresh vegetables and livestock products and reducing food expenditures. Dubbeling (2013) discusses the role played by urban agriculture in reducing the vulnerability of the urban poor and vulnerable groups and enhancing their coping capacity by diversifying their food and income sources and increasing the stability of household food consumption and savings on food expenditures against seasonality, disturbances in food supply from rural areas or imports, increases in food prices and (temporary) losses of income from other sources. Also Zezza and Tasciotti (2010), on the basis of a review of various studies, indicate that there is a correlation between income derived from agriculture (mostly from livestock) and household dietary diversity. In addition, the self-production of food (e.g., vegetables, poultry) results in cash savings on food expenditures that otherwise would have to be purchased (Prain and Dubbeling 2011).

Urban agriculture activities with a semi- or full market orientation contribute to the generation of (complementary or main) monetary family income and the creation of employment opportunities in the city. The provision of monetary income by urban agriculture appears to be related to the nature of products and the amount of invested capital (in particular irrigation, value of animals, input use). Monetary income tends to increase from staple food (e.g., rice, maize or cassava) to horticultural crops and more so: aquaculture and livestock; and from seasonal-dry to all-year irrigated crops (Moustier and Danso 2006, van Veenhuizen 2007).

A systematic assessment of intra- and peri-urban agriculture activities in four cities (Accra, Ghana; Bangalore, India; Lima, Peru; and Nairobi, Kenya), implemented by RUAF Foundation for the World Bank between March 2010 and May 2011, demonstrated the role of urban agriculture as an economic livelihood strategy (stable occupation and income) for low-income urban households (Prain and Dubbeling 2011). The same study found that urban agriculture is better rewarding than petty trading and casual labouring. Moreover, urban agriculture is highly compatible with several other kinds of employment and allows combining multiple income sources, which – for resource poor and vulnerable households – is a very important risk-reduction and adaptation strategy.

Mougeot summarised the research on the contributions of urban agriculture to urban employment and income as follows (Mougeot 2013):

- Urban agriculture contributes to considerable low-cost job creation in periods of crisis; and has the ability to grow in periods of recovery (as in Cuba after the oil crisis, in Argentina after the 2001 monetary crisis and in many other countries after the 2007–2008 food price hikes).
- The higher the market value of the produce, the larger its contribution to household income.
- Incomes and wages in market urban agriculture compare favourably to those of unskilled construction workers, even of mid-level civil servants (up to five times higher than national per capita income in Dakar and Nairobi and four times higher than the national poverty line in Maputo; FAO 2012).
- Annual savings on food expenditures can add up to several months of a minimum wage;
- Savings and incomes from home-based urban agriculture allow re-investing in other income-generating home business to improve household well-being.
- Market oriented urban agriculture provides a relatively accessible entry on job market for youth (with beneficial impacts on income, food, trade learning, own small business, and self-esteem).

The specific role of urban agriculture in urban food supply

Though it is recognised that (intra- and peri-) urban agriculture will by itself not be able to feed entire cities (Cofie et al. 2003, Moustier 2007), it provides important and specific contributions to urban food supply and nutrition especially in the provision of perishable food commodities. For fresh perishable vegetables the relative contribution of urban agriculture in total urban food supply in many cities is around 60–70% (and during the dry season even higher), whereas for other fresh vegetables, eggs, milk, poultry meat, and pork these percentages may reach levels of 40% or even higher with large variations between the cities (see Chapter 6 for more details).

The specific role of urban agriculture in the urban food supply is characterised by complementarity of food supply flows and advantages of proximity in market organisation.

Complementarity of food supply flows

A growing body of evidence supports the complementarity between urban food supply from within the city region and from outside the city region including rural areas and imports (Moustier 2007).

Perishable food products

Basic food products (cereals or tubers) and dry vegetables (onions) come mostly from rural areas in the country or are imported from abroad, whereas urban agriculture in the provision of fresh perishable vegetables, mainly leafy vegetables, poultry and dairy products come mostly from peri-urban areas.

Fresh vegetables in this category are mainly leafy vegetables such as amaranth, water convolvulus, sorrel, okra, morel, cabbage, lettuce and chives and related leafy plants. These vegetables top the list of vegetables consumed in Africa and in Asia. These vegetables are well known for their short shelf life: after one day they are no longer fresh – and in many countries, freshness is an important criterion for consumers, most of whom do not own refrigerators. These leafy vegetables are mostly brought into town from distances of less than 30 kilometres from the city centres. The (intra- and/or peri-) urban percentage of supply in most cities in Africa and Asia is above 70%, depending on the administrative city boundary.

In the case of less-perishable vegetables, such as tomatoes and cabbage, which can stay fresh for a few days, supply varies from peri-urban to rural production and the peri-urban percentage of supply is highly variable according to the city under study and season. Dry onion, which is even less perishable, originates only from rural areas or was imported in the investigated cities of Africa and Asia.

Improved broiler chicken, milk and eggs come from city farms or from the suburbs. These farms are run by city dwellers, whereas local beef comes from traditional pastoral or agro-pastoral farms. Urban animal food products are also imported from lower-end European production facilities and pose strong competition to certain local products, such as chicken, despite differences in quality (Laroche-Dupraz et al. 2009).

Most fresh milk found in Kumasi is produced in the urban area at the local university. In the peri-urban areas of Kumasi, large poultry farms produce 80% of the eggs consumed in the city, while these farms suffer increasingly from cheap poultry meat imports, especially from Brazil (Cofie et al. 2003).

Complementarities in time

A comparative advantage of (intra- and peri-) urban agriculture is lying in the continuity of product supply, either because of specific natural conditions, or because urban farmers are able to sustain continuous production due to more specialised and irrigated systems – characteristics they may share with some specialised rural areas. This comparative advantage is observed especially in the dry season and for temperate vegetables (Moustier and Danso 2006).

The seasonal advantage of intra- and peri-urban agriculture is further enhanced by access of intra- and peri-urban producers to piped and recycled urban wastewater, which allows (part of) the urban producers to produce year round (Raschid-Sally and Yayakody 2008).

The advantage of proximity in market organisation

Short marketing chains

Food produced in and around cities in Africa and Asia is normally distributed through very short marketing chains. More often than not, the producers sell their produce to retailers/collectors at their farm field (often many of these collectors are producers themselves) or at night at wholesale markets (e.g., 100 to 200 kg/ day^{-1} brought to the markets on overloaded bicycles, scooters or in minibuses). Another (smaller) part of the production is traditionally sold directly by the producers to consumers living nearby.

The short chain in the marketing of their products has a positive impact on the reduction of transaction costs in the marketing of perishable products of varying quality standards. The small-scale of production and low market prices make it attractive for producers to spend some hours in transportation to get as much as possible of the final price. Yet these characteristics contribute to further fragmentation of the final supply, while economies of scale could be reached by collective marketing. Experiences of collective marketing, until recently, are hardly developed in urban- and peri-urban areas though, or have had little success, given the variability of production in quantity and quality that makes farmers reluctant to "put their eggs in the same basket" as other farmers. Well-known success stories include the Horticulture Cooperative Horticulture Marketing Society (HOPSCOM) established in 1959. HOPSCOM buys vegetables and fruits from their members (over 16,000 horticulture producers in/around Bangalore and Mysore) in 13 procurement centres (direct cash payment) and sells these to consumers through a network of over 230 outlets located near bus stations and other easily accessible locations in the city (Chandrashekar 2011). Another success story is the AMUL Kaira District Dairy Co-operative Union, established in 1944, that buys milk from 231 primary cooperatives and sells fresh and packaged milk to consumers through its own distribution network (Laidlaw 1977). More recently, new innovative initiatives are found where intra- and peri-urban producers have identified reliable collective ways to market their products directly to urban buyers (consumers, restaurants, social food distribution programmes, etc.), as will be discussed in more detail in a later section of this chapter.

Geographical proximity is still important in the supply of perishable food commodities in Africa and Southeast Asia, especially for leafy vegetables, which play a strong role in the livelihoods of the poor, be they farmers or consumers. This situation can change with the development of transportation, cooling/storage facilities and increased pressure on urban land. For example, the comparison of areas supplying Hanoi between 2002 and 2011 (Sautier et al. 2012) shows that Hanoi province (which has been extended) supplies 75% of water convolvulus (rather than 89% in 2002), and nearby provinces have increased their share of supply. Cucumber is no longer supplied by Hanoi province, but is sourced in nearby provinces.

Next to geographical proximity, relational proximity plays an important role: the opportunities that urban producers have to establish direct linkages with consumers and other urban market parties especially to trade perishable products, as well as with urban sources of water and nutrients, or to gain direct access to information on market demand and consumer preferences.

FIGURE 5.1 Direct sales to consumers in Hanoi by a vegetable producer
Source: Moustier.

Low price differential

Short marketing chains contribute to a low price differential for products between farm and final consumption: in Hanoi these account for 30% on leafy vegetables, 35 to 50% for cabbage, and 75% for tomato (Gia 1999). In rural chains, wholesalers' incomes may be up to ten times higher than that of farmers, but the risks of bankruptcies are higher. Price differentials are higher for rural products due to higher transportation costs and higher wholesalers' margins. The references indicate the need for an update on the comparison of food price generation between rural and urban areas for a same commodity. Actually this kind of comparison is not easy because it is difficult to find the commodity with the same quality characteristics being available at the same time of the year, and with two possible origins, urban and rural. Simulations could be made on different scales of urban and rural production and transportation, and on their consequences on the final price formation.

Information on quality and control

The proximity of production areas to consumers and other urban market parties (e.g., restaurants, hotels, hospitals, school food programmes, supermarkets) makes it easier for consumers and other actors in the short chain to control quality, and at the same time, keeps producers from cheating on product quality. Proximity enables frequent contacts between farmers, traders, and consumers and checks on the production process. Proximity between farmers and consumers is not a perfect substitute for independent public control, which is still deficient in many countries, but it does reinforce the incentive for farmers not to deceive their customers. A survey of 356 consumers in Senegal showed that the first two factors influencing purchase decisions are: (i) trust in the vendor; and (ii) safety of food. They complain about illnesses having increased, one possible source being the growing use of pesticides by farmers. Half of those interviewed worry about food safety (Badj 2008).

Freshness

In situations of limited access to fridges, freshness of produce is especially valued by urban consumers. In Thiès (Senegal), more than 90% of 150 interviewed housewives thought that vegetables should be grown nearby, for freshness and quick access (Broutin et al. 2005). In Hanoi, freshness is the advantage of peri-urban vegetable production cited by 74% of the respondents (out of 500) (Figuié 2004). However, production in urban proximity can also affect produce quality negatively where, for example, polluted irrigation water is used (see Chapter 7 for more details).

The development of innovative collective short food chains in city regions of the Global South

During the last two decades several important changes have been taking place in developing countries regarding the urban food supply and distribution system, including – amongst others – the rapid rise of supermarket chains and the rise of new types of short food chains in the city region.

The impacts of the supermarket revolution

The rapid spread of supermarket chains in developing countries started in Latin America in the second half of the nineties, followed by Asia some years later and most recently in Africa. A crucial factor was the liberalisation of retail foreign direct investment in the early nineties, while domestic policies have often included tax incentives for supermarkets. The spread was further accelerated by intense competition, consolidation and multi-nationalisation in the supermarket sector seeking to improve their competitive positioning. The supermarkets first established in the larger cities serviced the higher-income groups but over time gradually also spread into the food markets of the middle- and lower-income sections of the population and into smaller towns (Reardon and Gulati 2008).

The description that Reardon and Gulati give of the impacts of the quick spread of supermarket chains in developing countries may be summarised as

FIGURE 5.2 Supermarket selling fresh vegetables, Vietnam
Source: Moustier.

follows: Supermarkets – due to their economies of scale and efficient procurement systems – tend to charge consumers lower prices (first only in the processed and semi-processed food segments) and offer more diverse products of constant and good quality. However, the food security and nutrition impacts on poor consumers may be limited where price savings may accrue to the middle class, mainly due to uneven physical access to supermarkets for the urban poor and/or because the offer of the supermarkets does not include fresh vegetables and fruits or only at higher prices.

As supermarkets modernise the procurement of fresh produce (some 10–15% of supermarkets' food sales in developing countries), they increasingly source through wholesalers that are specialised in certain product lines from larger, more reliable and better-equipped farmers (land, irrigation, etc.) and good access to infrastructure (like roads and cold chain facilities). Where supermarkets cannot source from medium- or large-scale farmers, supermarket chains may – in partnerships with other organisations – provide assistance to local small producers with training, credit, and other needs in order to secure sufficient supply of required quality. Such assistance is not likely to become generalised, however, and so over time asset-poor small farmers will face increasing challenges surviving in the market since they can't make the higher up-front investments, nor meet the greater demands for quality, consistency, and volume.

They recommend developing-country governments to put in place policies to help both traditional retailers and small farmers to pursue "competitiveness with inclusiveness" in the era of the supermarket revolution. "Some countries are already taking such steps, and their experiences offer lessons for others" (Reardon and Gulati 2008).

Innovative short food chain initiatives

Especially during the last decade, in cities in developing countries, more and more initiatives with several types of innovative collective businesses for the direct sales of food products to consumers and other urban markets parties could be observed. Such innovative short supply chains include, amongst others:

- Box schemes (e.g., Harvest of Hope in Cape Town, pooling vegetables grown ecologically by community gardeners in low-income neighbourhoods and delivering these weekly in boxes to their clients in better-off areas of the city; Hoekstra and Small 2010).
- Door-to-door delivery (e.g., by fresh mushrooms producers in Accra; Danso et al. 2002).
- Farmer shops (e.g., the Dang Xa Cooperative in Gia Lam (peri-urban Hanoi, Vietnam) selling "safe" vegetables directly to consumers in their own shops in Hanoi; Moustier and Nguyen 2010).
- Farmers' markets (e.g., in Rosario where the municipality supported the establishment of seven farmers' markets in different parts of the city where urban producers can sell their produce directly to interested customers; Mazzuca et al. 2009).
- Online food shops (e.g., the Jinghe online store in Beijing that delivers seasonal vegetables, fruits, eggs, milk, oil, poultry meat, etc., produced by several cooperatives of peri-urban producers to staff of government offices and universities in Beijing that order these food products through the Jinghe website; Renting and Dubbeling 2013).
- Producers cooperatives directly delivering to restaurants, hotels, schools, institutions (such as, for example, the Van Noi Cooperative in Hanoi) that deliver fresh vegetables directly to vegetable shops and food stalls at markets as well as directly to METRO Cash and Carry Supermarkets (Ho Than Son and Dao The Anh, 2006, Moustier and Nguyen 2010).
- Food buyers cooperatives (for example, the Canastas Comunitarias in Ecuador: groups of urban poor that bi-weekly collectively buy a basket of ca. 15 food items from ecological producers in the city region; Sherwood et al. 2013).
- Mobile food carts (for example, the Kedai Balitaku social business in Djakarta that buys food from ecologically producing small-scale producers in the city region and provides "healthy and affordable menus" to mobile food vendors that sell these menus to children in underserved areas of the city; Rosenberg 2011).

A recent analysis of 26 innovative short food chain initiatives in developing countries (Renting and Dubbeling 2013) and of eight cases in Asia, Africa and Brazil (Moustier 2013) showed that these initiatives have a wide diversity in various characteristics: the products marketed, the ways in which the products are distributed to the clients, the quality attributes that are brought to the fore in the marketing (ecologically grown, fresh, produced within the city region, by small-scale farmers, fair prices for farmer and consumer, safe, . . .), the degree and type of certification, the degree of external support received and the degree and speed of growth.

Yet also some common characteristics can be identified:

- These new short food supply chain (SFSC) initiatives use in their marketing often specific attributes of their products and process of production which address consumer concerns (e.g., reduction in use of agro-chemicals, food safety, solidarity with poor small-scale producers in the city region) and in this way create a special market niche for their products, generating better price margins by excluding intermediaries in the value chain and by valorising distinctive product qualities.
- Many SFSCs mainly concern fresh foods (vegetables, fruits, eggs, and exceptionally dairy) and often focus on a limited number of products. SFSC initiatives are often crucial in developing markets for local and organic food where these did not exist yet.
- Even when there is expansion of the SFSC, its share in the total food supply is in general rather low. In general there is a considerable demand for the food products produced by intra- and peri-urban producers that often is exceeding the production by the producers associated with the SFSC. Urban consumers appear to be increasingly interested in urban, locally produced and healthy food, especially when they receive reliable information about where, by whom and how (food safety, ecological practices) these products are produced.
- Many SFSC initiatives are "social enterprises" in which profit maximisation is not the main driver, but the realisation of certain social goals (e.g., to enable marketing against fair prices for small-scale urban producers and/or create jobs for jobless youth and/or facilitate access to healthy food from known sources) although – of course – also social enterprises need to – at least – break even. Eventual surpluses are reserved for future investments rather than distributed to owners/shareholders.
- Many of these new SFSC initiatives are supported by some external organisation, be it an NGO or governmental organisation, during their establishment and early development. The degree and length of this support varies a lot. SFSC initiatives which build on a well-balanced mix of governance (public, market and civic) mechanisms appear to be relatively successful and more sustainable in the longer term.

FIGURE 5.3 An organic farmers' market in Laos
Source: Moustier.

Main drivers for the development of such innovative short food chains include:

- On the producer side: new channels for selling products, obtaining higher margins, more security of sale, more working capital (advance payments by consumers).
- On the consumers side: obtain healthier and/or safer food, solidarity with small farmers, strengthening the regional economy, facilitate ecological/responsible production and nature conservation in the city region.
- Local authorities may value also other benefits, e.g., reduction of urban food(t) print, or enhancing the resilience of the urban food system, or improving food security/nutrition of the urban poor.

The above-mentioned study by Renting and Dubbeling also observed that the development of innovative short food supply chains often reinforces the development of multi-functional (intra- and peri-) urban agriculture, and that the latter reinforces urban agriculture. The direct contact between producers and consumers during the food-selling activities in the city (at farmers' markets, in home delivery schemes, cooperative shops, etc.) leads to involvement of the citizens in activities in the surrounding agricultural areas, e.g., for recreational activities, or – the other way around – increased recreational visits by citizens to the surrounding countryside may lead to more direct food sales (on farm or through participation in direct marketing schemes).

Moreover, local authorities start to value eco-services provided by urban producers (such as management of flood zones, city greening, capturing CO_2 and reduction of urban food(t) print and reuse of recycled urban organic wastes and wastewater). Services that may lead to cost savings for public goods compared to state provisioning (e.g., waste disposal, green space management) and cost avoidance (e.g., health costs due to floods and rising temperatures due to climate change). This may result in more local government support for urban agriculture producers and their marketing efforts through various measures like preferential procurement of ecological food produced in the city region by small farmers, support for the establishment of farmers' markets and other direct marketing enterprises, and other measures (Renting and Dubbeling 2013).

Some lessons learnt by SFSCs in the South

Collective marketing schemes by small-scale urban producers often have limited access to mainstream food trading and distribution systems due to the requirements of supermarkets (demanding large volumes, uniform and high quality of the products, secured delivery throughout the year, timely delivery, etc.) and public administrations (product safety regulations, etc.), as well as their limited scale of production that make it difficult to compete with other suppliers due to economies of scale in production and transport and resource limitations that make it difficult to make larger up-front investments.

Market-diversification appears to be an important factor to reach scale. Two or more marketing channels may be combined: e.g., an outlet at farmers' markets with an arrangement with local institutions or restaurants and/or an online food shop.

In order to ensure stable consumer demand, it turns out to be important that food safety is secured and that the origin of the products is traceable by the consumers, that product quality is guaranteed and standardised, and that attention is paid to the presentation of products (branding, packaging, barcode, etc.). Also accreditation with local government or establishing a participatory quality control/guarantee scheme helped SFSCs to enhance consumer confidence and outreach.

Building stable relations with specific consumer groups is instrumental for the creation of stable demand and the articulation of consumer preferences. Various of the SFSC initiatives involve the consumers in one way or other in the planning of production and market organisation (consumer supported agriculture), e.g., farmers inviting consumers to the farms to get to know how the food is produced, consumers making orders in advance (allowing the farmer to plan the production better and secure sales) and jointly defining quality criteria for the products and production practices to ensure safe, healthy and sustainable production.

Customer convenience plays another important role in generating demand. Enabling ordering by mobile phone or internet and home delivery of fresh food saves the consumers time and money (transport costs) and widens the group of clientele of the SFSC substantially.

Also product differentiation plays an important role in enhancing the customer satisfaction of SFSCs. Many SFSCs still mainly market a limited number of products, often starting with basic seasonal fresh vegetables and fruits only. In order to enhance sustainability of the SFSC it is important to broaden the product offer to a broader range of vegetables and fruits, and also include eggs, vegetable oil, kitchen herbs, etc., as well as transformed and conserved food products (produced by cooperative agro-enterprises in the city region).

Consequences for local policies and key issues for research

Consequences for local policies

Local governments can play an important role in the development of SFSCs in the city region by facilitating public–private linkages, especially by creating a facilitating legal framework and enabling conditions for SFSCs and specific support for new SFSC business, especially small and medium and social agro-enterprises involving small-scale producers from the city region.

Such facilitating policies might include the following:

- Promote networking and cooperation among ecologically producing small-scale producers in the city region and between them and urban consumer groups and service providers.
- Establish a city region SFSC development centre that provides start-up funds, such as low-interest matching loans, and training, technical assistance and business development services to new SFSC initiatives and during their first phase of development: support in-business planning, assisting in establishing quality control/certification schemes and commercial brands, start-up matching funds and soft loans, access to information on processing and packaging technologies and relevant policies and regulations (e.g., on food safety, waste management, etc.).
- Address the infrastructure needs of SFSCs for procurement, processing, warehousing, and distribution (establishment of farmers' markets or shops, regional food hubs/food procurement centres, provision of land/buildings for processing, storage and packaging).
- Adopt legislation and establish programmes regarding preferential local government food procurement of (nutritious, ecologically and fairly produced) food from small farmers in the city region (for canteens in offices, schools, hospitals, jails, food aid programmes, community centres, etc.).
- Organise and support campaigns to enhance consumer awareness about the need to eat healthy food and the importance of supporting ecologically produced fresh foods from the city region.

Box 5.1 provides an example of the many municipal or metropolitan programmes that support the development of short food supply chains in Latin America, Asia, the Middle East and Africa.

BOX 5.1 URBAN AGRICULTURE PROGRAMME ROSARIO, ARGENTINA: PROMOTING URBAN PRODUCTION, PROCESSING AND MARKETING

In response to the economic crisis of 2002, the municipal government of Rosario established the Municipal Urban Agriculture Programme with a very clear vision of establishing urban agriculture as a permanent and commercial activity in the city.

Vacant land in the city was mapped and areas that could not be built on and were suitable for farming were provided to citizens for gardening and agriculture. Basic equipment, training, seed, tools and compost were supplied. Within two years, some 10,000 low-income families were producing (organically grown) vegetables, earning from sales up to US$150 a month, well above the poverty line. To enhance security of tenure and facilitate permanent urban agricultural cultivation, in 2004 an ordinance was adopted that formalised grants of vacant urban land to residents for agriculture, and the Municipal Planning Secretariat integrated agriculture into Rosario's urban development plan.

A key part of its long-term strategy was the establishment of a system for the direct marketing of gardeners' produce amongst others by providing space, funding and technical support for the establishment of farmers' markets and associative agro-enterprises for the processing of vegetables, fruit, and medicinal and aromatic plants.

Also the city's commercial gardeners were supported to organise themselves in the Rosario Gardeners' Network and have been enrolled in the National Registry of Family Farmers, which entitles them to apply for municipal funding for their own investment projects, technical assistance and social benefits.

Source: FAO 2014.

Emerging themes for future research

On-going research in the context of the EU funded SUPURBFOOD programme (www.supurbfood.eu) shows that information on the business models applied by SFSCs in the Global South and their costs-benefits, their organisational and logistical setup, customer segments and market demand is still very scarce. Especially very few quantitative data can be found on costs and profits made and the economic margins realised by SFSC initiatives. This can be because of a real lack of data available, or, in other cases, the information is available but restricted because it is considered market-sensitive information or of poor quality. This constitutes an important bottleneck for the further analysis and development of business models for urban agriculture-based short chain enterprises.

Another research gap identified is the need to better understand the specific roles of governmental organisations, private entrepreneurs and civil society groups play in the organisation and development of SFSCs, and how these roles influences the sustainability of the SFSCs. What should be specific roles played by each of these sectors? What specific mix works best? This includes facilitating and supporting roles as well as taking part as a partner in the constitution and implementation of the SFSCs and their governance mechanisms.

Moreover, existing concepts and methods for business analyses are not always well-suited for application within the framework of SFSCs indicating a need for conceptual and methodological development, e.g., adaptation of the "business model canvas" approach to urban food procurement, processing and distribution in SFSCs in the context of countries in the Global South.

More research is needed into specific constraints encountered by SFSC initiatives in developing countries and through which strategies these might be tackled best. Issues related to enhancing scale and economic sustainability need special attention as well as issues related to access to (soft) financing and technical, marketing and management support services.

Also the value of urban agriculture and short food chains to the urban economy needs to be better estimated. This is first in terms of updated data on the contribution of short food chains to urban food consumption through self-consumption and market access, which requires rigorous consumer and market survey. This is also in terms of jobs and income generated. But also the economic value of the social benefits and eco-services provided by urban food systems should be estimated. A related challenging question to be further explored is how these social benefits and public costs savings provided by urban agriculture can be translated into economic opportunities for the urban producers and related SMEs in the city region.

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6

URBAN AGRICULTURE'S CONTRIBUTIONS TO URBAN FOOD SECURITY AND NUTRITION

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Introduction

Urban food security is a growing concern, and the number of food-insecure people in the cities is approaching the number of rural food-insecure people (FAO 2013). Urbanization, specifically in Africa, goes hand in hand with urban poverty and thus urban food insecurity (e.g. Sen 1981; IFPRI 2002; Burton et al. 2013). Satterthwaite et al. (2010) report that from six out of ten African cities under study, even a higher percentage of the urban population than rural population was energy deficient despite their more sedentary lifestyle and lower energy requirements than in rural areas. Population growth and urbanization in Latin America as well puts pressure on food production and the distribution systems and cannot be covered by national production (Piñeiro et al. 2010). The rise of food prices in 2007–2008 and consequent hunger problems particularly affecting cities (e.g. Cohen and Garrett 2009; Prain and de Zeeuw 2010) revealed the problem of urban food and nutrition security. Food prices are expected to remain at a relative high level (IIED 2013), with an increase in food insecurity for certain groups of the urban population. Food insecurity and malnutrition occur in various forms, such as undernutrition, micronutrient deficiency and overnutrition, with negative health implications.

In the first part of this chapter, the complex nature of urban food security is discussed. Subsequently, the literature regarding the potential of urban agriculture for addressing various dimensions of urban food security, nutrition and health is reviewed. Both direct and indirect effects will be looked into. Direct effects relate to the potentials of urban agriculture in facilitating access to fresh and nutritious food products, as well as risks associated with urban agriculture that might negatively influence the health of urban citizens. Indirect effects of urban agriculture relate to the contributions urban agriculture and forestry make to the urban environment (e.g. reduction of urban heat) and risk reduction (e.g. improved urban water management). The final part of the article discusses challenges to be addressed in order to promote urban agriculture and as an important element of a city's food system for its contributions to urban food security, nutrition and health.

The dimensions of urban food security and nutrition

This chapter is based on a holistic understanding of food and nutrition security as worded by FAO/AGN:

> Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life.
>
> *(cited in CFS 2012: 7)*

Urban food security needs to consider the peculiarities of the urban context, specifically concerning the households' sources of food, accessibility and reliability (see Figure 6.1). Food must be available and accessible for the urban

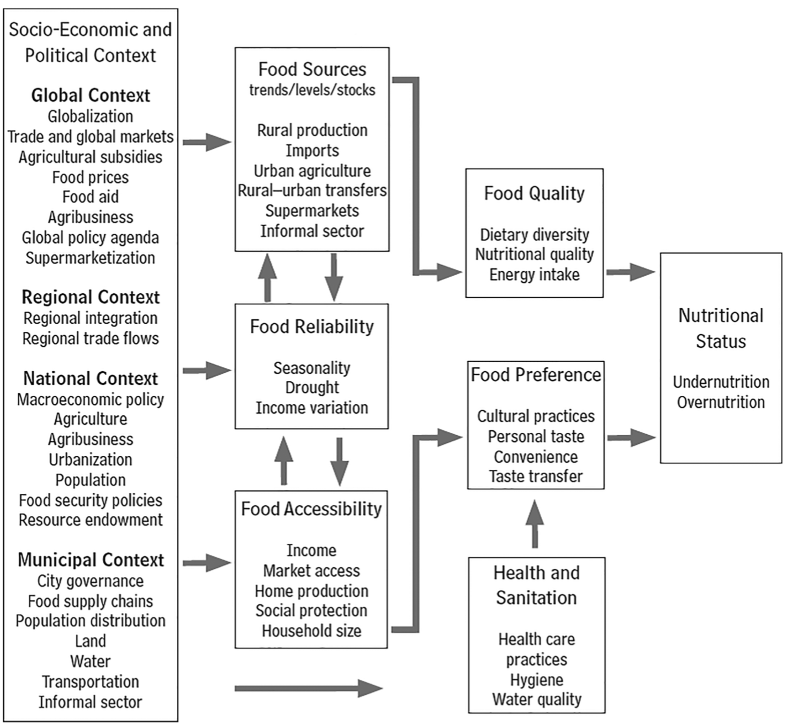

FIGURE 6.1 Dimensions of urban food security

Source: Dodson et al. 2012.

population at places they can reach, and it must be affordable. At household level, food must be prepared and consumed according to the individuals' dietary needs and preferences in the best possible quality. Health status, care for children and other weak household members, sanitation and hygiene aspects, as well as socio-cultural issues (specifically food preferences) all influence food intake at the household level and thus the nutritional status of the individual household member.

Looking at food and nutrition security from a rights-based approach (the right to adequate food) and the obligation of the states to respect, protect and fulfil that right, states should adopt measures to ensure that no individuals are deprived of their access to adequate food, and that they should proactively engage in activities to strengthen people's access to and use of resources, including means to ensure their livelihood and food security (McClain-Nhlapo 2004).

The key: access to food

The core of urban food (and nutrition) security is *access* to food (economically and physically). Economical access refers to the capacity of households to purchase food (Weingärtner 2009a) and, therefore, income is the decisive factor. Since food expenses for urban low-income households in cities in developing countries often make up 50–70% of their cash income, changes in income or food prices have tremendous impact on a household's food security (Zingel et al. 2011). The rapid increase of the number of food banks in cities in the USA, Canada and Europe indicates that problems related to economically restricted access to food are not restricted to developing countries (see, e.g., Riches and Silvasti 2014).

Physical access to food may be limited in cases where low-income areas lack grocery shops, supermarkets or fresh markets to obtain their day-to-day food nearby or have trouble reaching such outlets further away due to lack of, or costly, transport, fear of crime or other limitations (e.g. old age, physical handicaps). Especially, access to fresh and nutritious food may be a problem in certain parts of the city (and especially low-income areas) when neighbourhood shops are getting fewer in number (and/or tend to concentrate on food items with a longer shelf life) due to competition with large supermarkets at city or district margins, or where hot food takeaways and fast food eateries are becoming more frequent (offering food at affordable prices but also containing more trans fats and saturated fats and refined sugar and additives and less vitamins, minerals and fibres) (Pereira 2005). Literature on the urban food system, especially from the USA and the UK, often discuss the issue of the limited physical access of low-income urban households to food (especially healthy and nutritious food) due to flaws in the distribution system. Underserved low-income areas are often named "food deserts" (e.g. Wrighley 2002).

Battersby's (2011) research in two (densely build, inner-city, low-income) areas of Cape Town showed a diversity of food sources (Figure 6.2). The graph clearly

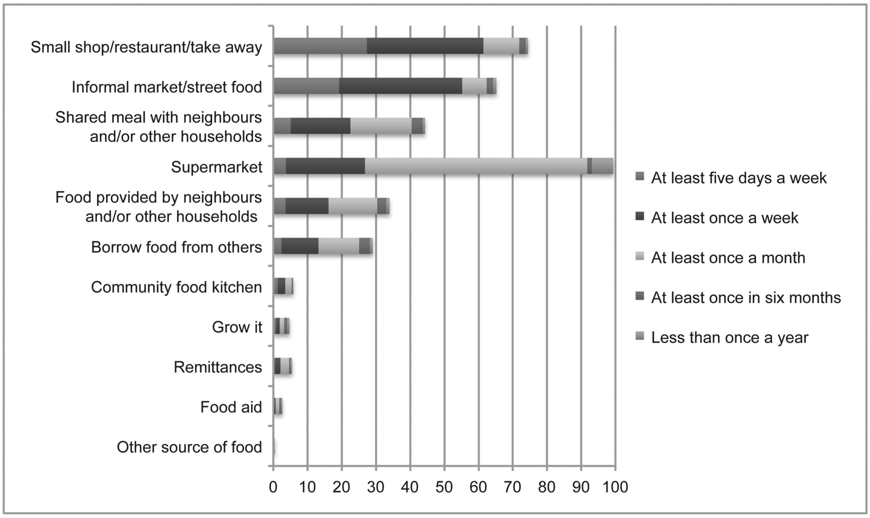

FIGURE 6.2 Sources of food and frequency of use in two low-income areas of Cape Town

Source: Battersby 2011.

shows the important role of the informal sector for the day-to-day provision of food to urban citizens, especially the low- and middle-income households.

Change in eating habits and dietary patterns

Globalization, economic growth and urbanization lead to important changes in the diets of urban consumers – specifically in the South – where populations especially shift towards processed foods richer in salt, sugar and saturated fats, foods that have a long shelf life and are attractive to urban populations and younger generations, but are often less nutritious and less healthy (Pinstrup-Andersen 2012). The drastic changes in food procurement and diets of urban households is related to the establishment of supermarkets and the increasing dominance of supermarket chains in the urban food provisioning as well as the increased reliance on food imports (de Schutter 2014).

Research in Asia (Anderson and Strutt 2012; IIED 2013), and specifically the two biggest growing countries, India and China (Gandhi and Zhou 2014), and also in megacities like Casablanca (Gerster-Bentaya et al. 2015) and other cities in southern Africa (Crush and Frayne 2010), have shown that food demand is undergoing a huge transformation and will undergo further change. The urban citizens consume more refined products (e.g. white bread instead of full-grain products), more fast food and more convenience food, such as meals and take-home food, and more sugar and fat/oil. Better-off households are also increasing their consumption of animal products, vegetables and fruits, and reducing their consumption of cereals.

Also people cook less at home. Due to the daily "migration" between living and working places, as well the lack of alternative choices and lack of means to prepare food at home, an increase of extra-household food consumption can be observed: meals in schools, canteens, street food, fast food restaurants in the inner cities, etc. The negative effect of fast food consumption on obesity (children and adults) is widely researched (e.g. Bowman et al. 2004; Schröder et al. 2007, Hollands et al. 2012).

The influence of health on nutrition and vice versa

The health status influences the body's capacity of using the food. Sick people can use good quality food less efficiently than a healthy person. In return, the quality and quantity of food influence the nutritional status and well-being of a person.

Negative health consequences of bad nutrition are various forms of malnutrition, such as stunting (low height for age, caused by long-term insufficient nutrient intake at young age; effects are largely irreversible), wasting (low weight for height of children under five, the result of acute significant food shortage and/or disease indicating a serious mortality risk) and overweight and obesity (excessive fat accumulation that presents a health risk. A body mass index [BMI] of more than 25 is considered overweight and obese if BMI is 30 or more).

Higher consumption of animal products, processed foods and eating-out-of-home in combination with less physical work can result in overweight and obesity. The health risks associated with obesity include type 2 diabetes, coronary artery disease, and stroke, cancers, osteoarthritis, liver and gall bladder disease (Kopelman 2007). Overweight may lead not only to obesity and influence physical health but also determines a person's well-being as a whole.

If the body lacks micronutrients, minerals and vitamins, these deficiencies may also cause health problems (such as anaemia, goiter, night blindness) (Weingärtner 2009b).

Undernutrition and overweight co-exist in many cities, leading to a double burden of malnutrition (see, e.g., Prain and Dubbeling 2011).

Who is food insecure in cities – or at risk of being so?

The food and nutrition security of urban household members is determined within the context of their livelihoods. Other than in rural areas, urban dwellers' livelihoods predominantly depend on cash economy: what urban people eat, they must buy. The food price hikes in the years 2007–2009 have clearly demonstrated that these strongly affect urban food security (e.g. Cohen and Garrett 2009; Tacoli et al. 2013), and that rising food prices (and economic crisis) especially affect the food security of households with a low and/or insecure or irregular income, because – as mentioned – already a large part of their income is spent on food items and the capacities of poor food insecure households to recover from stress and shocks (e.g. low food prices, economic crisis) is limited.

Research undertaken by RUAF Foundation in Rosario, Bogota, Accra, Kitwe and Colombo during the second half of 2009 (Prain and de Zeeuw 2010) – including household surveys, 24-hour food recall, and anthropometry of under-five-year-olds and women from 15 to 49 – showed that:

- In the large majority of households in low-income neighbourhoods, food accounted for half or more of all expenditures.
- In reaction to economic crisis and food price hikes, the low-income households reduced substantially the quantity of food intake and the quality of food purchased.
- This substantially further increased the already high levels of stunting and wasting, especially in Kitwe, Colombo and Accra, but less so in Rosario due to the presence of a strong urban agricultural programme in this city since the Argentinian economic crisis in 2002.
- Remedial actions taken in the other cities during the crisis had little effect on lessening food insecurity (too little, too late and not well directed).
- Together with underweight, there is also high incidence of overweight and obesity, especially among women, and also in some populations of children, indicating the earlier indicated "double burden" due to malnutrition.

IIED (2013) predicts stable but relatively high-level food prices for prospering economies and in the increasingly urban and non-agricultural Asian countries. In South America, food inflation has been constantly higher than in other sub-regions. Inflation of food price is expected to increase more significantly in Europe and in Asia, remain stable in Africa, and decrease in Latin America (FAO 2014). In the long run, food prices will rise again if agricultural productivity cannot keep up with the increasing demand and will have adverse effects on economic growth, "particularly to the detriment of the poor as higher prices make it more difficult to get out of poverty" (IIED 2013: vii).

Malnutrition in urban areas is often concentrated in poor neighbourhoods and associated with low income and unmet basic needs. Research carried out by the Food and Agriculture Organisation of the United Nations (FAO) shows that the poor consume fewer calories and nutrients than higher-income families, although they spend a greater share of their income on food (Argenti 1998). Moreover, the urban poor often live in slums, squatter and resettlement areas in unhealthy conditions due to poor access to clean and safe water, and poor sanitary conditions; exposure to HIV/AIDS, crime, violence, alcohol and other drug abuse; limited food choices and poor access to health and social support systems (Mercato et al. 2007). As indicated above, poor health and poor nutrition mutually reinforce each other.

At special risk are children. They show signs of malnutrition first. If young children do not get adequate nutrition over a longer period of time, some negative effects are irreversible (including the risk of becoming obese at adulthood

(Sawaya et al. 2004)). Another risk group are old and sick people in general, and people living with HIV/AIDS specifically.

Coping strategies of urban households in case of food insecurity

When urban households experience food insecurity, a range of coping strategies are activated by the household members, including both immediate actions like – amongst others – changes in diets/food intake (quality and quantity), shifts in the household budgets, using alternative food sources (e.g. food aid, food banks), taking up local food production and maintaining urban–rural linkages through multi-locational households. These strategies will be explained further in the following paragraphs.

Change in diets/food consumption

Consumption-related reactions to food (and income) shortages as reported, e.g., by Cohen and Garrett (2009), Prain and de Zeeuw (2010), Battersby (2011) and Owino et al. (2013), include reduction of the number of meals per day, reduction of portions per meal and eating cheaper/less quality food. Additional strategies reported by Hoisington et al. (2001) are mothers depriving themselves of nourishment to feed their children, and specifically their daughters.

Alternative food sources

Part of the coping strategies of food-insecure households include the participation in early childhood nutrition and school meals programmes, food aid programmes (in kind, stamps and vouchers, cash), soup kitchens and food banks and other ad hoc institutional arrangements to address emergency food needs (Mitchell and Heynen 2013); to borrow money from neighbours and relatives, share meals with neighbours or relatives (or send children to eat there) and other community based mechanisms (Gerster-Bentaya et al. 2011); and to scavenge food from restaurant dumpsters and waste left at fresh markets (Miewald and McCann 2014).

Shifts in household budget

If money is scarce and needs to be spent on food, other expenses are reduced or stopped, such as postponing buying needed medicines or clothes, delaying paying bills (e.g. house rent, water/electricity services, and school), and buying food on credit. The latter is rather possible with informal retail stores (Ligthelm 2005 in Battersby 2011; Knight et al. 2014). Also removing children temporally or permanently (especially girls) from school (if school meals are not provided) to save expenses for school fees, school material and uniforms is often practiced in emergencies (Prain and de Zeeuw 2010).

Socially marginalized strategies

Socially critical strategies are mentioned by Owino et al. (2013) who report about strategies of the urban poor to cope with food insecurity by arranging early marriages, engaging daughters in prostitution and sending children on streets to beg.

Local food production for self-consumption

Engaging in local food production for self-consumption and additional income (or exchange for other goods) is another coping strategy to enhance household food security (e.g. FAO 2009; Tambwe et al. 2011; Corbould 2013). We will discuss the role of urban agriculture (including market-oriented urban agriculture) in urban food supply and nutrition in the next section of this chapter in more detail.

Urban–rural linkages for (urban) food security

Tacoli (2000) points out that maintaining strong linkages between urban and rural households and between members of the same household located in both urban and rural areas is an important strategy to ensure their food security: sending food to urban relatives in need and temporary migration of some family members to rural relatives may contribute to the food security of urban households.

Schmidt-Kallert and Kreibich (2004) explain the phenomena of multi-locational households whereby one part of the household members stays in the countryside (mostly the elderly people and very young children) and the other part lives in the city (the adults and elder children for education). They describe the sharing of tasks as follows:

> The rural section of the household has the function of looking after the small children, taking care of the elderly and the sick, and producing surplus food for the urban household members. The urban members earn the cash income and take on a mentoring role for new migrants. They also organize the exchange of goods, services and information.
>
> *(Schmidt-Kallert and Kreibich 2004: 466)*

Such arrangements can work out for many years and exist in the North and the South equally (Dick and Schmidt-Kallert 2011).

The potential of (intra- and peri-) urban agriculture for urban food security, nutrition and health

According to Mougeot (2013), research shows that intra- and especially peri-urban agriculture contributes to a non-negligible share of all food consumed in the city, with high shares for all fresh and perishable products, and that food production in and around the cities contributes to enhancing household food security, especially of the poorer sections of the urban population and improving nutrition (more meals, more balanced diet year-round, savings for other food, less stunting and wasting) (Yeudall 2007; Zezza and Tasciotti 2010).

The contribution of urban agriculture in total urban food supply

Though it is recognized that (intra- and peri-) urban agriculture will by itself not be able to feed entire cities, nor will it provide all food that households need, it may constitute a relevant and needed food source to meet urban food demand. The available data confirm the importance of (especially peri-) urban agriculture in the provision of perishable food commodities, including fresh vegetables (e.g. amaranth, okra, cabbages, lettuces, tomatoes), fruits, eggs, milk, pork and other products. A compilation of available research data by Van Veenhuizen (2007) indicated that in many cities in the Global South a large part of the fresh vegetables consumed in the city are supplied from within the city region (see Table 6.1).

TABLE 6.1 Food provided by (intra- and peri-) urban agriculture

City (source)	*Percentage of urban demand met by (intra- and peri-) urban agriculture*						
	Leafy vegetables	*All vegetables*	*Eggs*	*Poultry*	*Milk*	*Pork*	*Fruit*
Havana (Gonzalez Novo and Murphy 2000)		58					39*
La Paz (Kreinecker 2000)		30					
Dakar (Mbaye and Moustier 2000)		70–80		65–70			
Dar es Salaam (Jacobi et al. 2000)		90			60		
Addis Ababa (Tegegne et al. 2000)					70		
Nairobi (Foeken and Mwangi 2000)							
Accra (Cofie et al. 2003)		90					
Brazzaville (Moustier 1999)	80						
Bangui (David 1992)	80						
Yaoundé (Dongmo 1990)	80						
Bissau (David and Moustier 1993)	90						
Nouakshott (Laurent 1999)	90						
Jakarta (Purnomohadi 2000)		10					16
Shanghai (Cai and Zhang 2000)		60	90	50	90–100	50	
Hong Kong (Smit et al. 1996)		45		68		15	
Singapore (Smit et al. 1996)		25					
Hanoi (GTZ 2000; Phuong Anh et al. 2004)	70–80	0–75 seasonal variation	40	50		50	
Vientiane (Kethongsa et al. 2004)	100	20–100 seasonal variation					

Note: * non-citrus.

Source: Van Veenhuizen 2007 (further elaboration of a table in Moustier and Danso 2006).

It is quite probable that due to ongoing urbanization and new developments in the food supply and distribution system during the last few years (e.g. improved road structure and cold storage facilities, the growing role of supermarkets) these percentages have undergone changes during the last decade, changes that are still under-researched.

The contribution of urban agriculture to enhancing access of the urban poor to nutritious and healthy food

For the households involved in local food production

Fresh, nutritious food is often relatively expensive and lower-income households tend to buy fewer such foods (Beaulac et al. 2009 cited in Gordon et al. 2011; Larson et al. 2009 cited in Hartline-Grafton 2011). Moreover, as discussed earlier, the offer of fresh and nutritious foods by groceries in their own neighbourhood might be limited. Moreover, good-quality food, especially fruits and perishable vegetables, imported from the rural areas or abroad, lose part of their nutritional value during transport and storage (Kader 2005).

Self-produced nutritious food

Local food production by the urban poor (in home and community gardens, and on temporally vacant plots, on the grounds of hospitals, schools and community centres, along highways and railways, below power lines and in flood zones) enhances local availability of fresh and nutritious foods (especially leafy vegetables, and also eggs and meat of small livestock) that are consumed by its producers and surpluses are sold at reasonable prices mainly in the same neighbourhoods.

The participation of the urban poor in urban agriculture is substantial in many cities, especially in sub-Saharan Africa, with considerable variation between cities (from 5 to 64% with an estimated average of about 20–25% of urban households involved in local food production in one way or another [Crush and Frayne 2010; Prain and Lee-Smith 2010]. However, the self-produced food is often only part of the total household food needs, although important to diversify the diets and adding essential vitamins and minerals to the diet. This is because the spaces available for intra-urban food production are often very small, land use insecure, and production practices and conditions far from optimal.

Savings and income to purchase more/better food

Next to consuming their self-produced fresh food, the producing urban households also save money on the purchase of vegetables and other self-produced products. The systematic assessment of the socio-economic impacts of (mainly intra-) urban agriculture undertaken by the RUAF Foundation for the World Bank in four major cities (Accra, Bangalore, Lima and Nairobi) showed that high percentages of respondents in most cities (Bangalore 56%; Nairobi 70%; Lima 73%; Accra 80%) report that savings coming from own food production enabled them to purchase other types of food (either local staple foods like rice or floor) or higher-value items in the diet like fish, eggs, dairy, meat, sugar, oil) or essential other non-food household needs (e.g. house rent or health care) (Prain and Dubbeling 2011).

A third route to improved nutrition for the urban poor who are involved in local food production is through income generated from the sales of (the surpluses) of their produce. As stated earlier, economic access to food is a key factor in urban food security. Local market-oriented food production, processing and selling can help the urban poor to gain an additional, or the only, income needed to obtain food they could not afford otherwise.

The above-mentioned RUAF study demonstrated the role of urban agriculture as an economic livelihood strategy (stable occupation and income) for vulnerable urban households, especially women-headed households and households with elderly or less-educated people. The same study found that urban agriculture is highly compatible with several other kinds of employment and better rewarding than petty trading and casual labouring. Urban agricultural activities can also be combined relatively easily with other occupations and thus allows combining multiple income sources, which – for resource poor and vulnerable households – is a very important risk-reduction and adaptation strategy. Most of the interviewed households considered the income generation from urban agriculture of greater importance than access to additional food. The study also found that an important part of the income from their agricultural production (e.g. vegetables, poultry) consisted of cash savings on food expenditures that otherwise would have to be purchased (Prain and Dubbeling 2011).

Zezza and Tasciotti (2010) compiled data from various reports worldwide published between 1998 and 2005 on the contribution of (intra- and peri-) urban agriculture to household income. The greatest was in African countries (18–24%) and Asia (3–13%) while, in other regions, the contribution was below 5%. These values are averages for all urban producers (for subsistence-oriented and market-oriented producers). For specific categories of the urban producers, especially for the livestock keepers, (mainly peri-urban) irrigated vegetable producers, and fish or mushroom producers, the percentages of income derived from agriculture are often quite higher as well as the level of incomes derived by them.

The provision of monetary income by urban agriculture appears to be related to the nature of produced products and the amount of invested capital (in particular in irrigation, animals and inputs). Monetary income tends to increase from staple food (e.g. rice, maize or cassava) to horticultural crops, aquaculture and livestock; and from seasonal-dry to all-year irrigated crops (Moustier and Danso 2006). Studies by Danso et al. (2002a, 2002b) indicate that irrigated mixed vegetable farming in Ghanaian cities generates incomes close to gross national income per capita. In Bangkok the activity generating the highest income and also requiring the most capital is shrimp farming (Vagneron 2007). Omore et al. (2004) calculate that the number of jobs (mobile collectors, assemblers, small-scale processors and distributors) generated in (mainly urban and peri-urban) small scale dairy per 100 litres of milk was 13.4 in Bangladesh, 13.7 in Kenya and 17.2 in Bangladesh, and that the wage of the workers ranged between US$20 in Bangladesh and US$67 in Kenya. Knowing that, e.g., in Kenya over 1 million litres of milk were collected, processed and marketed, these values indicate substantial incomes and jobs generated.

Zezza and Tasciotti (2010) conclude that there is a correlation between income derived from urban agriculture and household dietary diversity. They also report a correlation between participation in agriculture and poverty, with participation in the poorest quintiles being higher than 50% in eight out of fifteen countries.

However, Frayne et al. (2014) report from the comparison between 11 African cities in southern Africa that rather relatively "richer" households can benefit more from urban agriculture than poor ones, because poorer households have less means of production (access to land and water, capital to buy seeds and other inputs, and to invest in animals, irrigation, etc.).

So while the urban poor are participating more in (often intra-) urban agriculture to secure their food security and livelihood, the higher incomes from agriculture are obtained by the less-poor and middle-income producers (often small-scale commercial and mainly peri-urban producers).

According to FAO (2010), urban households that engage in farming activities tend to consume greater quantities of food (sometimes up to 30% more) and have a more diversified diet, as indicated by an increase in the number of food groups consumed. Vegetable, fruit and meat products are consumed in greater quantities, which translate into an overall higher intake of energy as well as higher calorie availability (see also Alaimo et al. 2008; Davis et al. 2011). Positive effects of self-production activities on the nutritional balance and micronutrient intake of the households are enhanced if the participants receive assistance in crop choice and nutrition education (HKI 2012).

Davies et al. (2011) observed positive health benefits of the physical gardening activities.

For non-producing urban poor households

The earlier section on the role of urban agriculture in total urban food supply indicates that urban agriculture makes substantial, specific and complementary contributions to urban food supply, especially of perishable goods. But do these products produced within the city region also end up being consumed by the (non-producing) urban poor?

Figure 6.1 on the food distribution sources used by the urban lower-income groups in Cape Town underlined the importance of the informal sector in the urban food distribution to the urban poor. According to FAO (2003), the informal sector participates in urban food supply and distribution at three levels: (1) maintaining urban–rural links via exchanges of food items and services within or outside the family or through direct sale by urban producers; (2) serving as an intermediary in the supply and distribution of unprocessed products (transporters and retailers, including mobile fresh food vendors; also generating jobs and income for these informal workers); and (3) the processing and sale of ready-to-eat food: street food and small catering, mainly performed by low- and middle-income households.

FAO specifically recognizes the significant role of street food for millions of low- and middle-income consumers in urban areas on a daily basis. Street foods (e.g. mobile carts selling hot food, open air hot food shops at markets) may be the least expensive and most accessible means of obtaining a nutritionally balanced meal outside the home for many low- and middle-income people, provided that the consumer is informed and able to choose the proper combination of foods. But at the same time, street food includes a number of challenges regarding food safety, sanitation, traffic congestion and accidents (FAO 2009; Chakravarty 2011).

Next to the traditional informal channels, products from market-oriented (intra- and peri-) urban producers also reach the consumers through innovative short food chains (farmers markets, box schemes, virtual shops, buyers' cooperatives, etc.). However, only a part of these new distribution channels reach the urban poor, while other parts are more directed towards the higher income groups in order to enlarge their margins (see Chapter 5 for more details).

When low-income households can purchase food directly from urban producers, this enhances their access to fresh and nutritious food and probably at lower prices (fewer intermediaries, less transport and storage costs) than in longer food chains, although supermarkets nowadays may have such advantages of scale that it may be more difficult to compete on price (e.g. Mkwambisi et al. 2011; Prain and Dubbeling 2011). Because of lengthy transport and the related deterioration of quality, the nutritive quality of products in the short food chains can be better (FAO 2011).

The contribution of urban agriculture to the resilience of the urban food system

Urban food supply can be heavily affected by distortions in food imports due to price hikes and other distortions in the global food markets, droughts and other natural disasters that reduce rural agricultural production, and floods and armed conflicts that interrupt the transport of food to the cities from harbours and rural areas.

As discussed earlier, it is quite probable that international food prices will continue to increase. The climate change will affect rural production and transport to the city. Also the risk that food supply from distant or global sources will be interrupted due to armed conflicts has recently increased substantially in large parts of Africa and the Middle East.

Producing more in and around the cities will enhance the resilience of the urban food system by reducing the reliance on more distant and global supply chains and creating a buffer against shocks in affecting the supply from rural and global sources (FAO 2011; Burton et al. 2013).

UN Habitat (2014) considers urban agriculture as an important strategy for mitigating the negative effects of climate change in cities. Indirectly, urban agriculture reduces the negative effects of floods by keeping flood zones free from construction, reducing run off and facilitating prevention of infiltration. It also reduces urban heat in providing more shade and evapotranspiration. In both cases important health costs and deaths are prevented. For a more extensive discussion on urban agriculture and climate change, see Chapter 8.

Change in nutrition habits – specifically in children – occur best if knowledge of nutrition and dietary intake is coupled with information about the food chain (including production, storage, processing and transport) (see Heim et al. 2009; Guitart et al. 2014), especially when they are actively involved in this process themselves or at least can see how food is produced. This also creates enhanced understanding of the food system and thus an awareness and willingness to pay for healthy food, as some public health programmes have shown (Bellows et al. 2004).

Health risks associated with urban agriculture

There are a number of health risks for human health related to producing food close to many human beings. A number of factors may affect the quality of the food produced in urban areas and have a negative influence on the consumer's health. The production and processing itself also includes some risks for human health of the workers. Lock and de Zeeuw (2001), Gerster-Bentaya (2013) and others have provided overviews of such risks and on how these can be reduced or prevented, which we briefly summarize below.

Most of the health risks associated with urban agriculture can be well managed if these risks are well assessed and taken into account during planning (e.g. appropriate selection of sites and production systems), appropriate preventive measures are taken, and people involved in local production, processing and marketing are well instructed on health aspects related to their activities and how to reduce/prevent health risks through adequate practices.

Main health issues related to urban agriculture include the following:

Uptake of heavy metals and other toxic residues from polluted soils, irrigation water and air

The heavy metals contained in contaminated soils and irrigation may accumulate in the edible parts of crops that are consumed by people or fed to animals and may provoke – after a long period – carcinogenic effects on human health (Birley and Lock 2000). However, Puschenreiter et al. (1999) conclude that, after considering the several available pathways of heavy metals to the human food chain, that soils with slight heavy metal contamination can be used safely for gardening and agriculture if proper precautions are followed.

Specifically when growing on brownfields, special caution is needed (e.g. Heinegg et al. 2002; Egwu and Agbenin 2013). Where soil contamination is likely, soil testing is highly recommended, also to know what measures have to be taken (von Hoffen and Säumel 2014). Such measures may include removal of certain layers, biological remediation, application of lime or farmyard to immobilize the heavy metals, and crop restrictions (excluding crops that take up heavy metals easily like spinach). See, for example, the guidelines developed by the EPA (2011).

Contamination of irrigation water by industry has to be prevented by regulations and programmes to promote treatment at the source and reduce disposal of toxic residues in streams and rivers and in the air. The quality of sources of irrigation water should be regularly tested and, if needed, preventive measures taken (e.g. crop restriction and changes in the irrigation practices, application of lime and farmyard). Where air pollution is above critical level, e.g. downwind of heavy industry and within 50–100 meters of main highways, buffer areas with trees could be created and/or crop choice restricted and washing crops before marketing required (Birley and Lock 2000).

Contamination of crops with pathogenic organisms due to re-use of urban wastewater and organic solid wastes

Irrigation with water from rivers and streams contaminated with human and animal excreta and improperly treated wastewater may contain various bacteria, protozoan parasites, enteric viruses and helminths, which may cause a variety of negative health effects in human beings. Urban farmers in developing countries use these water sources because it may be the only water source available to them and/or for the nutrients this water contains (Huibers and van Lier 2005; Drechsel et al. 2006).

Also, the re-use of urban organic solid wastes (household wastes, market refuse, night soil, manure, and agro-industrial wastes) as a soil improver in urban agriculture (and as an ingredient for livestock and fish feed) may contaminate crops with pathogens if the compost is not properly prepared (too-low temperature).

The World Health Organisation (WHO) published in 2006 revised guidelines for the use of wastewater and excreta in agriculture, indicating various risk management strategies, including establishment of adequate wastewater treatment facilities and improved functioning of existing ones; waste separation at source and application of proper composting methods; restriction of crop choice in areas where water quality cannot be guaranteed; farmer education on adequate crop choice and proper irrigation techniques; education of food traders and retailers and consumers (hygiene, washing, etc.) (WHO 2006). For more details, see Chapter 7.

Unhygienic handling of food

Food safety does not end with production. Frequently, food is contaminated during processing, storing or distribution. Frequent sources of contamination are, for example, vegetable markets, slaughterhouses and small-scale processing units (e.g. of dairy products) that lack clean water, good standards of hygiene and/or adequate equipment (Gerster-Bentaya 2013). Risk management strategies include proper education of the entrepreneurs involved in processing, transport and storage of food produced in the city region on safety issues, regular control of processing businesses and assistance in improving the infrastructure.

Residues of agrochemicals

Intensive use of agrochemicals (fertilizers, pesticides, fungicides) in agriculture may lead to residues of agrochemicals in crops, especially vegetables, as well as in meat, milk or eggs (FAO 1988). Especially after many years of intensive commercial horticulture, residues of noxious chemicals may accumulate in the crops. However, most small-scale urban producers do not use large amounts of agrochemicals due to lack of means to buy these inputs or because they use compost and apply Integrated Pest and Disease Management (IPM) and other sustainable farming principles (Lee-Smith and Prain 2006).

Among the many risk management strategies, the following items figure amongst others: farmer education on the proper management of agrochemicals; promotion of ecological farming practices and IPM; better control of sales of banned pesticides; introduction of cheap protective clothing and equipment; and monitoring of product quality especially in areas of intensive production. See also Chapter 9.

Zoonotic diseases and diseases transferred to humans by rodents and flies attracted by agriculture

Zoonotic diseases are infectious diseases transmitted through direct contact of human beings with animals during production, processing or consumption of contaminated animal products (bovine tuberculosis and brucellosis mainly from ingestion of contaminated unpasteurised milk; tapeworms and trichinosis mainly by consumption of infected meat; Leptospirosis mainly through contact of humans with infected animal urine; and Salmonella and campylobacter through contamination of animal feed). Malaria occurs in many environments but particularly in areas where irrigation is practiced mainly in relatively clean water. The mosquitos that spread filiarsis and dengue breed in standing water containing much organic matter. Farms attract rodents and flies that may be carriers of diseases (e.g. plague). Scavenging by pigs is associated with food-borne diseases such as amoebic and bacillary dysentery.

Risk management strategies include, amongst others: farmer education on proper waste management practices in livestock; restriction of uncontrolled movement of livestock in urban areas and promotion of stall feeding; proper design of water tanks and irrigation systems in peri-urban areas; strict slaughterhouse regulations; consumer education regarding heating of milk and proper cooking or freezing of meat products; and composting of manure before application. See also Chapter 10.

Conclusion

Many cities have recognized the urgent need to place food on the policy agenda and to develop adequate policies and programmes to secure urban food security and create favourable conditions for the development of an urban food system that provides safe and nutritious and affordable food to all categories of the urban population.

The above sections show that urban food security and nutrition are influenced by a variety of factors that vary from city to city and even within cities. This implies that urban food security and nutrition policies need to be comprehensive and integrate a variety of policy measures and programmes.

Such policies and programmes need to be based on thorough knowledge about food insecure groups, their localities, the magnitude, type of food insecurity, times and duration as well as the reasons for food insecurity and the likelihood of occurrence of these factors, and these basic aspects need to be explored prior to any action. Food security situation analysis including risk assessments to prevent food insecurity situations need to be conducted specifically in poverty pocket areas of the cities.

Important challenges that need to be tackled are, amongst others:

- Lack of awareness and knowledge among consumers as well as planners and decision makers about the links between food, adequate nutrition and health as well as insufficient insight into the complexity of the urban food system with its variety of actors, channels, linkages, drivers and trends and how this effects urban food security, nutrition and health.
- Ongoing city expansion: Urban centres often expand on the most productive land because cities are historically built on fertile soils (Satterthwaite et al. 2010). In addition, urbanization causes environmental perturbations in the surrounding agricultural ecosystems (e.g. landscape fragmentation, changes in the water cycle and reduced habitats) (Gardi et al. 2014). City planners for a long time have not given much attention to safeguarding the food production and eco-services of productive open spaces in and around the city and have to develop new ways of incorporating such functions in the urban system and preserve the green and productive spaces (see also Chapter 4).
- Need for inter-institutional collaboration: Food and nutrition issues are normally dealt with by Departments of Health mainly. However, as seen above, enhancing urban food security and nutrition have as much to do with other departments too: economic development, planning, urban agriculture, to mention a few, which need to collaborate closely in situation analysis and food system planning.

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7

PRODUCTIVE AND SAFE USE OF URBAN ORGANIC WASTES AND WASTEWATER IN URBAN FOOD PRODUCTION SYSTEMS IN LOW-INCOME COUNTRIES

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Introduction

Rapid urbanization in developing countries raises the challenges of urban food supplies and management of the waste flows from urban households and markets. Large amounts of municipal solid waste, human excreta and wastewater are produced, which mostly end up in non-engineered landfills or polluting the urban environment, especially in low-income countries where sanitation infrastructure is less developed. Wastewater and many organic wastes are nutrient rich and can be productively used in intra- and peri-urban agricultural systems, enhancing the resilience of the urban metabolism.

However, productive reuse of waste faces a variety of challenges. These range from securing cost recovery for up- and out-scaling successful examples of planned reuse to the acceptance of safety practices within the informal reuse sector in urban and peri-urban areas. Opportunities for addressing the first challenge include more attention to business models which can build on different value propositions beyond 'water' or normal 'composting', and for the second challenge they include more attention to social marketing options, private-sector engagement and incentive systems for catalysing behaviour change towards the adoption of safety practices.

A shift in thinking about solid and liquid waste

Cities are hungry and thirsty and there are enormous hubs of consumption of all kinds of goods including food. This in turn makes them major centres of generation of food waste. If this waste remains in the urban environment or its landfills,

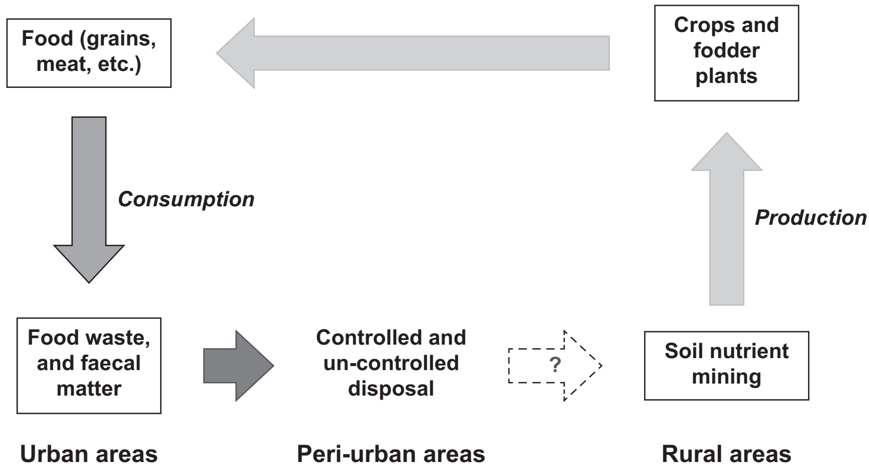

FIGURE 7.1 Urban and peri-urban areas as vast nutrient sinks
Source: authors.

cities will also become vast sinks for the resources, like crop nutrients, while rural production areas face degradation of soil fertility (Figure 7.1). The same applies to nutrient-rich wastewater discharged from households (excreta, urine and grey water), and commercial and industrial establishments, which could also be mixed with storm water as may be present.

Given the value of the resources hidden in waste, and the environmental burden of a business-as-usual scenario in growing cities, there is need for a paradigm shift. For example, in solid waste management, there is increasing advocacy to a shift in the behaviour of the public towards the 'three Rs', i.e., 'Reduce, Reuse and Recycle' (UNEP 2011). Social science research is re-conceptualizing waste from 'risk, hazard or dirt' towards 'resources, values, assets and potentials' (Moore 2012). In wastewater management, a clear shift from nutrient removal to nutrient recovery is taking place with treatment facilities shifting from waste disposal to resource conservation (Murray and Buckley 2010). This conceptual thinking of 'design for reuse' or a 'reverse water chain approach' considers the ultimate fate of the water as the design base for the urban water chain, including treatment and upstream issues (Huibers and van Lier 2005).

This thinking has been strengthened through an increasing focus on dry sanitation systems, especially ecological sanitation systems, in regard to the managing of human faecal matter. Ecological sanitation is based on three principals: (i) preventing pollution rather than attempting to control it afterwards, (ii) sanitizing urine and faeces (excreta), and (iii) using safe products for agricultural purposes (Winblad and Simposon-Herbert 2004). There is also increasing efforts for using faecal waste and other organic waste in energy production through biogas schemes.

The modern dry sanitation systems facilitate the transport of faeces and potential resource recovery through the 'drop-store-sanitize-and-reuse' approach in a controlled environment which conventional approaches like 'drop-and-flush' or 'drop-and-forget' of sewered systems or pit latrines, respectively, do not support (Rautanen and Viskari 2006). These newer approaches incorporate the 'three Rs' thinking across scales for increasing the resilience of urban areas, and society at large. A change in thinking is not only a possibility but, in many cases, a 'must' as limited water resources do not allow flush sewer systems while some resources like phosphorus are non-renewable, and especially poorer countries will be the first to feel increasing fertilizer prices (Mihelcic et al. 2011).

Resource recovery ideally starts at the household level. Supported by public awareness, households reduce their waste collection fees by separating, for example, old glass, used paper, plastic waste and organic kitchen residues into dedicated collection systems. Where space and regulations allow, backyard composting of kitchen residues for urban farming is encouraged. For grey water from kitchens and bathrooms and black water from toilets, local reuse options, e.g., via urine diverting toilets, are being explored, although for the large majority of urban households the conventional target remains the removal of faecal matter from household premises through the sewer system.

In most developing countries, collection of wastewater and solid waste and the separation of different solid waste streams are still a major challenge, resulting in severe pollution of water bodies. Less than 10% of the urban population in sub-Saharan Africa, about 3% in South-East Asia and 31% in South Asia are connected to any wastewater collection system (Lautze et al. 2014). Collection of solid waste does not require expensive infrastructure but shows a similar picture with South Asia and Africa ranking lowest with 65% and 46% collection rates, respectively (Hoornweg and Bhada-Tata 2012). The remaining waste is a severe public health hazard. As most households are poor, waste management cannot rely on fees and taxes to finance its operations. In fact, expenditure on waste management often takes up to half of the municipal budget and even then is seldom enough to cope with waste generation, especially in the low-income high-density parts of the city which are difficult to access. The possibility of increasing household fees is not only limited by poverty, but also due to low education, resulting in limited environmental awareness and responsibility. If collection fees are raised, households are likely to start dumping their waste in the street or drains.

In low-income countries, increasing collection coverage is the highest priority in most local authorities, much more so than introducing resource recovery activities, which often remain at pilot scale. However, recycling takes place, but is more poverty-driven than done for environmental reasons, with landfill scavenging and e-waste burning for metal recovery being popular examples. However, an increasing number of entrepreneurs are engaged in activities such as commercial plastic recycling, and the reuse of organic residues for various purposes.

While urban and peri-urban food production and especially food safety clearly suffer from poor sanitation, urban farmers do often take advantage of underutilized solid and liquid waste resources. This may be food waste from agro-industrial production, such as cotton husks or poultry manure, composted market-waste, domestic wastewater or faecal matter.

In this context, we need to consider two waste 'streams': the waste that is managed and on its way to treatment or disposal; and the waste that bypasses formal systems, leaking out or never getting there in the first place (Drechsel et al. 2011). This chapter will focus on both streams in developing-country contexts (though there are many similarities with developed countries), and the related challenges and opportunities for the productive and safe use of urban organic wastes and wastewater. While there are several reuse options, from industrial reuse to the production of potable water, in the context of this publication, agricultural reuse, especially in intra- and peri-urban farming, will be the focus.

With the emergence of intensive – high input, high output – urban and peri-urban food production systems, which are often a direct response to changing diets in urban areas, we see an increasing interest in water reuse and alternative fertilizer making use of different types of waste (Box 7.1).

BOX 7.1 FORMS OF URBAN WASTE OF VALUE IN AGRICULTURE

Urban waste can be solid, partially solid (e.g., manure, sludge) or liquid (grey water), organic or inorganic, recyclable or non-recyclable. Of interest to urban agriculture as a source of nutrient and organic matter is the organic fraction of municipal solid waste (MSW) and agro-industrial waste, and as a source of water and nutrients also domestic wastewater. For example, at least 50% of urban solid waste is biodegradable and hence of immediate interest in recycling. Wastewater on the other hand is often already used, directly where water is scarce or indirectly if mixed with other water sources. Typical types of waste commonly used in urban farming are:

1. **Solid waste:** Domestic and market wastes, food waste including vegetable and fruit peelings, and charcoal ash. This also includes waste from institutions and commercial centres.
2. **Horticultural and agricultural waste:** Common especially in high-income areas: garden refuse, leaf litter, cut grass, tree cuttings, weeds, animal dung, crop residues, waste from public parks, etc.
3. **Agro-industrial waste:** Waste generated by abattoirs, breweries, timber mills, poultry farms, food processing and agro-based industries.
4. **Sludge and biosolids:** Human faecal matter from septic tanks and treatment plants.
5. **Wastewater:** Typically, it is estimated that 70–80% of total water supplied for domestic use leaves the household as wastewater. However, high wastewater collection is not always successful because of the low coverage of sewer.

Source: Cofie et al. 2006; modified.

Resources in urban organic waste and wastewater

Municipal solid waste (MSW)

Current global MSW generation levels are approximately 1.3 billion tons per year ($Btyr^{-1}$), and are expected to increase to approximately 2.2 $Btyr^{-1}$ by 2025. This represents a significant increase in per capita waste generation rates, from 1.2 to 1.42 kg $person^{-1}day^{-1}$ in the next 15 years (Hoornweg and Bhada-Tata 2012). In sub-Saharan Africa, approximately 62 million tons of MSW are generated per year. Per capita waste generation is generally low in this region, but spans a wide range, from 0.09 to 3.0 kg $person^{-1}day^{-1}$, with an average of 0.65 kg $capita^{-1}$ day^{-1}. In the MSW stream, waste can be organic and inorganic, and generally categorized organic, paper/cardboards, plastics, glass, metals, textiles and other materials (see Figure 7.2).

Of most relevance to urban food production systems is the organic waste, which is most commonly used to improve soil productivity. In general, the organic fraction is the largest one within domestic waste (Figure 7.2). According to Hoornweg and Bhada-Tata (2012), low-income countries have an organic fraction of 64% compared to 28% in high-income countries. The potential benefits of organic waste recycling are particularly in reducing the environmental impact of disposal sites, in extending existing landfill capacity, in replenishing the soil humus layer and in minimizing waste quantity (Zurbruegg and Drescher 2002).

In a comprehensive review on MSW use in agriculture, Hargreaves et al. (2008) described the positive effects of MSW on the biological, physical and chemical soil properties. The review showed that MSW has high organic matter

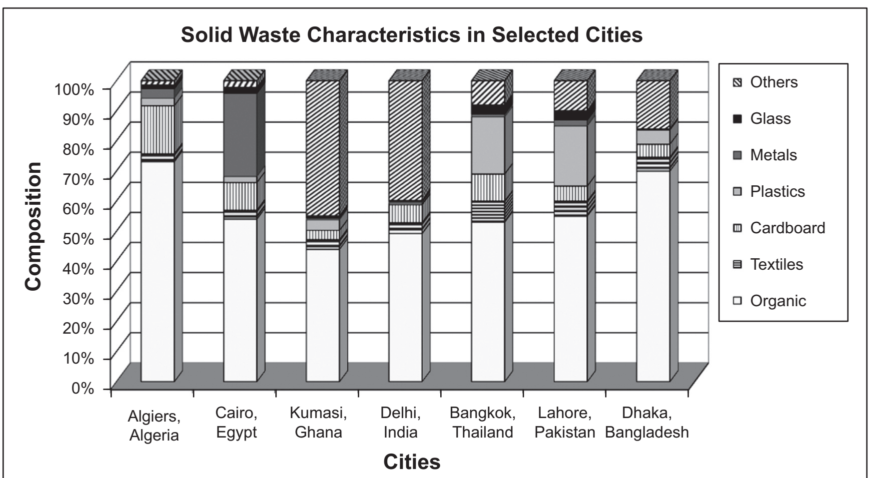

FIGURE 7.2 MSW characteristics in selected cities

Source: Cofie et al. 2006.

content, limited amounts of nutrients and low bulk density. Once composted, these characteristics can influence, in particular, the physical properties of soils by increasing the soil C/N ratio, water-holding capacity, etc. In view of biological properties, the review showed a general improvement on soil microbial health through increasing organic biomass, increasing soil aeration and accelerating the activities of enzymes which help in the transformation of nutrients. Reduced soil acidity and – depending on the type of waste or supplements – the addition of nutrients was identified as a possible beneficial effect on soil chemical properties.

Other benefits adapted and summarized from Hoornweg et al. (1999), with particular reference to organic waste composting, are that it:

- Reduces overall waste volume, transport costs and landfill lifetime.
- Enhances recycling and incineration operations by removing moist organic matter from the waste stream.
- Promotes environmentally sound practices, such as the reduction of methane generation at landfills.
- Is flexible for implementation at different levels, from household efforts to large-scale centralized facilities; i.e., can also be started with very little capital and operating costs.
- Addresses possible health impacts from faecal matter due to the composting (sanitizing) process.
- Can integrate existing informal sectors involved in the collection, separation and recycling of wastes, and contributes to the 'green economy' of a city.

However, despite these benefits, current MSW management practices show very small proportions of MSW being recycled and/or composted. This ranges from over 30% in some high-income countries to as low as less than 2% in low-income countries (see Table 7.1). On average, only 1.5% of MSW is

TABLE 7.1 Global MSW disposal practices (by income levels of the countries)

	High income (%) Total = 588.05 million tons	*Upper middle income (%) Total = 135.78 million tons*	*Lower middle income (%) Total = 55.32 million tons*	*Low income (%) Total = 3.76 million tons*
Dumps	0	33	49*	13
Landfills	43	59	11	59
Compost	11	1	2	1
Recycled	22	1	5	1
Incinerated	21	0	0	1
Other	3	6	33	25

Note: * including China.

Source: adapted from Hoornweg and Bhada-Tata 2012.

composted in low- and middle-income countries. The reasons for these low shares are as various as the theoretical benefits. More than a decade ago, Hoornweg et al. (1999) had already identified six common challenges preventing compost initiatives from going to scale: (i) inadequate attention to the biological process requirements like under tropical climates; (ii) over-emphasis placed on electricity-demanding and often fragile mechanized processes rather than labour-intensive operations; (iii) lack of vision and marketing plans for the final product – compost; (iv) poor feed stock which yields poor-quality finished compost, for example, when contaminated by heavy metals; (v) poor accounting practices which neglect the fact that the economics of composting rely on externalities, such as reduced water contamination, avoided transport and disposal costs, etc.; and (vi) difficulties in securing finances since the revenue generated from the sale of compost will rarely cover processing, transportation and application costs.

Although there are an increasing number of success stories, as documented for example in the *Urban Agriculture Magazine* Vol. 23 (www.ruaf.org), an over-reliance on technical approaches and lack of business thinking was reconfirmed also in more recent studies. Based on experiences from composting projects in Africa, Drechsel et al. (2010) identified as a key constraint that the composting gains in terms of reduced transport volumes and cost are seldom made available to (run) the composting unit due to poor coordination among involved institutions and the lack of an enabling institutional (e.g., private–public partnership) framework. While, for example, city authorities stress that composting is most welcome as a means to reduce waste volume and transport costs, the savings remain inaccessible to the private compost plant operator. However, in many situations, and especially for larger cities, these 'savings' would be a higher benefit (revenue stream) than the actual compost sales. The situation might be very different for smaller towns where agricultural demand might surpass waste supply.

The importance of transport costs derives from the increasing problems of city authorities to find community-supported landfill sites in the city vicinity, while local communities are less reluctant to accept a compost station (Drechsel et al. 2010). From this point of view, compost stations should be planned as close as possible to the points of waste generation, and from the sales perspective as decentralized as possible to support farmers' access to the product. Knowing customers' locations and demand, the corresponding daily production of compost, transport and operation and maintenance (O&M) costs, it is possible to determine the optimal number of decentralized compost (and transfer) stations to minimize costs.

Possible market segments go beyond intra- and peri-urban crop production and include landscaping, housing sector, coffee and tea plantations, forestry, etc. As long as the reuse market is not fully assessed, cost recovery for compost

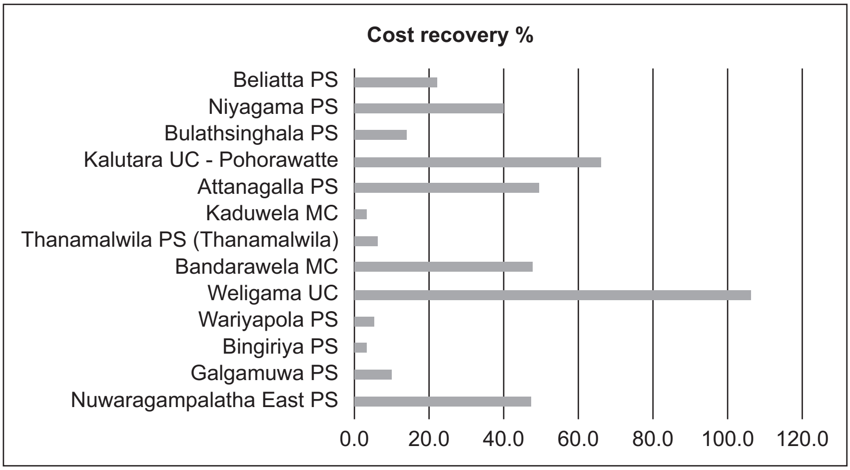

FIGURE 7.3 Range of O&M cost recovery among selected compost plants in Sri Lanka
Source: Fernando et al. 2014.

production will remain small, and any compost business will have to be based on subsidies based on transport and landfill cost saving.

Based only on compost sales, cost recovery can vary in wide margins, as the Pilisaru project in Sri Lanka has shown. More than 110 compost plants were set up under the first project phase, with an average cost recovery of less than one-third of the O&M costs (Figure 7.3). The average value hides the fact that several compost plants produced far less compost than planned (reducing also the O&M cost), although several accepted more waste than they were designed for, targeting more volume reduction than the production of a marketable product (Fernando et al. 2014). However, some plants in Sri Lanka performed well and even achieved profits (Otoo and Drechsel 2015). This was interesting, as almost all MSW compost plants in the country are owned by the public sector. Thus the differences between poor- and well-performing stations could not be easily attributed to management, technology or regulatory differences, allowing cross-case analysis. A typical reason for difference in performance related to different expertise and knowledge about local markets and the emergence of private–public partnerships.

Human excreta

Human excreta are the final 'food waste' and a key component of domestic waste production. Like animal manure, they are an excellent fertilizer, and richer in organic matter with essential plant nutrients such as nitrogen, phosphorus and potassium than the average organic MSW. The use of human excreta as a fertilizer dates back to many centuries. For example, Chinese were aware of the benefits of using excreta in crop production more than 2,500 years ago, enabling them to sustain more people at a higher density than any other system of agriculture (Lüthi et al. 2011). Even in many European cities, fertilization of farm lands continued into the middle of the 19th century as farmers took advantage of the value of nutrients in excreta to increase production, and urban sanitation benefited as they used farming lands as a way of treatment and disposal (Lüthi et al. 2011). The practice only stopped due to the need to manage possible health risks within increasingly dense human settlements.

It has been shown that the nutrient content of human waste collected in a year is approximately equal to what has been eaten during the year (Drangert 1998). Each year, a human excretes up to 500 litres of urine and 50 to 180 kg (wet weight) of faeces, depending on water and food intake (Drangert 1998). These contain about 4 kg of nitrogen, 0.6 kg of phosphorus and 1 kg of potassium, with variations depending on protein intake (Drangert 1998; Jönsson et al. 2004). Phosphorus (P) recovery from excreta is of particular importance due to the fast depletion of phosphorus reserves (see Box 7.2).

BOX 7.2 THE NEXT INCONVENIENT TRUTH – PEAK PHOSPHORUS

Phosphorus is an essential nutrient for all plants and animals. About 80% of mined phosphate rock, the main source of phosphorus, is used in fertilizers, thus making it very vital for the world's agriculture sector. Today, about 90% of phosphate rock reserves are found in only five countries and the largest commercially recoverable reserves are found in three countries – China, United States and Morocco/Western Sahara. The US Geological Survey reports that phosphate rock reserves are running out and that phosphate rock extraction will peak around the year 2030. The extraction rate of phosphate rock in the United States (US) peaked 15 years ago and present forecasts show that the US will deplete its reserves within 30 years. Globally, phosphate rock reserves are estimated to be depleted within 75–100 years. Being a non-renewable resource, phosphorus cannot be manufactured from alternative sources. Therefore, there is need for agricultural reforms and innovative and sustainable strategies to recover phosphorus from human, animal and other organic wastes for use in agriculture.

Source: Rosemarin et al. 2009.

While most of the organic matter is contained in faecal matter, most of the nutrients (88% of the nitrogen, 67% of the phosphorus and 71% of the potassium) are found in urine (Heinonen-Tanski and van Wijk-Sijbesma 2005) in forms that are readily available for crops. Organic matter from decomposed faeces can also serve as a soil conditioner, improve soil structure, increase water-holding capacity, and can reduce pests and diseases while neutralizing certain soil toxins like heavy metals (Esrey et al. 2001). An important benefit from recycling excreta is the reduction of environmental pollution and degradation of water quality from uncontrolled dumping of faecal sludge.

Following the promotion of urine-diverting toilets, extensive field trials conducted both in tropical and temperate climates have shown increase in yields from using human excreta compared to when the soils are unfertilized. Jönsson et al. (2004) reviewed various field experiences regarding agricultural yields on using human excreta in agricultural production. Despite very promising agronomic results, the reuse of faecal matter (excreta and urine) is facing various challenges from the cost of toilets separating the resources, to limitations based on perception or health regulations, or the logistics of transportation where households do not have the opportunity of on-site reuse. More progress has been achieved in view of urine and its high phosphorus content. Modern technologies allow the recovery of high percentages of P before it starts damaging pipes and valves in wastewater treatment systems through unwanted precipitation. This results in significant savings for treatment operators by reducing the use of chemicals otherwise needed to remove the crystals. Enterprises specialized in P recovery thrive on these savings while the generated P fertilizer (struvite) is still struggling to move beyond selected niche markets given the lower price of natural rock phosphate (Otoo et al. 2015).

Wastewater

For reasons of simplicity, and in comparison with safe freshwater sources, the term 'wastewater' is commonly used in the literature on urban and peri-urban agriculture, although the water quality varies in very wide margins from raw wastewater to diluted wastewater to grey water and polluted stream water. These differences might even be larger than between treated and untreated wastewater, as what is called treated in one country might still be considered unsafe in another one. In general, treated wastewater reuse is more common in developed countries while a ten-time larger area is irrigated with diluted or raw wastewater in developing countries and emerging economies (Scott et al. 2010). The most direct benefits of wastewater use in urban food production systems can be the nutrients in the water, especially in raw wastewater, but otherwise it is the water itself, or more precisely the reliable and low/no cost supply of water where and when freshwater is not available. A typology of different common reuse scenarios is attempted in Table 7.2.

TABLE 7.2 Typology of water reuse

Type	*Value addition to the resource*	*Farmer pays?*	*Commonly seen in (examples)*	*Reuse-based business model*
1. **Direct** use of **untreated** wastewater	None, except for facilitation of water access (canals). Water use can be considered a land treatment	Seldom as usually illegal, but if then, e.g. for land near wastewater channel	Pakistan Mexico Vietnam Peru	Where resources are scarce, farmers might pay for access to land or wastewater (which could support wastewater collection, basic treatment or health care)
2. **Indirect** use of **untreated** wastewater	Dilution and natural treatment depending on distance between source and use	Wastewater is diluted and not perceived as wastewater	India Ghana Mexico China	Water perceived as natural water with low willingness to pay. Business model could request for safety measures against market or tenure incentives
3. **Direct** use of **treated** wastewater	Provision of water safe for agricultural use through treatment	For provision of treated wastewater (but see right for inverse cash flow)	Tunisia Egypt USA Australia Chile Israel	Several revenue options: Payment for access to safe wastewater, or farmers are paid for swapping freshwater with wastewater, or savings in freshwater use pay for reuse system
4. **Indirect** use of **treated** wastewater	Provision of safe water through treatment before mixing with surface water or for groundwater recharge	As above, if water users know about treatment and appreciate it	Jordan Spain Mexico USA	Water often perceived as natural water limiting farmers' willingness to pay. Otherwise also water swap models are possible exchanging freshwater against treated wastewater

Source: Evans et al. 2013; modified.

Undiluted wastewater has nutrients that can significantly contribute to crop growth and improving soil fertility. It is estimated that 1,000 m^3 of municipal wastewater for irrigating one hectare can contribute 16–62 kg total nitrogen, 4–24 kg phosphorus, 2–69 kg potassium, 18–208 kg calcium, 9–110 kg magnesium and 27–182 kg sodium (Qadir et al. 2007). In Mexico's Mezquital (Tula) Valley, wastewater irrigation provides 2,400 kg of organic matter, 195 kg of nitrogen and 81 kg of phosphorus ha^{-1} yr^{-1}, contributing significantly to crop yields (Jimenez 2005). Larger crops and reduced growth periods in wastewater irrigated fields are also reported from Dakar, Senegal, which is attributed to the nutrients in wastewater (Faruqui et al. 2004).

Wastewater not only adds nutrients to soil, but can also amend soils through its organic matter content (biosolids or stabilized sludge) (Christie et al. 2001). Compared to freshwater, there is a significant body of literature showing advantages for soils and yields under wastewater irrigation, although many comparative assessments are not free from shortcomings (Drechsel, Danso and Qadir 2015). In Guanajuato, Mexico, the estimated cost for farmers for replacing the nitrogen and phosphorus loss through wastewater treatment was estimated at US$900 ha^{-1} (Scott et al. 2000).

Making an asset out of wastewater appears as a necessity especially where farming faces increasing water competition from the urban and industrial sectors. Other than availability and its low price, many farmers use wastewater because it is reliable, allowing year-round production, hence giving a strong competitive advantage during the dry season. Studies conducted in Hubli–Dharwad showed that wastewater allowed farming to be done in the dry season when farmers could sell their produce at 3–5 times the kharif (monsoon) season prices (Bradford et al. 2002). Reliability of wastewater also allows for multiple cultivation cycles and flexibility of crops planted (Raschid-Sally et al. 2005). In Haroonabad, Pakistan, the reliability and flexibility of untreated wastewater supply allow farmers to cultivate even-priced, high-value and short-duration crops (van der Hoek et al. 2002). In Ghana, the reliability of free wastewater allows urban farmers to intensify vegetable production to multiple cycles year-round. Similarly in Dakar, Senegal, untreated wastewater allows 8–12 harvests per year, compared to 5–6 harvests per year when farmers had no access to wastewater (Gaye and Niang 2002).

Where wastewater reuse is formally promoted and culturally acceptable, a critical question concerns the viability of the wastewater treatment facility and reuse scheme. The main challenges in this regard are the commonly low revenues from the sale of treated wastewater especially where already freshwater is subsidized. In this situation not only the financial gains but also economic benefits for the society should be considered as well as other possible value propositions and revenue streams from wastewater treatment, which might benefit farming or other sectors (Figure 7.4).

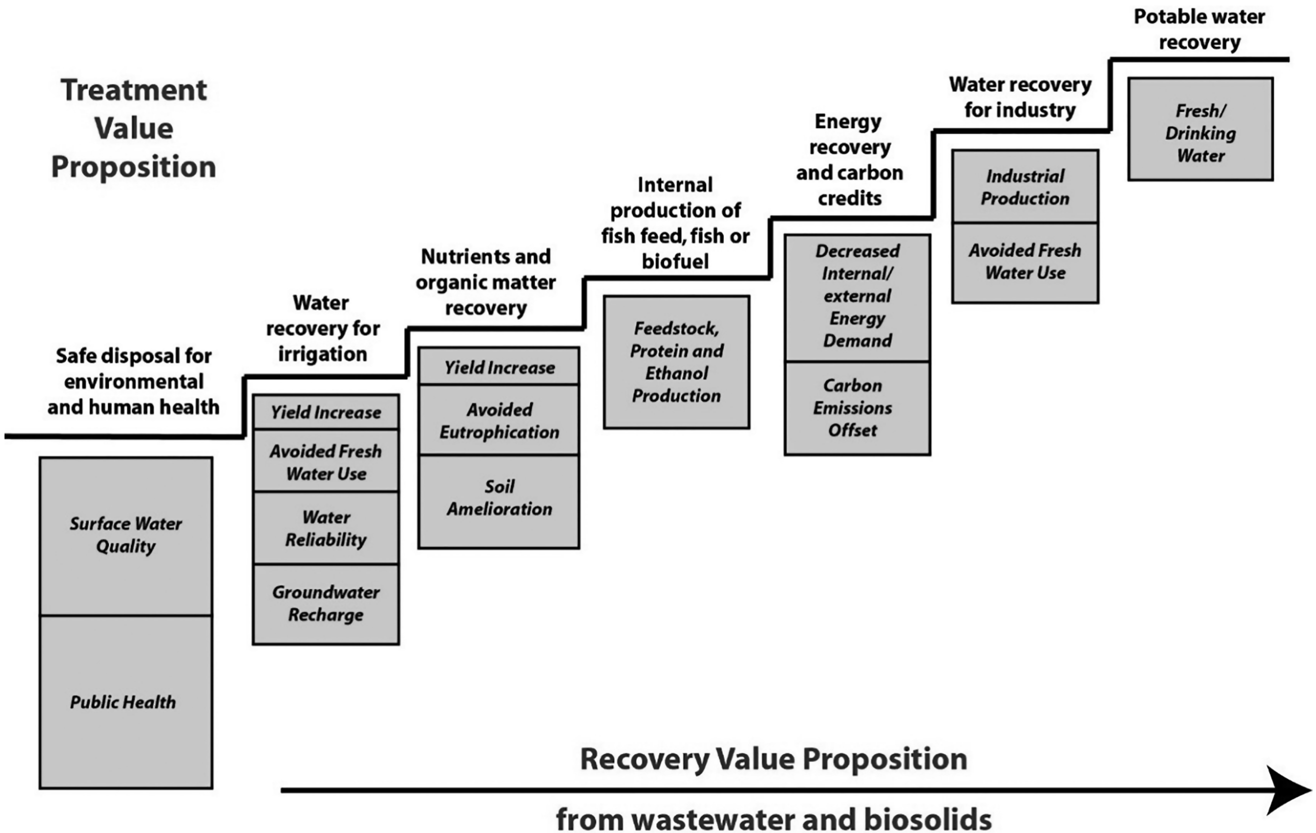

FIGURE 7.4 Value propositions related to water, nutrient and energy recovery from wastewater

Source: Rao et al. 2015.

Concerns of using solid and liquid waste in urban food production systems

Productive use of urban waste and wastewater faces a number of challenges from institutional and technical obstacles like the required treatment capacity, to the distance between waste/water generation and the agricultural market, as intra-urban farming can usually only absorb a small amount of the waste generated, making this farming sector not the major target for effective volume reduction or cost recovery. However, the largest concerns resource recovery, and reuse is facing possible risks for human and environmental health, especially where waste products are used in food production (Table 7.3). Depending on their origin, solid and liquid wastes can carry harmful chemicals and, when mixed with human faecal matter, also pathogens, potentially causing various diseases. In low-income countries, with only emerging industrial production, emphasis is laid on pathogens, since people in these countries are most affected by diseases caused by poor sanitation such as diarrhoeal diseases and helminth infections (Prüss-Ustün and Corvalan 2006). The situation changes in transitional economies with increasing industrialization and is again different in high-income countries, where infections from pathogens are largely under control while chemical pollution like heavy metals, and so-called emerging pollutants (e.g., residues of antibiotics) are of significant public concern.

While data on pathogens and heavy metals are frequently reported from irrigated urban agriculture, emerging contaminants are so far more difficult to analyse in low-income countries and data are rare (e.g., Asem-Hiablie et al. 2013; Amoah et al. 2014; Keraita et al. 2014).

TABLE 7.3 Common uses of different types of waste and related concerns

Type of waste	*Common use in low-income countries by farmers in urban and peri-urban areas*	*General concerns/risks*
MSW – Food waste	• Food waste fed to animals, deposited on nearby dumps, used in community composting and vermicomposting	• Direct feeding of household livestock is probably rather low-risk compared to livestock roaming streets • Low chemical risk as farmers know contents but community compost heaps could be harmful to children when playing around the heaps and attract rodents and other disease vectors

(*Continued*)

TABLE 7.3 (Continued)

Type of waste	*Common use in low-income countries by farmers in urban and peri-urban areas*	*General concerns/risks*
MSW – Mixed waste	• Farmers collect formally or naturally composted waste from decentralized dumping sites and apply it to fields; other stakeholders might use formally composted waste in parks or for landscaping	• Pathogens – when insufficiently composted which pose health risks to waste handlers, farmers, produce consumers and children playing near or on dumping sites • Toxic substances – such as heavy metals could cause soil and crop contamination • Glass splinters, plastics – cause physical harm to handlers
Human excreta – faeces, urine and faecal sludge	• Normally disposed of via toilets or latrines, but in some regions also used raw or after storage in farming • In urine diversion toilets, urine can be separated from faeces and used after storage, often diluted	• High risk from pathogens, especially in faeces and faecal sludge if not well handled and treated before use or use on low-growing crops • If sludge derives from treatment plants (sewage sludge) also high probability of chemical contaminants. This is significantly less the case for sludge of on-site systems like septic tanks (septage) • Foul smell and flies • Negative public and authority perceptions on using excreta for crop production and aquaculture
Wastewater	• In water-scarce countries, used formally as a source of irrigation water (often after some level of treatment) or informally without treatment • In more humid countries with poor sanitation, wastewater is disposed to drains and urban water streams which farmers might use in crop production	• High risk of exposed groups (farmers, produce traders and consumers, children playing in wastewater irrigated sites) from pollutants if not well-managed. • These pollutants can include pathogens, salts, metals/metalloids, residual drugs and other organic contaminants, also dependent on the water source • Smell (concern is lower than that of excreta) • High concentration of chemicals can also affect crop growth and productivity • Negative public and authority perceptions on using especially untreated wastewater for irrigating vegetables

Source: adapted from Keraita et al. 2006.

Safe and productive use of solid and liquid waste

While composting has, across many cultures, a long tradition, awareness, perceptions and acceptance of the use of treated wastewater, urine or faecal matter vary with the development stage of the society, and can be a very dynamic process which makes social feasibility studies, close participation of target groups, and trust-building essential components of successful reuse programmes (Drechsel, Mahjoub and Keraita 2015).

On the other hand, where reuse already takes place in the informal sector, a favourable economic benefit and limited risk awareness can jeopardize the introduction of risk-mitigation measures (Karg and Drechsel 2011). However, where markets or farmers are aware of risks, the range of technical options for conventional and/or farm-based treatment has been established (e.g., Koné et al. 2010; Libhaber and Orozco-Jaramillo 2013; Keraita et al. 2015).

The following sections will discuss experiences, challenges and opportunities for resource recovery from MSW and wastewater.

Increasing the value of composting and co-composting

Composting the organic fraction of MSW is seen as one of the most successful methods of preventing organic waste materials to end on landfills, while creating a valuable product at relatively low cost that is suitable for agricultural purposes (Wolkowski 2003). The benefits are not only attributed to increased soil fertility, but as mentioned above also to economic and environmental factors, such as costs associated with landfilling and transportation, decreasing use of commercial fertilizer imports, etc. (Hargreaves et al. 2008).

Success stories of MSW composting range from community-level projects to large-scale composting (Otoo and Drechsel 2015). An often-cited example is the 1995 established 'Waste Concern' which, since 2009, has managed to treat in Dhaka city more than 100,000 tons of waste, is tapping into carbon credits as an additional revenue stream and which, between 2001 and 2006, has produced compost in the larger Bangladesh area worth more than USD 1 million in local currency (www.wasteconcern.org).

These success stories on compost do not, however, rely only on urban farming, especially in larger cities, for reasons concerning compost quality and quantity (Danso et al. 2008), such as quality and quantity, as follows:

a) ***Quality:*** Urban farmers with a sufficiently high willingness to pay for compost (allowing compost stations to break even) are those producing for the urban market, not subsistence farmers. Commercial crops are often of short rotation, like exotic vegetables, which need most of all a nitrogen fertilizer, less an organic soil ameliorant. Even on sandy soils where compost can help retain soil water, farmers complained about additional labour as the compost first of all absorbed the water and required more irrigation. In addition, these premium customers often have poor tenure security and seek a more short-term fertilizer supply than a long-term soil ameliorant.

b) ***Quantity:*** Urban waste management is usually only interested in embarking on composting if this can reduce a significant volume of the waste. To start a compost station for saving, for example 3% of its transport volume, is usually not worth the effort. However, most intra- and peri-urban farming systems can hardly absorb any larger amounts of compost. A detailed market assessment by IWMI in Kumasi and Accra (both in Ghana) found that, of the organic waste which is collected and not otherwise used, if composted, less than 1% could be absorbed across all intra- and peri-urban farming systems if the willingness to pay should cover compost operational production costs. It was only in smaller cities with less waste generation, like in Tamale (also Ghana), that up to 5% was possible, and higher percentages can be expected from towns. But also in a city like Accra, the percentage can increase up to 20% if, for example, the non-agricultural demand, like from the housing sector, is considered.

If resource recovery is the target, and not only waste-volume reduction, then it is important to produce a high-quality product which can be attractive and competitive for different market segments. One possibility is to 'boost' the fertilizer value and attractiveness of the MSW compost (Figure 7.5), for example, through (i) co-composting organic MSW with dewatered but nutrient-rich urban faecal sludge or other nutrient-rich waste products; (ii) further enriching the compost with inorganic fertilizer, rock phosphate or urine to create a 'fortified' organo-mineral material tailored to market needs; and (iii) pelletizing the compost to reduce its bulkiness and to create a product similar in its appearance and handling to an inorganic fertilizer (Adamtey et al. 2009; Nikiema et al. 2014; Figure 7.6).

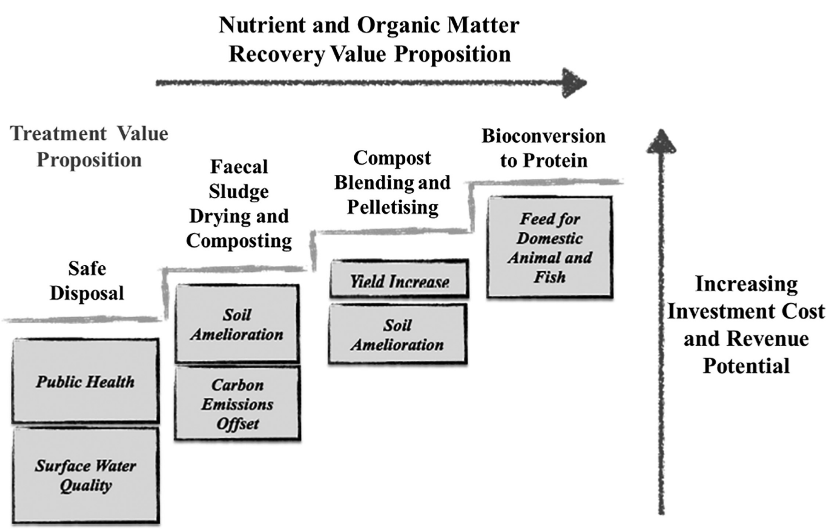

FIGURE 7.5 Value propositions for nutrient and organic matter recovery and reuse from septage from household-based sanitation systems

Source: Otoo et al. 2015.

FIGURE 7.6 Pellets of MSW-faecal sludge co-compost
Source: IWMI.

These options can also be combined with due care that any related increase in production costs is matched by the willingness to pay of the targeted customer segments, and remains competitive to alternative (and sometimes subsidized industrial) fertilizer.

Pelletized and un-pelletized co-compost is being tested for its safety for selected soils and crops, including vegetables and cereals in field and greenhouse trials. In most cases, the product proved to be competitive to inorganic fertilizer as for maize and cabbage[1] (Figure 7.7). While long-term trials are still needed to match more soils and crops with different types of pellets, farmers' interest and willingness to pay (WTP) for the product has been confirmed in very different cultural contexts, like Vietnam, Uganda, India, Bangladesh, Ghana and Sri Lanka (IWMI, unpublished). A market survey conducted, for example, in Kurunegala (Sri Lanka), where a co-composting pilot station started in 2014 its operations, showed a high WTP for nutrient-rich pelletized co-compost with a common WTP of Rs.17–20 per kg, which is 70–100% higher than what is normally paid for MSW compost (Fernando et al. 2014).

However, although the concepts of co-composting and compost pelletizing do not require any technical proof of concept anymore, related advanced compost stations remain few and research continues to be needed to capture customer feedback to adjust the technical process for market satisfaction.

Another option for increasing the value of organic waste as shown in Figure 7.5 is the use of the Black Soldier fly larvae *(Hermetia illucens)*, which feeds on organic matter, such as faecal sludge and organic wastes, and leapfrogs the

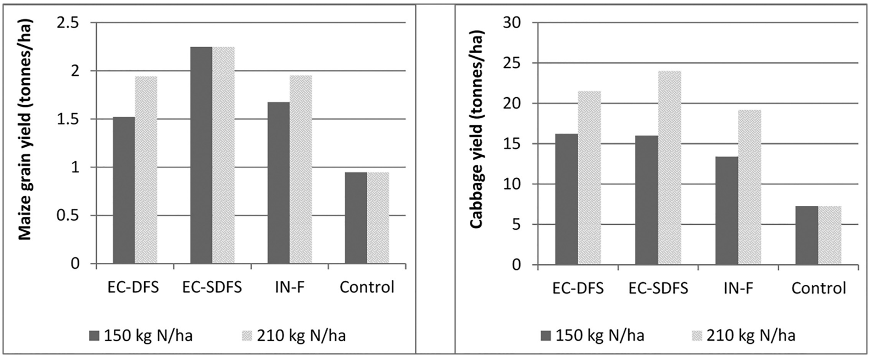

FIGURE 7.7 Maize and cabbage yields with different nitrogen (N) rates
Source: after Impraim et al. 2014.

nutrient extraction via crops by directly generating high-value protein and fat, which can be marketed for poultry, duck, pig and fish feed (Diener et al. 2014).

Increasing the safety of wastewater use

For wastewater irrigation, the focus has always been on reduction of health risk. This applies to the introduction of formal reuse schemes as well as to the challenges of already ongoing informal reuse. For formal schemes the additional challenge is cost recovery.

Due to the common shortfall in wastewater collection and treatment, WHO (2006) recommends a multi-barrier approach which decentralizes the responsibility of safeguarding public health along the food chain from production to consumption (see Figure 7.8). This approach is similar to the Hazard Analysis and Critical Control Points (HACCP) concept for food safety, which has been adopted in many developed countries. The advantage of multiple barriers is the additional security if one barrier fails. A typical example is 'crop restriction', which was successfully introduced, e.g., in Chile, Jordan or Mauritius, while farmers in other countries might ignore them due to market demand and their need to generate profits for sustaining their livelihood.

To determine how much safety is needed, WHO guidelines recommend the so-called health-based targets. These targets need to be realistic, measurable, based on scientific data and feasible within local conditions. Examples of health-based targets can be:

- Health-outcome targets (e.g., tolerable burdens of disease).
- Water-quality targets (e.g., guideline values for chemical hazards).

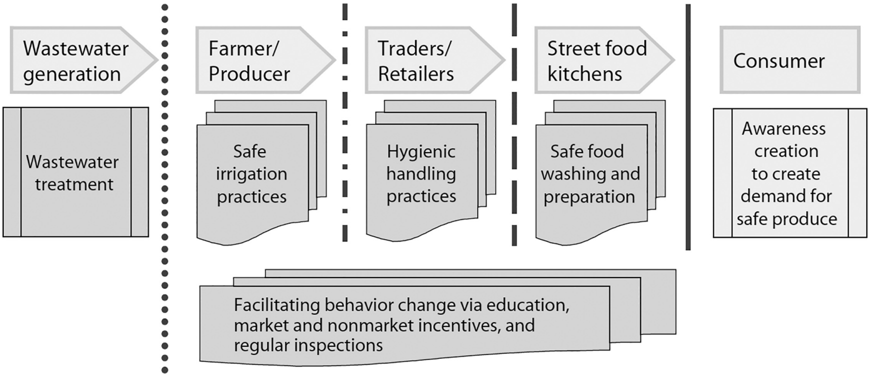

FIGURE 7.8 The multiple-barrier approach for consumption-related risks along the food chain as applied in wastewater irrigation

Source: Amoah et al. 2011.

- Performance targets (e.g., reductions of specific pathogen levels).
- Specified technology targets (e.g., application of defined treatment processes).

Looking at a risk scale from 1 to 7 with 1 being safe and 7 presenting the worst-case scenario, then a common management option is to assume the worst case and aim at maximum risk reduction of 6 units down to 1, which can be cumulative from one barrier to the other.

Table 7.4 shows some examples of the strength of some risk reduction. Some options, like cooking irrigated crops, are very powerful on their own, and can achieve 6 units, but do not fit every crop and diet. It might thus be safer to support several alternative barriers which in combination can achieve the targeted 6 units, like through combining (i) a minimal (farm-based) wastewater treatment (1–2 units pathogen reduction), (ii) drip irrigation (2–4 units pathogen reduction), and (iii) washing vegetables after harvesting, which can reduce in addition 2–3 units (Amoah et al. 2011; Drechsel and Keraita 2014).

Compared with other options for health risk reduction, including the construction of wastewater treatment plants, these on-farm or off-farm-based interventions are highly cost effective (Drechsel and Seidu 2011).

The advantage of the multi-barrier approach became obvious through the disastrous earthquake that afflicted Chile in early 2010. It affected, according to WHO, the only chlorine-producing plant in Chile, and two weeks later 30,000–40,000 cases of diarrhoea were reported from the North where chlorine is used as a single safeguard in agricultural production systems based on wastewater irrigation (R. Bos, pers. communication).

TABLE 7.4 Examples of risk-reduction barriers and effectiveness in pathogen removal

Control measure	*Units* (max = 7)*	*Notes*
A. Wastewater treatment	6–7	Reduction of pathogens depends on type and degree of treatment selected
B. On-farm options		
Crop restriction (i.e. no food crops eaten uncooked)	6–7	Depends on (a) effectiveness of local enforcement of crop restriction, and (b) comparative profit margin of the alternative crop(s)
On-farm treatment:		
(a) Three-tank system	1–2	One pond is being filled by the farmer, one is settling and the settled water from the third is being used
(b) Simple sedimentation	0.5–1	Sedimentation for ~18 hours.
(c) Simple filtration	1–3	Value depends on filtration system used
Method of wastewater application:		
(a) Furrow irrigation	1–2	Crop density and yield may be reduced
(b) Low-cost drip irrigation	2–4	Lower value for low-growing crops, higher value for high-growing crops
(c) Reduction of splashing	1–2	Splashing adds contaminated soil particles on to crop surfaces, which can be minimized
Pathogen die-off per day	0.5–2	Die-off between last irrigation and harvest (value depends on climate, crop type, etc.)
C. Post-harvest options at local markets		
Overnight storage in baskets	0.5–1	Selling produce after overnight storage in baskets (rather than overnight storage in sacks or selling fresh produce without overnight storage)
Produce preparation prior to sale	1–2	(a) Washing salad crops, vegetables and fruits with clean water.
	2–3	(b) Washing salad crops, vegetables and fruits with running tap water
	1–3	(c) Removing the outer leaves on cabbages, lettuce, etc.
D. In-kitchen produce-preparation options		
Produce disinfection	2–3	Washing salad crops, vegetables and fruits with an appropriate disinfectant and rinsing with clean water
Produce peeling	2	Fruits, root crops
Produce cooking	5–6	Option depends on local diet and preference for cooked food

Note: * log units of pathogen reduction

Sources: EPHC-NRMMC-AHMC 2006; WHO 2006; Amoah et al. 2011.

Influencing perceptions and behaviour on the use of urban waste

With respect to the promotion of waste reuse, two common situations prevail: (i) the introduction of reuse as a coping strategy to water shortage and (ii) the trajectory of already ongoing informal reuse to formal reuse to facilitate the adoption of safety measures. Both situations require social acceptance and behaviour change. While the informal use of waste products is a common practice in low-income countries, the largest challenge is the transformation of the practice into one that does not put public health in jeopardy. This concerns especially the production for urban markets, where along the food chain the number of people at risk is continuously increasing. For urban Ghana, for example, it was estimated that up to 2,000 urban vegetable farmers produce salad greens consumed eventually by up to 800,000 urban dwellers every day (Table 7.5).

TABLE 7.5 Estimated number of urban farmers, street food kitchens, and urban consumers along the lettuce and cabbage value chain in Ghana based on survey and sector data

Urban farmers producing lettuce and cabbage	*Street restaurants offering salad side dishes*	*Daily consumers of salad side dishes in Ghana cities*
Ca. 1,700–2,000	Ca. 3,600–5,300	Ca. 500,000–800,000

Source: Drechsel et al. 2014.

The situation where *treated wastewater* is being introduced as an alternative water source is more common in countries with established treatment capacity and freshwater shortage, like in the MENA region, Australia or USA. In these cases, negative perceptions can be a key constraint, while cost recovery is a key challenge. Where public perception is positive, the right business plan can, however, combine several revenue streams for a high cost-recovery rate as the example of the Drarga plant near Agadir in Morocco shows. The municipality collects sewage fees to recover its O&M costs and designed the plant to generate additional revenue from the sale of (i) treated wastewater to crop farmers, (ii) reed grass from the constructed wetlands, (iii) sludge compost, and (iv) methane gas from energy recovery (Rao et al. 2015). Although not all of these components have been implemented so far, a noteworthy innovation in this case is that all sales revenues and revenues from the water and sewage tariff and connection fee are deposited into a special account, independent of the main community account to serve solely the wastewater treatment plant. This special arrangement is a response to common bottlenecks in public financing of O&M costs like spare parts which contributed to the breakdown of about 70% of the wastewater treatment plants in the country (Choukr-Allah et al. 2005).

The compliance with food safety measures is a common reality in more developed countries where the HACCP approach has been adopted. In low-income countries where *untreated wastewater* use dominates, the adoption of farm or off-farm based safety measures still requires its proof of concept as so far the WHO

2006 Guidelines have not been implemented in any low-income country. Feasibility studies for such an implementation showed that the likely success will depend on a number of internal and external factors such as risk awareness and risk perceptions (not only of producers but also of the market), peer pressure, incentives, or the possible need for investments in terms of additional space, labour or capital which could affect, e.g., time allocation or the profit margin (Drechsel, Mahjoub and Keraita 2015). As behavioural change is a complex subject and often underestimated as an 'educational' challenge, it can be slow or of short duration (Karg and Drechsel 2011).

Another potential shortcoming in addressing behavioural change is an underestimation of the wider system within which key actors operate, like institutions, regulatory bodies, media and in- and output-market agents, which can have a significant influence on key actors' decision making (Figure 7.9):

FIGURE 7.9 Behaviour change support factors
Source: authors.

- ***Awareness creation:*** It is important to understand that behavioural change can hardly be achieved through educational means and awareness creation alone, while both have, however, an important supporting role. A pilot social marketing study in Kumasi showed that it is more likely that safe practices spread from farmer to farmer through social networks than through external facilitation, although the reason was not the absence of contact with extension officers. Farmers preferred, however, field demonstrations and/or learning by doing.

A particular communication challenge in countries with limited public-risk awareness is the invisible nature of most risk carriers, like pathogens (Amoah et al. 2009; Keraita et al. 2007, 2010).

- ***Incentives:*** Studies show that people are most likely to adopt innovations for direct economic returns on investments (Frewer et al. 1998). However, this will only happen if consumers are willing to pay more for safer products. But, in low-income countries, where risk awareness might be low and no dedicated marketing channels for safe produce exists, economic incentives from the public sector (subsidies, credit access, tax reductions, etc.) based on likely savings in the health sector, or indirect economic incentives like tenure security, could be considered. For public support, a quantification of costs and benefits would help justify the intervention (FAO 2010). A particular incentive for compliance is fear of going out of business. In Ghana, for example, farmers experienced significant pressure from media when using wastewater (Drechsel and Keraita 2014).
- ***Social responsibility:*** Private-sector involvement can facilitate a shift towards safety. Out-grower schemes supplying wholesale or supermarkets might be urged to comply with, e.g., a 'responsible sourcing policy' or any other type of 'sustainable agricultural code of conduct' which the private-sector demands from its own policy perspective and/or reasons of international competiveness and branding.
- ***Social marketing:*** Where economic incentives might not work due to low risk awareness, social marketing strategies could help identify valuable benefits in support of behaviour change, similar to hand-wash campaigns. Studies must identify positive core values that can trigger the target audience to voluntarily accept, modify or abandon behaviour for the benefit of personal and or public health (Drechsel and Karg 2013).
- ***Laws and regulations:*** Regulations are an important external factor to institutionalize safe and productive reuse practices for compliance monitoring, and to provide the legal framework for both incentives (for example, certificates, tenure arrangements) and disincentives (such as fees). However, regulations should not be based on imported standards, but rather on locally feasible standards that are viewed as practical and are not prone to corruption. In this way, regulation and institutionalization may contribute to ensuring the long-term sustainability of behaviour change, whereas promotional and educational activities are usually limited to a specific time frame.

Conclusion

There are many good reasons, including financial and economic gains, for the recovery of resources from liquid and solid waste. In this regard, it is no surprise that the productive use, especially of wastewater in urban agricultural systems, is already a common reality. However, the reason is not only water scarcity but also, especially in low-income countries, water pollution, making it difficult for farmers to find clean water sources. The resulting use of polluted water is mostly charged in the informal sector, resulting potentially in significant health risks for farmers and consumers.

Wastewater treatment to reduce the volume of polluted water discharged into water bodies will remain the most powerful means to address this concern. However, the costs of comprehensive wastewater collection and treatment are often prohibitive in developing countries where, so far, most investments are more 'upstream', targeting water supply. As a result, the generation of untreated wastewater will continue to increase and it is essential that authorities give attention to the food safety along those food chains, depending on irrigated urban and peri-urban agriculture.

The multi-barrier approach recommended by WHO (2006) is addressing this situation in low-income countries. However, the approach is relying on behaviour change, which is not without challenges, and the implementation of related concepts, like HACCP, is so far limited to more-developed countries with treatment capacity, risk awareness and regulations which allow compliance monitoring. Moreover, in such countries, public health relies significantly on wastewater treatment and the institutional capacities and incentives to maintain its technical functionality. In low-income countries with limited treatment capacity, public health will have to rely solely on the adoption of safety practices by farmers and food traders, which requires significant efforts to increase public risk awareness to eventually create market incentives for safer food production. Till this is achieved, officials must determine the best ways to motivate and/or regulate farmers, food vendors and consumers to buy into the multi-barrier approach. Successful strategies will probably include combinations of financial and non-financial incentives, as well as regulations and awareness campaigns that enhance understanding of the potential harm involved when safe practices are not adopted. Supporting policies and related education will be milestones in this process, but might not be sufficient on their own to trigger behaviour change (Drechsel and Karg 2013).

Where treatment plants are in place and reuse is formally organized, the ideal situation is that farmers pay for the water to contribute to the recovery of the operational costs of the treatment facility. In most situations, the direct revenues from selling treated wastewater are, however, very small, given that freshwater prices are usually subsidized and the wastewater has to be sold even cheaper. However, there are options to increase the value of the wastewater and also business models to maximize cost recovery, or to reverse the cash flow and pay farmers for accepting treated urban wastewater while renouncing their freshwater rights for urban development (Otoo and Drechsel 2015).

In view of organic waste and faecal sludge, especially from on-site sanitation facilities, composting and co-composting offer low-cost means for pathogen destruction and risk minimization. The resulting organic product is a well-accepted soil input with a long tradition of use. An important benefit is reduced transport costs through the reduction of the waste volume. If in addition, revenues from compost reuse are targeted, then a professional business approach will be needed to move with customer-specific value propositions' organic waste recycling from the traditional appearance of a household- or community-based initiative to scale. The customers will certainly include urban and peri-urban farmers but, even more so, other sectors interested in organic matter, if the target is to effectively reduce the urban waste volume.

Note

1 EC-DFS: Enriched compost of dewatered faecal sludge; EC-SDFS: Enriched co-compost with sawdust faecal sludge; IN-F: inorganic fertilizer (i.e., ammonium nitrate, supplemented with muriate of potash and triple super phosphate); Control: soil only. Application rates: 150 and 210 kg of nitrogen per hectare.

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8

URBAN AGRICULTURE AND CLIMATE CHANGE

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Introduction

Communities in many cities around the world have practised (intra- and peri-) urban agriculture for various reasons (Dubbeling et al. 2010; FAO 2012 and 2014). Urban agriculture is considered as a holistic set of activities that involve production systems such as horticulture, livestock, forestry and agroforestry and aquaculture, as well as related input supply, processing and marketing activities contributing to regional food systems (Mougeot 2001).

For several years urban agriculture has been analyzed for its potential to contribute to poverty alleviation and social inclusion, enhanced food security and nutrient recycling, income and employment generation, and productive reuse of organic wastes and wastewater (de Zeeuw et al. 2011). More recently urban agriculture has also been identified as a strategy for mitigating the impacts of climate change and reduction of climate related risks (Dubbeling 2013a; Lwasa et al. 2013; Lwasa 2014). Urban agriculture has a potential for the provision of micro-level ecosystem services, with a cumulative impact at the macro-scale, next to delivering a number of developmental benefits such as poverty reduction and social inclusion (Grimm et al. 2008; Padoch et al. 2008; Swalheim and Dodman 2008; Lwasa et al. 2009).

At the same time, urban agriculture is affected by climate variability and change, posing risks to the sustenance of city regional food systems (Dubbeling 2013a; Lwasa et al. 2013). Urban agriculture systems and practices have to be adapted to the changing climatological conditions in order to continue fulfilling the role in sustainable and smart urban development.

This chapter analyzes the opportunities and limitations for urban agriculture in the context of climate change mitigation and adaptation, and provides information on some first-city projects, monitoring data and policies in this field, and using examples from different cities and climatic conditions. It also outlines innovations needed to make urban agriculture more resilient to climate change. The chapter concludes with the identification of challenges for research and policy development regarding the potential for urban agriculture as a city climate change and disaster risk-reduction strategy.

The chapter is based on a recent global literature review on urban agriculture and climate change. It also draws on studies regarding the potential of (intra- and peri-) urban agriculture and forestry for city climate change mitigation and adaptation undertaken by RUAF Foundation with Climate Change and Development Knowledge Network (CDKN) (Dubbeling 2014a) and UN Habitat (Dubbeling 2014b), respectively,[1] and on synthesis studies conducted in various cities across Africa that analyzed grey and peer-reviewed literature for urban resilience building (Lwasa et al. 2013).

Cities and climate change

Climate change and climate-related disasters are recognized as key challenges facing cities today. Impacts of variable and extreme climate events are reported in many cities (Lwasa et al. 2013). The *Fifth Assessment Report* (AR5) of the Intergovernmental Panel on Climate Change (IPCC) (University of Cambridge and ICLEI 2014) reports that many emerging climate change risks are concentrated in urban areas and these impacts are increasing. The climate risks faced by cities include storm surges, sea level rise, droughts and water scarcity, excessive rainfall, floods and landslides, heat waves and cold waves leading to infrastructure damage, disrupted food systems, pollution of water, and ultimately negative health impacts with associated economic losses (UN-Habitat 2011). Moreover, urban poor are particularly vulnerable to variations in food prices and income since food makes up a large part of the household expenses. Variations in income or food prices have a significant and direct impact on their diets (lower food intake, turning to cheaper/less-nutritious food), leading to a further reduction of health care and schooling expenditures or to the sale of productive assets (FAO 2008; Prain 2010). The World Bank estimated that the rise in food prices between 2007 and 2008 increased the number of people living in extreme poverty in urban areas in East and South Asia, the Middle East and sub-Saharan Africa by at least 1.5% (Baker 2008). Reduced food supply to the cities due to climate change distortions will result in further increases in food prices affecting the urban poor.

Climate change may also be aggravating the urban heat island effect (characterized by higher mean temperatures and less variation in night-time and day-time temperatures in built-up areas). This relates to human and industrial activities that absorb heat, which leads to an increase in the amount of energy used for cooling and refrigeration purposes (Grimm et al. 2008; Rosenzweig et al. 2011; University of Cambridge and ICLEI 2014). The levels of exposure and vulnerability to the impacts of climate change vary from city to city. Within cities, there is even more marked differentiated vulnerability associated with socio-economic and spatial structures of the cities (Action Aid 2006; Douglas et al. 2008; Frayne et al. 2012). As noted by Adelekan (2010), the urban poor may be disproportionally affected by the impacts of climate change. This is because the urban poor largely live in informal settlements often located on marginal land such as low-lying and flood-prone areas or steep slopes. In addition, the limited resources of the urban poor hamper their ability to respond to the changing climatic conditions (Satterthwaite 2008).

BOX 8.1 FLOODING DUE TO CONVERSION OF FLOOD PLAINS TO RESIDENTIAL AREAS AND INCREASING RAINFALL AND EXTREMES

A vulnerability assessment implemented in the city of Kesbewa (Sri Lanka) indicated highest risks on former rice or paddy fields converted into other uses and their surrounding areas. In the ancient land use system in Sri Lanka, low-lying lands were kept free from construction for drainage of rainwater and paddy cultivation. However, the rapid filling and conversion of these lands to residential and commercial lands has significantly altered the natural water flow and drainage in the area. This, coupled with increases in rainfall, has made recurrent flooding a common sight in these and surrounding areas, leading to damages to infrastructure and lower agricultural production.

Source: Mohamed and Gunasekera 2014.

Cities are increasingly called upon to address the vulnerability of people, places and sectors that may be affected by a changing climate, but they also have a responsibility to mitigate their greenhouse gas emissions to avoid unmanageable climate change. At the same time, cities have the responsibility to ensure access to food, water and energy for their growing population (Tuts 2014). Cities are therefore at the centre not only of climate change mitigation but also of adaptation.

According to the World Bank (IBRD 2010), building resilience in a city requires an integrated approach "that considers mitigation, adaptation and development." Such an integrated approach brings together strategies that reduce greenhouse gas emissions and also reduce the vulnerability of settlements to climate change while addressing developmental needs. The latter involves reducing urban poverty, promoting social inclusion, and the provision of health, water and sanitation services. In that perspective, the World Bank recommends orienting urban climate change programmes towards realization of the Millennium Development Goals (or the new Sustainable Development Goals (SDGs)), and asks for priority attention to the inclusion of measures that reduce the vulnerability of the urban poor, enhance the resilience of community organizations, improve settlements to reduce slums, improve building quality and ensure local food security by encouraging local food production as important key components of climate change strategies (see: http://sustainabledevelopment.un.org/?menu=1300). The Communitas Coalition specifically calls for more attention for urban climate change, sustainable urbanization in the SDGs, as well as linkages with rural development, food security and ecosystems resources (Forster 2014).

In 2010, the World Bank (IBRD 2010) has also already made a plea for "innovative solutions" to climate change adaptation. It points out that environmentally sustainable solutions for food, water, energy and transport should be integrated components of a city climate change adaptation and disaster risk-management plan. The recent IPCC AR5 report indeed indicates that adaptation options exist in the areas such as water, food, energy and transport in urban areas (University of Cambridge and ICLEI 2014).

The effects of climate variability and change on urban agriculture; required innovation

Climate variability and change are affecting urban agricultural systems, with varying effects to the urban agriculture systems across spatial and temporal scales. Depending on the specific local context, climate change, as an intervening factor influencing production, may present risks such as droughts, flooding or increased temperatures that would affect the production systems negatively as well as opportunities mainly in terms of water resource availability or prolonged growing seasons (Atkinson 2000; Abdulsalam-Saghir and Oshijo 2009; Mkwambisi et al. 2011; Brownlee et al. 2013). The latter has so far not received much attention in the climate change discourse, although the uncertainty about variability of climate may offset potential opportunities.

Enhancing the resilience of the urban agricultural production systems to a variable climate, to mitigate the negative effects of climate change on urban agriculture and to facilitate the optimal use of the new opportunities require (preferably participatory) technology development and innovation of urban agricultural systems and practices. Response strategies could include adjustment of production systems, cropping patterns, selection of adapted crop varieties, diversification of farming systems, improved water management and rezoning of urban agriculture. For example, in cities where fresh water is relatively scarce, such as Dakar (Senegal) and Addis Ababa (Ethiopia), technologies using trapezoidal water collection ponds at the household level have been used in mountainous regions to provide water during the drier part of the year (Van Rooijen et al. 2010). This kind of technology is appropriate with high-value and low-water-consuming enterprises, some of which include leafy vegetables, poultry and medicinal plants.

Rainfall harvesting from roof and road runoff has been promoted in Beijing (China) since 2000, as climate change trends also project increasing water scarcity in that region. Harvested water is collected in water ponds for primary treatment (sedimentation) and later used for irrigation of parks and gardens, aquifer recharge and maintaining water levels in small ponds and lakes in the city. Capacity for collecting rainwater can reach up to 40 million cubic meters (m^3). Capturing rainwater from greenhouses has been propagated since 2005. On average, 200–300 m^3 of rainwater can be annually collected from greenhouses with roofs covering

667 m^2, allowing to irrigate 2–3 times this area of crops if efficient irrigation methods (drip irrigation) are used (personal communication, Yang 26–04–2012).

Also reuse of organic wastes and wastewater is a key element for enhanced resource efficiency in urban agricultural production systems where producers adapt to more irregular rainfall or periods of drought (see also Chapter 7 of this volume). Because of (perceived) health risks, there is generally a hesitation to take advantage of the great potential of wastewater reuse in urban agriculture. Low-cost technologies for decentralized wastewater treatment and reuse in urban and peri-urban agriculture are available (including, amongst others, natural infiltration and oxidation ponds or reed bed systems), but their further development and larger-scale implementation are needed (RUAF Foundation 2013).

In the context of climate change, there is also a need to further investigate production systems and technologies that are resource efficient and use more renewable energy in areas of irrigation and pumping of water, soil preparation and plant management, drying, processing, storing and transport of food.

Pest and (zoonotic) disease management (including potential livestock mortality due to heat waves) may become even more crucial as a result of changing climate (Magnusson and Follis Bergman 2014), and further farmer training on the subject is required. Local innovation funds are interesting mechanisms by which farmers can not only fund testing of new technical innovations, but also social and organizational innovations (Dubbeling 2013b). Also, more research is needed to improve the understanding of the interactions between climate stressors and non-climate stressors and their impacts on urban agriculture.

BOX 8.2 INNOVATING FOOD PRODUCTION IN VIEW OF CLIMATE CHANGE IN DUMANGAS (THE PHILIPPINES)

Being a flood and drought-prone area, Dumangas organizes Climate Field Schools that seek to combine indigenous knowledge with scientific methods. It helps local communities to strengthen their food security and livelihoods by teaching farmers to read weather forecasts, interpret satellite photos, set up their own weather stations, and to decide what and when to plant based on this timely information. Its overall goal is to reduce disaster risks and enhance the capacities of local institutions and communities. Dumangas recognizes the role of peri-urban and rural farmers in the long-term resilience of the city-region food system, and the need to enhance their capacity and production systems. This results in reduced damages to infrastructure, which lessens reconstruction and rehabilitation expenses for the government. In addition, the livelihoods of both producers and inhabitants are protected and local production is preserved and increased, contributing to a more resilient urban food supply system.

Source: ICLEI and RUAF Foundation 2013.

Potential of urban agriculture for city adaptation to climate change

The climate projections in the IPCC AR5 indicate that there is likely to be a loss of food production and productive arable lands due to storms, floods, shifting seasonal patterns, droughts or water scarcity (University of Cambridge and ICLEI 2014). For example, changing rainfall patterns are expected to affect rural agricultural productivity and threaten yields in many developing countries (Lotsch 2007; Nellemann et al. 2009). Cities with a heavy reliance on food imports would be more significantly affected (University of Cambridge and ICLEI 2014). Related adaptation options for, and local responses to, climate change include, next to other strategies in the field of water, transport and energy, support for intra- and peri-urban agriculture, green roofs, local markets and enhanced social safety nets and development of alternative food sources, including inland aquaculture (University of Cambridge and ICLEI 2014). Intra-urban and peri-urban agriculture also involves the growing of trees and the raising of livestock (including fisheries) within the built-up area or on the fringe of cities.

Diversifying food and income sources

Urban agriculture can help cities to become more resilient through enhancing access to nutritious food, diversifying food sources, reducing the impacts of disturbances in food supply from rural areas or imports and reducing shocks of food prices. Urban agriculture can support the urban poor to enhance adaptation through diversifying income opportunities, creating "green jobs" and functioning as a safety net in times of economic crises (Dubbeling 2013b).

Reducing the urban heat island effect

Urban areas are also associated with local climate effects of high temperature due to impervious surfaces and reduced vegetation. The urban heat island (UHI) effect is moderated by urban agriculture when land cover by crops and trees offsets UHI effects by increasing the amount of green space in urban areas and peri-urban zones (Tidball and Krasny 2007). The urban gardens, agricultural lands, street and fruit trees, parks and forests decrease solar radiation, increase evapotranspiration and lower temperatures through evaporative cooling and by providing shade and facilitating faster cooling at night-time (Simon 2012).

Reduced UHI is assessed highest for specific types of urban agriculture, such as intra- and peri-urban forestry and green productive rooftops, that help regulate temperatures of buildings. For this reason, cities such as Kathmandu Metropolitan City (Nepal) promote rooftop gardening as part of its environmental policy (Dubbeling 2013a). The city of Bobo-Dioulasso (Burkina Faso) promotes intra-urban green way (by promoting agroforestry types of activities in open urban lots) and peri-urban forestry management to reduce increasing urban temperatures. Satellite images and remote sensing data were used to quantify the effect of land uses on land surface temperatures (LST) in Bobo-Dioulasso. A comparison of 1991–2013 data showed that LST differences between urban and peri-urban areas increased approximately 6% a year. The study also showed that mean LST over a ten-year period were consistently cooler (0.3 °C) in the three specific green infrastructural areas analyzed than in adjacent urbanized areas (Di Leo et al. forthcoming 2015). Where tree density is higher, the UHI reduction capacity will be higher.

Windstorm control benefits

Along with changes in local temperatures, urban environments are subject to increasing wind intensities, partially due to loss of vegetation. Areas of vegetation can provide windbreaks that absorb the energy of strong gusts, and provide buffers between large structures. Nonetheless, urbanization often simplifies landscapes and removes such features along with their storm-mitigating benefits. Cities such as Ibadan (Nigeria) and Makati (the Philippines) have started using urban forestry to reduce effects of windstorm events and also for city beautification and prevention of landslides (Adelekan 2012; Dubbeling 2013a). Increasing tree cover through urban (agro-) forestry provides breaks between built-up areas. Storm mitigation is an adaptation measure that cities can integrate into the climate change plans.

Runoff and flood-risk reduction

Increases in impervious surfaces associated with urbanization reduce soil infiltration and increase surface runoff during rainstorms. As a result, flooding is common in dense urban developments that lack adequate drainage systems. In cities including Kampala (Uganda), Ibadan (Nigeria), Addis Ababa (Ethiopia) and Dar es Salaam (Tanzania), increased runoff has caused greater frequency of flooding associated with building in retention swamps and hill slopes and the increase of impervious surfaces (Matagi 2002). Shifting rainfall patterns, coupled with expanding urban settlements have similarly increased flooding hazards (Mbow et al. 2008).

Urban agriculture may provide one economical approach to address this climate impact by reducing flood hazards through the control and reduction of surface runoff. Urban agriculture can reduce the impacts of higher rainfall (average/extremes) by keeping low-lying zones free from construction so that floods have less impact, storm water runoff is reduced, and excess water is stored and infiltrated in the green open spaces. A range of sustainable urban drainage designs solutions are under validation in some cities to assess the cumulative reduction of floods through proper drainage design, grassing, infiltration ponds and urban agriculture (Ellis et al. 2011). Several cities that are increasingly confronted with floods are considering the role of urban agriculture as alternative options for flood-risk management. In Sri Lanka, rehabilitation of former paddy fields and drainage channels has proven to be an effective strategy for the reduction of flood risks (Dubbeling 2014a).

The city of Freetown (Sierra Leone) has zoned all wetlands and low-lying valleys for urban agriculture. Next to promoting local food production, this measure is expected to help keep flood-zones free from construction and improve water infiltration, resulting in reduced flooding incidences and related damage. Other positive effects may be reduction of costs associated with maintenance of such areas (Dubbeling 2013a). The city of Rosario (Argentina) promotes the preservation and protection of green and productive areas on stream banks to reduce flood risks (Hardoy and Ruete 2013). Agricultural use of lowlands in Antananarivo (Madagascar) is reported to prevent flooding as the lowland rice and watercress systems can store large amounts of water. It has been calculated that one of the city's low-lying valleys with a total area of 287 ha can store up to 850,000 m^3 of water, corresponding to three successive days of heavy rains (Aubry et al. 2012).

Under the Sustainable Urban Drainage Systems framework (Ellis et al. 2011), a combination of upstream and downstream measures aimed at increasing infiltration and retention of water in urban systems is now a new principle for design of such drainage systems. Permaculture and agroforestry are particularly well-suited to reduce flooding and landslides by creating extensive root structures that stabilize soils and enhance infiltration, and by providing permanent soil cover.

Coastal flooding hazards result from different conditions, but may benefit from some similar solutions. For example, Mangrove forests play a particularly important role for suppressing coastal inundation during extreme events (Badola et al. 2005). In cities, including Douala (Cameroon), Dakar (Senegal) and Dar es Salaam

FIGURE 8.1 Productive use of flood zones in Rosario, Argentina
Source: Dubbeling.

(Tanzania), where coastal flooding is projected to constitute an increasing climate hazard, mangrove restoration is now a key component of the climate change adaptation strategies (Din et al. 2008). Efforts to improve coastal flood control have taken into account the economic incentives and provisioning services provided by coastal ecosystems.

While reducing runoff, more porous land surfaces also support recharge of groundwater flows. The steady recharge of water tables and surface water supplies through infiltration plays a critical role in supporting urban water supplies. Natural movement through the water cycle helps to purify water supplies and reduces contamination from surface runoff in urban areas.

The value of ecosystems, particularly urban wetlands, for purifying water supplies has become increasingly recognized, and the restoration of wetlands is now considered as an economical alternative to traditional industrial water-treatment solutions (Chichilnisky and Heal 1998). Several studies have demonstrated the effectiveness of wastewater treatment using wetland systems and, if coupled with aquaculture, the effect would be a double win. Ecological management of water purification may provide a useful strategy to address the challenges of water purification in many cities.

In some cities, runoff capture in ponds for use as irrigation water has utilized relatively simple techniques of water plants to fight breeding of vectors responsible for certain diseases. When designed to enhance flood regulation, agriculture may actually provide a second-order service of disease regulation by reducing the extent of breeding grounds of flood waters for disease vectors.

BOX 8.3 URBAN AGRICULTURE AS A STORM WATER MANAGEMENT STRATEGY IN NEW YORK CITY (USA)

In the past years, many cities have suffered from extreme weather events – which may occur more frequently due to climate change – with heavy rains that cannot be absorbed by the storm water drainage system and flooding roads and properties. A conventional strategy to address this is to invest in "grey infrastructure": such as increased-diameter sewage pipes that hold larger volumes of storm water. This is, however, quite costly and politically unpopular in communities faced with the prospect of road break up and disturbances. A potentially more cost-effective option is to increase the permeability of the cityscape through diverse forms of "green infrastructure": parks, green corridors, agricultural sites, permeable pavement, and green multifunctional spaces.

Since 2011, New York City has provided funding to various urban agriculture projects through its Green Infrastructure Grant Program. New York's experience suggests that if productive landscapes are integrated into storm water management planning, cities may be able to reduce storm water flow and at the same time support the creation of farms and edible gardens, with their respective social and other benefits, at a lower cost than traditional storm water adaptation measures would require.

In developing its strategy, the city evaluated the costs and benefits of grey and green infrastructure and found that investing in a green scenario that includes some grey infrastructure was significantly more cost-effective than a conventional approach. New York City's Department of Environmental Protection (DEP) is committed to investing USD 192 million in green infrastructure by 2015, including "blue roofs" that hold rainwater and release it to the sewage system slowly, extra-large street tree planters, landscaped storm water "green streets", parking lots paved with porous concrete, and vacant paved lots and asphalt rooftops turned into gardens. Over 20 years, the green scenario would cost USD 5.3 billion, including the USD 2.4 billion for this green infrastructure. In contrast, an estimated USD 6.8 billion would be required for a scenario based solely on grey infrastructure. The green infrastructure scenario thus saves the city and the property owners who pay water and sewer fees USD 1.5 billion in costs over a 20-year period. Beyond initial saving, there are also the lower maintenance fees, which would be considerably higher for grey infrastructure over the years.

Nevertheless, there are obstacles to expanding urban agriculture's role as green infrastructure. Administrative agencies in charge of water pollution control, like New York City's DEP, focus primarily on the absorptive capacity of green infrastructure. This is also because the agency mandates do not include supporting urban agriculture. Nutritional, education and other benefits are valued, but are subsidiary to water retention capacity. A second challenge is that farms require active management to produce storm water retention benefits year-round, including a cover crop outside of the growing season, as bare soil retains less storm water than plant-covered soil and is also subject to erosion. Though this management is often provided by for-profit farming businesses like Brooklyn Grange or non-profit community organizations, thus lowering public management costs, public agencies need assurances that these entities are financially viable or, in the case of a non-profit, well-established within the community, and therefore likely to maintain site management over the long run.

Source: Cohen and Wijsman 2014.

Enhancing resource efficiency

Urban agriculture has potential to close nutrient cycle and resource flows. Nutrient cycles are more open in urban systems with nutrients imported (as food and other commercial products) and then often exported as wastes (disposed of in rivers, streams and in disposal sites resulting in river pollution and methane emissions). Urban agriculture and (agro-) forestry have demonstrated capability for nutrient uptake by recycling urban organic waste and wastewater (Smit et al. 1996; Drechsel and Kunze 2001; Troschinetz and Mihelcic 2009). Agricultural lands can benefit from the nutrients contained in (preferably composted) organic wastes, while providing an important service to the city (Asomani-Boateng 2007). Organic waste use in agriculture additionally improves water-holding capacity. It reduces the need for chemical fertilizers and related greenhouse gas emissions (NO_2 and CO_2) during their production and reduces nitrate leaching and sequesters carbon in the soil (Jansma et al. 2012).

Biodiversity conservation

Urban biodiversity is now recognized as important in maintaining ecosystem services. Studies have shown and highly agree that different urban surfaces are rich in agro-biodiversity, including genetic, functional and species diversity, that can serve to diversify household nutritional and livelihoods portfolios under changing conditions. Such diversity may be particularly important for adaptation of agricultural practices under climate change. Urban agriculture can support in situ conservation of plant genetic diversity, particularly of indigenous varieties (Trinh et al. 2003; Eyzaguirre and Linares 2004).

Potential of urban agriculture for climate change mitigation

Carbon storage and sequestration

In respect to mitigation of climate change, urban agriculture (Stoffberg et al. 2010) can contribute to reducing emissions, particularly if permanent soil cover and no-till production systems are applied. Permanent soil cover has low carbon emissions because the soil is left intact, and also stores carbon in the structure of the trees. Properly managed trees have carbon sequestration benefits (Havstad et al. 2007), though the scale of production may not be feasible for many urban settings due to high density of buildings and limited land area, although even trees planted along roads have a potential to increase carbon storage. Studies illustrate that CO_2 stocking by street trees and the urban green surfaces covered with multiple functional plants and trees is potentially high in cities. The structure of the landscape mosaic is thus important; canopy cover in agroforestry plots and the relatively less-intensive uses of field crops can shape climate resilient urban landscapes (Perfecto and Vandermeer 2010).

Carbon storage (the total current carbon stocks as a function of plant biomass) can be around 30 and 80 metric tons of carbon per hectare of forest, depending on the tree species, size, climate and planting area. Existing trees in Toronto are estimated to store about 61.1 metric tons of carbon per hectare, equalling 1.1 million metric tons of carbon given total tree cover area. If these trees were to be removed, the loss or emission of carbon that was stored by these trees would be equivalent to the annual carbon emissions from 733,000 automobiles or 367,900 single-family houses (Nowak et al. 2010).

Carbon sequestration by urban forests in Hangzhou (China) is calculated to add up 1.66 metric tons of carbon per hectare per year. This offsets 18.57% of the amount of carbon emitted by industrial enterprises in the city region (Zhao et al. 2010). Although urban and peri-urban forestry does not represent a major sink for global greenhouse gases, it can help offset a city's greenhouse gas (GHG) emissions to a certain extent (IBRD 2010).

Reducing energy use and emissions

Urban agriculture may furthermore contributes to the reduction of urban energy use and GHG emissions as it produces fresh food close to the city. This can reduce energy use for transport, cooling, storage, and less packaging. Reuse of composted organic wastes that otherwise would be disposed of in landfills and reduces the emission of methane and other GHGs at the landfill (Jansma et al. 2012). Furthermore, reuse of organic wastes in urban agriculture can be combined with controlled fermentation and production of bio-gas as a renewable energy source. Resource efficient technologies of urban agriculture have both adaptation benefits and climate mitigation potential. Reuse of urban wastewater in urban agriculture has a potential to free fresh water for higher value uses and reduce emissions from wastewater treatment.

Seattle's (USA) goal of reducing fossil fuel emissions is one of the reasons behind their Local Food Action Initiative that promotes community gardening, local food sourcing and increased food waste recycling (Dubbeling 2013a).

BOX 8.4 PRESERVATION OF AGRICULTURE IN FLOOD PLAINS AND PERI-URBAN AREAS IN ROSARIO (ARGENTINA)

Rosario (Argentina) is currently monitoring impacts of different (productive) green areas on runoff and flooding, and calculating energy and GHG reductions in different scenarios of local urban food production. Different land-use scenarios were developed with varying models of urbanization with different degrees/ways of protection/promotion of productive green areas.

Based on expert consultations on the role that urban agriculture can play in reducing runoff and flood risks, the first results of measurements in test sites and scenario development (indicating that substantial increase in built-up area would lead to tripled flood risks), a policy proposal on inclusion of intra- and peri-urban agriculture and forestry in watershed management was developed by a group of local researchers and presented to the Urban Agriculture Programme of the Municipality of Rosario for their review.

The proposal advises that public policy for highly urbanized watersheds and sub-watersheds should aim (1) to reduce the risk of flooding and waterlogging by optimizing urban vegetation; (2) to increase the area of green roofs on new and existing buildings through ordinances that define where they should be built, and specifying technical characteristics; (3) to integrate urban agriculture in public parks, squares, walkways, side of motorways, railways, institutional green spaces, and public woodland; and (4) to increase urban agriculture surface in flood areas by means of land use ordinances and intersectoral strategies and preserve existing urban agriculture production zones in peri-urban areas.

Similarly, different scenarios for local food production were developed in order to understand their impacts on local food production, energy use and GHG emissions. The traditional horticulture zone in Rosario's peri-urban area is under threat by urbanization and conversion of agricultural land to soybean production. Horticulture production from the greenbelt used to supply most of the fruits and vegetables to the city. The number of horticulture farms has, however, steadily decreased, while remaining farms generally apply high levels of chemicals and pesticides, constituting a potential human health risk (increasing incidences of diseases have been observed among households living in or close to the area). Preliminary results of the urban food systems scenario study led to increased awareness of policy makers at city and provincial levels of the need to protect and preserve the horticulture greenbelt around Rosario and promote more agro-ecological production technologies. In order to preserve agricultural production in peri-urban areas, the municipality has included a new land use category on "land used for primary production" in their urban development plan. They have currently doubled the peri-urban agricultural protection zone from 400 to 800 ha. A first group of producers in the peri-urban area of Rosario are now receiving technical and financial support to convert to more agro-ecological practices. Together with marketing support and buyer agreements, this will allow increasing producer income, while reducing environmental contamination, which on its turn will contribute to preserving agricultural zones around the city.

Source: Piacentini et al. 2014.

The amount of food that can be actually produced in intra- and peri-urban areas was more recently a subject of study in Almere (the Netherlands). A scenario study found that 20% of total food demand (in terms of potatoes, vegetables, fruits, milk and eggs) projected for a future population of 350,000 can be produced locally in a radius of 20 km around the city (with more than 50% of the area destined to animal production: grass and fodder). When replacing 20% of the food basket by local production in Almere, while at the same time promoting fossil fuel reduction in production, processing and cooling by renewable energy sources, energy savings (363 TJ) would add up to the equivalent of the energy used by 11,000 Dutch households. Savings in GHG emissions (27.1 Kt CO_2 equivalent) would equal carbon sequestration of about 1,360 ha of forest or the emission of 2,000 Dutch households. The largest savings are due to: (a) reduction in transport, (b) replacing fossil fuel use by renewable energy sources (solar, wind energy; use of excess heat from greenhouses), and (c) replacing conventional production by organic production (Jansma et al. 2012).

Urban agriculture is also a source of GHG emissions. Emissions depend on production intensity, management aspects such as degree of external inputs (such as chemical fertilizers and pesticides; fuel); materials used and their related energy costs/GHG emissions; seasonality (production per unit of energy); and energy costs of setting up the system (for example, for rooftop gardens). Emissions will be highest for more mechanized (fuel costs), input-intensive systems and specific production systems such as livestock. Especially for livestock, waste management practices will be key for reducing emissions.

The specific type of urban agricultural systems to be promoted will depend on local socio-economic, climatic and spatial conditions. Each agricultural system varies in its suitability and relevancy for certain urban areas and the kind of climate change-relevant impacts they may have (see Table 8.1). Other variables influencing the extent to which certain impacts can be achieved include total surface area, product choices, type of food distribution network, and type of water and waste management.

BOX 8.5 PROMOTING GREEN AND PRODUCTIVE ROOFTOPS IN DURBAN, SOUTH AFRICA

Integrating food production with building infrastructure (rooftops, balcony gardening, growing walls, greenhouses) may contribute to reducing the urban heat island effect, reducing/slowing down storm water runoff and regulating temperature (heating and cooling requirements), depending on the type of production system and local climatic conditions. Studies in Durban (South Africa) showed that the average ambient air temperature above a green roof was substantially lower (on average 18°C) than above a blank roof (22°C and 41°C respectively). The daily temperature fluctuations are also smaller: 2.7°C fluctuation above the green roof as against 9.8°C fluctuation above the blank roof (Van Niekerk et al. 2011). See also Figure 8.2.

Reductions in energy savings and emissions may, however, be offset against energy use and GHG emissions related to maintenance of the green roof and to production activities and related transport of inputs and products. Effects on heating and cooling will also depend on degree of (permanent) cover of the rooftop, local climatic conditions, building insulation, building types, and heating and cooling behaviour of the owners (are homes or buildings cooled/heated using energy intensive equipment?).

Green rooftops may also contribute to storm water drainage and reducing runoff, depending on the depth of soil or type of substrate used and type of vegetation cover. According to eThekwini Municipality's Environmental Planning and Climate Protection Department studies on Durban, the amount of the storm water runoff from green roofs is eight times less as the amount from blank roofs (Van Niekerk et al. 2011). The efficiency to reduce rainwater runoff from green roofs depends on several factors especially the soil depth, type of plants grown, degree of green cover and seasonality of production.

The climate mitigation impact of green roofs also depends on the extent to which "building integrated agriculture" enables synergic and cyclical processes between urban agriculture and other industrial sectors (e.g., agricultural use of excess heat or cooling water produced by the block heating facility or by industry in a neighbouring area).

Significant barriers to using rooftop space for agricultural production are: structural requirements, existing building codes, access (e.g., transport of inputs/outputs and customers) and insurance issues.

Source: authors.

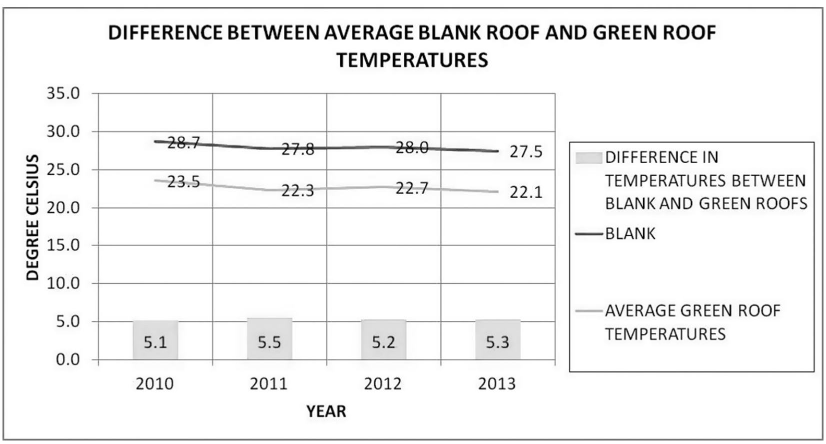

FIGURE 8.2 Difference between average blank roofs and green roofs in Durban 2010–2013

Source: Clive Greenstone, PHD student UKZN School of Built Environment & Development Studies.

The extent to which urban agriculture may mitigate climate change, contribute to city adaptation to climate change and enhance city resilience will depend also on the level of urban development, the status and quality of infrastructure and degree of integration of urban agriculture into urban policies. Often, the latter has been obstructed or slowed down as a result of (perceived and potential) environmental and health risks related to urban agricultural production (de Zeeuw et al. 2011). Use of organic municipal waste, sewage and market refuse in crop production has been found to cause microbial and heavy metal contamination of produce (Keraita and Drechsel 2004; Amoah et al. 2005). Production in sensitive areas can also result in soil or water contamination with heavy metals such as cadmium (Cd) and lead (Pb) (Nabulo 2002; Amoah et al. 2005). Additionally, inappropriate usage of contaminated water supplied from rivers or canals to irrigate crops is a concern, particularly in cities where treatment is unavailable. Access to, and availability of, land are other limiting factors for many urban agricultural enterprises. In densely urbanized areas, food production can be limited by space and conflicts on land, while extensive institutional land may remain largely unutilized in many cities, creating complex challenges for urban planners when considering sustainability at various scales (Aubry et al. 2012).

FIGURE 8.3 Peri-urban agricultural land use in Mbale Town, Uganda

Source: Lwasa.

TABLE 8.1 Potential impacts of selected urban agriculture production systems on climate change mitigation, adaptation and developmental benefits

City zone	*Urban agriculture production system*	*Impacts on climate change*				*Development benefits*	*Variables that determine the extent to which such impacts on climate change can be achieved*
		Mitigation benefits		*Adaptation benefits*			
A	**Backyard and community gardening**	++	Less energy use and GHG emission due to reduced food miles Reduction of waste volumes due to on-the-spot composting/reuse Minor carbon storage and sequestration	+++	Less vulnerable to an increase in food prices and disturbances in food imports to city due to enhanced local production and diversification of food (and income) sources Positive effects on urban biodiversity (especially niche species)	Enhanced food security and nutrition (especially for the urban poor and women) due to improved access to nutritious food close to consumer Positive effect on urban biodiversity and liveabilityEducational and recreational opportunities	Food import and consumer transport distances for buying food Degree of external inputs and materials used in UPAF and related energy costs/GHG emissions (ecological vs. conventional production; degree of recycling and use of organic waste, use of rainwater harvesting and water-saving production techniques; crop choice: use of drought-resistant species)
A	**Green productive rooftops**	++	Less energy use and GHG emission due to reduced urban temperatures and insulation: less energy use for acclimatization of homes and offices Minor carbon storage and sequestration	+++	Minor: less vulnerable due to enhanced local production and diversification of food (and income) sources Enhanced water retention capacity and reduced runoff Reduced urban heat island effect Positive effects on urban biodiversity (e.g., migratory stops)	Enhanced food security and nutrition due to improved access to nutritious food close to consumer Educational and recreational opportunities Multifunctional use Enhanced city liveability	Degree of external inputs and materials used in UPAF and related energy costs/GHG emissions (degree of recycling and use of organic waste, use of rainwater harvesting and water-saving production techniques; crop choice: use of drought-resistant species; choice of production technologies and inputs required, (energy-costs of setting up the system)

A-B	**Food and biomass production (e.g., agroforestry) in flood zones and other urban open spaces needing conservation**	+++	Less energy use and GHG emissions due to reduced transport, cooling, refrigeration, storage and packaging Carbon storage and sequestration	+++	Less vulnerable due to enhanced local production and diversification of food (and income) sources Enhanced water storage and retention capacity Reduced flooding incidences/ lower water peaks; lower impacts of floods due to prevention of housing in flood plains Positive effects on urban biodiversity	Food production (volumes) Enhanced food security and nutrition due to improved access to nutritious food close to consumer EmploymentPositive effect on urban biodiversity and liveability Multifunctional use	Seasonality of production Degree of external inputs and materials used in UPAF and related energy costs/GHG emissions (ecological vs. conventional production; degree of recycling and use of organic waste, use of rainwater harvesting and water-saving production techniques; crop choice: use of drought-resistant species)
B-C	**Forestry and agroforestry (especially on steep slopes and other areas susceptible to erosion and landslides)**	+++	Carbon storage and sequestration Less energy use for cooling/refrigeration/ acclimatization due to reduction of urban temperature (in warmer climates) Reduction of air pollution	+++	Less incidence of floods and landslides due toreduced runoff and enhanced water storage and retention capacityPositive effect on biodiversity conservation	Production of food (crops, fruit, nuts)/fuel/woodLiveability enhanced (shade, aesthetics, temperature, air quality)Less health problems due to less heat stress (heat stroke, skin diseases, and heart problems) and air pollution	% under high-/low-density productionDegree of combination with food productionChoice of tree species (growth rate; water needs, maintenance requirements; retaining leaves year-round or not, long- or short-living, etc.)Degree of maintenance and maintenance techniques applied and related energy costs and GHG emissionsForest fires and other causes of reduction of tree coverage

(*Continued*)

TABLE 8.1 (Continued)

City zone	*Urban agriculture production system*	*Impacts on climate change*				*Development benefits*	*Variables that determine the extent to which such impacts on climate change can be achieved*
		Mitigation benefits		*Adaptation benefits*			
B–C	**Agriculture in city fringes/peri-urban areas, including wetlands (where appropriate)**	+++	Less energy and GHG emissions due to reduced food miles and more locally produced fresh food: less transport, cooling/refrigeration, storage and packaging Less cost in maintaining infrastructure for transport, storage and cooling Carbon storage and sequestration	+++	Improved health of biodiversity for appropriate habitats and species, especially in conjunction with organic, low-till agriculture Enhancing food resilience for city (especially during disasters and political/financial crisis periods); less vulnerability due to enhanced local production and diversification of food (and income) sources	Enhanced food security and nutrition due to improved access to nutritious food close to consumers EmploymentPositive effect on urban biodiversity and liveability	Seasonality/lower production per unit of energy Degree of external inputs and materials used in UPAF and related energy costs/GHG emissions (ecological vs. conventional production; degree of recycling and use of organic waste; use of rainwater harvesting and water-saving production techniques; crop choice: use of drought resistant species)

Notes:

City zone: *A = Inner city; B = Suburban (less densely built up); C = Peri-urban (mainly open spaces).*

Mitigation benefits: *the mitigation effects expected to be obtained from each urban agriculture production system. The number of plusses indicates the expectations regarding the magnitude of these impacts at city level.*

Adaptation benefits: *the adaptation effects expected to be obtained from each urban agriculture production system. The number of plusses indicates the expectations regarding the magnitude of these impacts at city level.*

Developmental benefits: *the expected developmental benefits of each urban agriculture production system measure (on food security, on income and employment creation, on city liveability, etc.).*

Scale used: *+ to +++ indicating low to high level of potential impact.*

Source: adapted from RUAF Foundation 2014.

Research and policy challenges

Urban policies need to incorporate food-security considerations and focus on building cities that are more resilient to crises. There is growing recognition of intra- and peri-urban agriculture and forestry as an important strategy for climate change adaptation and disaster-risk reduction. But there are research and policy challenges that require attention.

More research is needed to assess thresholds for mitigation of climate change (such as reduction of GHG emissions) that may be expected to be realized by different urban food production scenarios and pathways. City-specific scenarios and thresholds will be useful in informing policy and integration of urban agriculture into climate change strategies and urban development plans and translating the potential into actions. Testing and quantification of the adaptation potential of urban agriculture under different climate risks also require further research and identification of actions for adaptation that can be integrated into policy.

With regard to policy, it will also be important to enhance the awareness of local authorities and other pertinent stakeholders involved in urban climate change and other programmes (land department, agriculture and green spaces) of the potentials (and limitations) of urban agriculture and forestry for climate change adaptation and mitigation. Metropolitan, municipal and other local government institutions can play a proactive and coordinating role in enhancing urban food security and city resilience by the following:

1 Integrating urban food security and urban agriculture into climate change adaptation and disaster management strategies.
2 Maintaining and managing agricultural projects as part of the urban and peri-urban green infrastructure.
3 Identifying open urban spaces prone to floods and landslides, and protecting or developing these as permanent agricultural and multifunctional areas.
4 Integrating urban agriculture and forestry into comprehensive city watershed management plans, and in social housing and slum upgrading programmes.
5 Developing a municipal urban agriculture and food security policy and programme (Dubbeling 2013a).

As the impacts of specific types of urban agriculture and forestry on climate change vary, policies and strategies should specify which types of urban agriculture will be promoted, where and why.

If intra- and peri-urban agriculture are to be further promoted as integral strategies for climate change adaptation, mitigation and disaster risk reduction, respective indicators and monitoring frameworks are needed to better understand its actual contributions. It was in response to this request that the RUAF Foundation, with support from UN-Habitat and CDKN, designed a framework for indicators and tools to monitor the actual adaptation and risk-reduction impacts and development benefits of urban agricultural activities in different cities and for different urban agricultural models. The monitoring framework is currently being tested and improved upon in various partner cities. Application of this model at wider scale, and in different contexts, will enhance availability of data and evidence-based policy-making.

Conclusion

Urban agriculture interfaces with climate change in various ways. Though challenges and risks of urban agriculture exist, if well managed and innovated, its activities have a potential to be a low-cost and locally adaptable strategy for adaptation as well as mitigation of climate change. Research to generate more evidence-based data and examples about the mitigation potential of various urban agricultural systems is needed to inform policy that can be implemented at various scales of the city. This will need to be supported through sharing of knowledge and other resources that can help scale out and scale up best practices. Policy interventions needed include integrated urban development, with special attention to productive green infrastructure, access to water and innovation of production systems.

Building urban resilience will require broad strategies from micro- to city-region scales. Finally, for climate change and urban food systems planning to be meaningful, it is important to consider planning along the urban–rural gradient at the city-region level – beyond the boundaries of the urban centre itself, including towns, semi-urban areas, and outlying rural hinterlands. At this level, there are key opportunities to plan for landscape mosaic patterns that protect valuable ecosystems and biodiversity hotspots; preserve natural corridors that prevent flooding and landslides; optimize and expand existing transportation network infrastructure; construct a built environment that uses water and energy efficiently; and promote compact cities and planned extensions. In terms of urban management, special attention needs to be paid to health standards, storage and processing, land zoning, land tenure systems, use of vacant land and access to water. In terms of urban governance, it is important for vulnerable groups, producers and other actors in the food chain, particularly women, youth and migrant workers, to have a voice in a transparent decision-making process (Tuts 2014).

Note

1 The projects by RUAF Foundation with CDKN (Dubbeling 2014a) and UN Habitat (Dubbeling 2014b), respectively, were implemented in Kesbewa (Sri Lanka), Bobo Dioulasso (Burkina Faso), Rosario (Argentina) and Kathmandu (Nepal). The projects designed and tested a methodological framework and tools for the assessment of main potential contributions of urban productive green infrastructure to city mitigating of, and adaptation to, climate change. Also different urban food scenarios were developed and their respective impacts on energy use and greenhouse gas emissions were calculated. Pilot projects on potential urban agriculture models with highest expected climate change impacts were implemented and monitored in each of the cities. Finally the integration of types of urban agriculture that contribute most to climate change

mitigation and adaptation into city climate change plans or strategies was facilitated. For more details, see: www.ruaf.org/projects/monitoring-impacts-urban-agriculture-climate-change-adaptation-and-mitigation-cities, and www.ruaf.org/projects/integrating-urban-agriculture-and-forestry-climate-change-adaptation-and-mitigation.

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9

URBAN HORTICULTURE

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Introduction

Intra- and peri-urban horticulture includes all horticultural crops grown for human consumption and ornamental use within, and in the immediate vicinity of, cities. Although crops have always been grown inside the city, the practice is expanding and gaining more attention. The products of urban horticulture include a large variety of vegetables, cereals, flowers, ornamental trees, aromatic vegetables and mushrooms. Table 9.1 presents the main species cultivated in urban horticultural systems and more specifically those presented in this chapter.

Generally, the types of crops cultivated vary according to the area, influenced by culture and tradition. In cities, short-cycle crops are preferred, while in the vicinity of the city crops with longer cycles are cultivated, for example in orchards.

Crops are grown in small gardens or larger fields, using traditional or high-tech and innovative practices. The major plant production systems and practices of urban horticulture are described in this chapter, together with the major constraints. Some new techniques that have been adapted to the urban situation and tackle the main city restrictions are also documented. These include horticultural production on built-up land using various types of substrates (e.g., rooftop, organic production and hydroponic production), water saving in highly populated areas, and the production of pesticide-free vegetables year-round with control of wastes and leaching (fertilizers, pesticides, organic matter, water) in the urban environment. The aspects of waste recycling, local consumers and producers' links will be always taken into account.

Urban horticulture also contributes to strengthening social sustainability and increasing ecological sustainability by transforming wastes, conserving natural resources, preventing soil erosion, and reducing pollution. Urban horticulture, like urban agriculture in general, has multiple functions. The main function is supplying fresh food, but emerging functions that are becoming more and more

TABLE 9.1 Horticultural and other plants cultivated in urban areas

Vegetables	***Aromatic and flowering plants***
Amaranth, Genius ***Amaranthus***	Agati, ***Sesbania grandiflora***
Beans, ***Vigna radiata*** & ***Phaseolus vulgaris***	Basil, ***Ocimum basilicum***
Beetroot, ***Beta vulgaris* var**. ***Esculenta***	Chives, ***Allium schoenoprasum***
Bitterleaf, ***Vernonia amygdalina***	Horseradish tree, ***Armoracia rusticana***
Broccoli, ***Brassica oleracea* var*. italic***	Indian borage, ***Plectranthus amboinicus***
Cabbage, ***Brassica oleracea* var. *Capitata***	Kohlrabi, ***Brassica oleracea* var. *gongylodes***
Cardoon, ***Cynara cardunculus***	Lemon grass, ***Cymbopogon citratus***
Cassava leaves, ***Manihot esculenta***	Mustard, ***Brassica compestris***
Cauliflower, ***Brassica oleracea***	Pakchoy, ***Brassica camperstris* var *chinensis***
Chinese cabbage, ***Brassica rapa* var. *Pekinensis***	Parsley, ***Petroselinum crispum***
Chinese mustard, ***Brassica juncea* var. Rugosa**	Peppers, Genius ***Schinus***
Choy sum, ***Brassica rapa* var. *Parachinensis***	Perilla, ***Perilla frutescens***
Cucumber, ***Cucumis sativus***	Roselle, ***Hibiscus sabdariffa***
Eggplant, ***Solanum melongena***	Tuberose, ***Polianthes tuberosa***
French bean, ***Phaseolus vulgaris***	***Fruits***
Garlic, ***Allium sativum***	Banana, Genius ***Musa***
Gourd, Genius ***Cucurbita***	Melon, ***Cucumis melo***
Indian mustard, ***Brassica juncea***	Orange, ***Citrus sinensis***
Jaxatu, ***Solanum aethiopicum***	Papaya, ***Carica papaya***
Kangkong (water convolvulus), ***Ipomoea aquatica***	Peach, ***Prunus persica***
Leek, ***Allium ampeloprasum***	Pineapple, ***Ananas comosus***
Lettuce, ***Lactuca sativa***	Strawberry, Genius ***Fragaria***
Lotus, ***Nelumbo nucifera***	Drumstick, ***Moringa oleifera***
Melindjo***, Gnetum gnemon***	***Ornemental plants***
Mizuna, ***Brassica rapa*** var. ***Japónica***	***Bougainvillea (Genius)***
Mungo bean, ***Vigna radiata***	***Chrysanthemum (Genius)***
Okra, ***Hibiscus esculentus***	Kumquat, Genius ***Fortunella***
Onion, ***Allium cepa***	Rose, Genius ***Rosa***
Palak, ***Beta vulgaris***	
Pea, ***Pisum sativum***	
Potato, ***Solanum tuberosum***	
Squash, ***Cucurbita máxima***	
Sweet pea, ***Lathyrus odoratus***	
Sweet pepper, ***Capsicum annuum***	
Snow pea, ***Pisum sativum***	
Tomato, ***Lycopersicon esculentum***	
Wheat, ***Triticum aestivum***	
Yardlong bean, ***Vigna unguiculata sesquipedalis***	

essential are economic (income generation), social (labour), cultural, living environment (open spaces and greening), environmental (recycling wastes and wastewater) and security (food and natural risks).

Policy makers around the world are showing an increased interest in urban horticulture, although their major focus is still on the temporary use of peri-urban lands. Peri-urban agriculture is "encouraged" in poor countries, mainly because it improves food security of poor households and the urban population's nutritional status (freshness of products and better access to fruits and vegetables, considered as a major source of vitamins and micronutrients), especially in view of the inefficient transportation and storage facilities in these countries. Policy makers also encourage urban horticulture because it provides jobs and incomes to poor and landless urban dwellers and because it is well adapted to the urban environment where water and land are scarce.

Urban demand, crop diversification and sustainability

Urban demands for horticulture

The proximity to urban markets often defines the production of specific fruits or vegetables, while there are also seasonal differences between rural and urban areas in terms of supply to the urban market. The case study from Hanoi, Vietnam, is an interesting example of how the horticultural market has evolved dynamically over the years in relation to social, climatic and cultural factors. Fruits and vegetables for city markets are supplied from different areas: rural, peri-urban and intra-urban, from within the country or from foreign countries. There is complementarity between the supply flows from the various origins, which may change over time. Products from urban horticulture make up a very large part of the supply of vegetables to urban markets, such as in the capital city Hanoi (with a population of 2.7 million). Here, 80% of the vegetables (118,628 tonnes) comes from the Province of Hanoi, an area of 7,095 ha of urban gardens (Mai Thi Phuong Anh 2000).

Factors such as climate, soil, access to water, insects and diseases, costs of production and, most importantly, the shelf life of the crop itself influence the location of vegetable production. The last factor explains why, for most urban markets, leafy vegetables are produced in urban and peri-urban areas. Some leafy vegetables are well adapted to a hot wet season. The very short shelf life of cut flowers such as roses and chrysanthemums explains the development of these horticultural crops around Hanoi, where they are grown on 1,000 ha. The season also influences the distribution of supply to the urban market from rural/urban areas. In Bangui, the share of tomatoes from rural areas increases from 40 to 50% in the wet season. In Bissau, the share of tomatoes from urban areas increases from 10 to 20% in the wet season. Urban horticultural areas may also supply the urban market more regularly than the rural areas. In Nouakchott, urban horticulture supplies the urban market during nine months of the year, whereas the rural areas provide vegetables to the city only during three months

(Margiotta 1997). Around Hanoi, *choysum* and leafy mustard are grown year-round. In Dar-es-Salaam, amaranth is grown throughout the year. This tendency to crop year-round is increased by the urban producers' need to derive an income from various high-value crops throughout the year. This bias towards urban horticulture may also be due to production constraints and access to transportation infrastructure during the rainy seasons or to socio-economic causes. In some countries, however, where flooding of urban areas increases every year, it is easier to find suitable spaces to grow vegetables in rural areas (Phnom Penh, Dacca).

Even if the consumption of vegetables per person is relatively low, consumer demand remains the major driving force behind urban horticulture. In developing countries, the consumption of vegetables is generally lower than the FAO recommendation of 75 kg/year/inhabitant (205 g/capita/day). The importance of vegetable consumption depends on the population group. Over the period 1994–1998, consumption in Vietnam was higher in urban areas (182 g/capita/day) than in rural areas (122 g/capita/day), but lower than in mountainous areas (196 g/capita/day) (Nguyen Thi Lam and Ha Huy Khoi 1999). As shown in Table 9.2, the consumption of vegetables in Bangladesh was higher in urban areas than in rural areas (Ali 2000). The same observation has been made in developed countries (Dean and Sharkey 2011).

TABLE 9.2 Monthly per capita consumption of vegetables (kg) in Bangladesh

	Total vegetables	*Leafy vegetables*	*Potato*	*Banana, papaya, eggplant*	*Other vegetables*
Urban	6.20	1.42	1.67	0.82	2.29
Rural	5.13	1.08	1.13	0.80	2.12

Source: Ali 2000.

Urban consumption is related to the size of households, income and socio-cultural characteristics (Bricas 1998). In Africa, the most popular vegetables are tomatoes, onion and leafy vegetables, but there are location-specific variations. In Brazzaville, for instance, the importance of vegetables varies from one socio-economic group to another (Moustier 1999b; see Table 9.3).

Culture and festivals also have a very strong influence on consumer demand for specific products. In many countries, the main demand for flowers occurs on Mother's Day, Valentine's Day and during the Christmas period. In Vietnam, the Tet celebration is the opportunity to offer two ornamental trees: kumquats bearing mature orange fruits and peach trees in blossom. In urban and peri-urban areas in Hanoi, ornamental fruit tree specialists have set up production to meet this demand, which means that they nurture young trees for a period of one year to prepare them for sale.

TABLE 9.3 Most-frequently eaten vegetables per socio-economic group in Brazzaville (Congo) (in order of importance per group)

Socio-economic groups	*Vegetables eaten most frequently*
Congolese households	Cassava leaves, cherry tomato, pakchoy, roselle, melinjo, dry kidney bean
Non-Congolese African households	Potato, cassava leaves, cherry tomato, dry kidney bean, amaranth, lettuce
Expatriates	Potato, "European-type" vegetables

Source: Moustier 1999b.

Crop diversification and biodiversity

Through the large variety of crops that are produced, urban horticulture makes a major contribution to the food and economic security (see Chapters 5 and 6).

Although most of these species are not specific to peri-urban horticultural systems and can also be grown elsewhere, horticulture in urban areas minimizes the transportation time for the supply of fresh produce to city dwellers. The cropping system in urban and peri-urban areas is usually adapted to the specific circumstances. Many traditional crops have been adapted to better respond to the needs of city consumers. Horticulture is practised for home consumption and for the market as high-value cash crops. In such a competitive environment, a focus on profitability may lead to improper management, such as the intensive use of water, land and other (chemical) inputs, and thereby pose threats to humans and the environment. This issue will be discussed later in this chapter.

The urban horticultural farms present a high diversification of the fruits and vegetables produced. In Africa, Maundu et al. (2009) mentioned that about 1,000 species are used as vegetables, the majority of which (about 800) are leafy vegetables. They include very diverse forms including annual and perennial crops and some trees such as *Moringa oleifera*. Large areas of vegetable production with market-gardeners specialized in one or two crops have been developed in various parts of the world with long supply chains, for instance: melon in the Languedoc region of France; tomatoes in the Senegal River valley; and onions in the valleys of Maggia, Tarka and Aïr in Niger.

In other areas, like the peri-urban area of Montpellier (France), a large number of market-gardeners have highly diversified their crops, in terms of species and varieties, to fit the consumers' demands. Small vegetable farmers, with one to ten hectares (ha), might produce more than 30 different vegetables (Lenoble 2013) and we note the same phenomenon in the peri-urban area of Paris (Pourias 2010).

Urban home gardens also show a large crop diversity (Keatinge et al. 2012). Such diversity can be considered as a repository of rarer plant varieties or land races, thus acting as areas of *in situ* germplasm preservation (Oluoch et al. 2009; Galluzi et al. 2010). Moreover, the Community Supported Agriculture (CSA) movement pushed for the (re)discovery of old species and varieties. We observe

TABLE 9.4 Daily fruit and vegetable intake in 2006, Brazos Valley (Texas)

Servings (mean+/–SD)	*Combined*	*Urban*	*Rural*
Fruits	1.4+/-0.99	1.6+/-0.99	1.3+/-0.9
Vegetables	2.0+/-0.92	2.0+/-0.94	2.0+/-0.92
Total fruits and vegetables	3.4+/-1.61	3.6+/-1.63	3.3+/-1.59

Source: Dean and Skarkey 2011.

nowadays a renewal of forgotten vegetables like parsnip (*Pastinaca sativa* L.) and Jerusalem artichoke *(Helianthemum tuberosus),* or of old tomato varieties like "Coeur de boeuf". This phenomenon contributes to a real cultivated biodiversity near the cities (Lovell 2010).

The diversity of crops and the diversity of the farming activities (producing, transporting, selling, managing the communication with customers, etc.) lead to a more complex farm management in comparison with the more specialized farm with a few crops. This complexity sometimes leads to a difficult sustainability of the farm system, not because of economic or ecological aspects, but because of a lack of "liveability" (Petit et al. 2013): too much workload and economic and practical difficulties to employ new workers lead some of these farms to have no successor inside the farmer's family. In the Paris region, for example, around 37% of market-gardeners in short supply chains ceased their activities and their farms generally contributed to the growing size of arable crop farms in around ten years. Around Montpellier (France), the small vegetable farmers (with around 1.3 ha) have difficulty in paying a second full-time worker, so they turn to trainees or familial support. They grow 15 different species per year. If short supply chains are an opportunity for peri-urban horticulture, very often it is not at all sufficient to ensure the survival of peri-urban horticultural farms. The combination of different ways of marketing is a solution to improve its sustainability.

Statistics and research about these peri-urban horticultural farms are dramatically failing, especially in European countries: since horticulture is not an activity that is supported by the Common Agricultural Policy (CAP), it is poorly informed at statistical level, and if research about short supply chains at economic and sociological levels is increasing, their consequences on technical management and work organizations are scarcely studied. Nevertheless, data seem to show that the above-mentioned points could be critical ones for the sustainability of such forms of urban horticulture.

Factors influencing urban horticulture

The development of horticultural systems in urban and peri-urban areas is determined by specific opportunities and constraints in the city. The constraints are mainly related to resource scarcity (water, land, labour and access to other inputs) and pollution.

Access to natural resources and labour

Access to suitable land is a key factor in urban agricultural development. Land-ownership and tenure arrangements are important. In the large and fast-growing cities of developing countries, land pressure is high and often leads to rising prices. In this context, access to land by intra- and peri-urban producers is difficult and poses a major constraint to their activities. As they are usually not landowners, they are obliged to rent from others or to squat on public land in order to have a small plot to cultivate. This uncertainty of land tenure has a strong influence on land-use strategy and maintenance. Producers may select fast-growing plants (such as leafy vegetables) rather than perennials (such as fruit trees), and may use places regarded as unsuitable for dwellings (such as swamps), which limit the range of crops that can be grown.

Insecurity of land tenure is a major problem that often leads to two types of responses by producers: they might choose inputs with strong and quick effects, such as chemical fertilizers and pesticides, rather than improving the soil using long-acting fertilizers and integrated production techniques, or urban producers may turn to soilless production systems on diverse substrata. But sometimes short land leases also create some flexibility that could be an advantage. For instance, around Montpellier (France), the peri-urban growers prefer to rent land for melons (2 years) and potatoes (1 year) to avoid damages due to the soil-borne diseases such as *Fusarium spp.* or nematodes (Lenoble 2013).

The size of plots is also a constraint. In the inner cities or peri-urban areas, horticultural crops are grown on very small parcels of land. This leads to the development of specific systems: intensive, high-yielding and year-round production with the same or different crops. High yields require high use of inputs – water and fertilizer – combined with good light. As will be discussed later, different techniques have been developed for situations with land scarcity or poor soil quality, such as hydroponics or organoponics (to be discussed later in this chapter).

Different sources of water are available in urban and peri-urban areas: potable water, wastewater, rivers, lakes and ponds. The specificity of horticultural systems is their adaptability in using these different sources, particularly the use of wastewater (see Chapter 7). In all cases, this scarce source needs to be used efficiently and with precaution. Drip irrigation with different systems of micro-irrigation is possible. Use of a watering tank is more popular and is also one of the most efficient systems. The advantage of using wastewater is that it provides nutrients together with the water. This saves the cost of fertilizers and labour to apply the fertilizer.

In urban areas, there is fierce competition for the use of land and water between horticultural and other economic activities. In a context of high economical competition, horticulture can be maintained if it generates more benefits than any other use of the resources (see also Chapter 5). Yet, even without intensification of production and even if it is less profitable, horticulture continues to exist, if its other functions (i.e., social, greening, water management) are valued by city stakeholders.

Another aspect of this competition comes from the many other human economic activities that occupy urban producers. In Hanoi, for instance, peri-urban gardeners seek jobs in industry, business and administration. Most often urban horticulture is a part-time job in this city, and different activities are combined in order to maintain livelihoods. The household members also divide their activities between production, sales and employment. The multiple economic activities of most urban gardeners may lead to a lack of sufficient labour during certain cropping periods, such as planting or harvesting or for irrigation.

Environmental pollution

Industry, services, traffic and high population density in urban areas are known to cause pollution to water, soil and air and reduce light intensity. A major challenge for urban horticulture is to supply safe products in this often-polluted environment. In urban or peri-urban areas, the main pollutants of horticultural crops are heavy metals, pesticide residues, and biological contaminants. Such pollution presents a risk not only to the consumers, but also to the producers who come in contact with contaminated materials, for instance in wastewater. Additionally, these forms of pollution can be major factors in limiting crop growth. The source of human parasites is wastewater or animal wastes that are not composted (see Chapter 7).

Heavy metals

The causes of soil pollution from heavy metals (including lead, cadmium, chromium, zinc, copper, nickel, mercury, manganese, selenium and arsenic) are diverse: irrigation with water from streams and wastewater contaminated by industry, application of contaminated solid wastes and the use of former industrial land contaminated by spilled oil and industrial wastes, or inorganic fertilizers that may contain relatively some proportions of heavy metals. If the concentration of these elements in human food increases, it may cause toxic symptoms and cause damage to health (carcinogenic and mutagenic effects). The soils of urban gardens are very often more polluted by heavy metals than are rural ones (Chenot et al. 2013). Toxicity from heavy metals can directly affect plant physiology and growth, and many cases of toxicity from heavy metals have been reported. For example, Jørgensen et al. (2005) show that intensive horticultural systems (particularly in greenhouses) in urban areas may be threatened by soil toxicity through trace elements such as Zn, Cu, As and Pb.

The health effects and the heavy metal threshold concentration under which it is possible to practise safe agriculture have been subjects of much discussion. Puschenreiter et al. (1999) conclude that, having considered the several available pathways to reduce the transfer of heavy metals to the human food chain, urban soils with slight contamination by heavy metals can be used safely for gardening and agriculture if proper precautions are taken. However, Birley and Lock (2000) argue that little is known of the chronic health effects of consuming tiny amounts of heavy metals over long periods of time and that further research is needed. Mapanda et al. (2005) show that, in vegetable gardens of Harare (Zimbabwe), irrigation by wastewater may lead to significant heavy metal (Cu, Zn, Cd, Ni, Cr and Pb) enrichment in the soils. On the other hand, studies have shown that production in urban and peri-urban areas does not produce lower-quality vegetables than in rural areas (Midmore 1998).

Depending on the species and the plant parts, accumulation of heavy metals varies. Leaves can reach a high level while seeds are often less affected. It is possible to adapt the choice of crops in relation to the degree and type of contamination. Some horticultural crops such as bean, pea, melon, tomato and pepper show very low uptake of heavy metals.

The risk of pollution depends directly on the location of the fields. The rate of absorption of heavy metals by vegetables seems to be linked with their levels in the soil. Lead is taken up by the plant roots and is then transported to the leaves. Lead from traffic fumes in the air settles on the leaves. It can be washed away by watering the leaves, especially when the leaf surface is waxy (cruciferous plants, Alliums). Cadmium can be taken up by plants through roots and leaves. For these two very poisonous heavy metals with no positive biological functions, their presence in plants is controlled by respecting the soil standards. The location of vegetable production, with regard to roads and polluting industries, should be selected carefully.

In European countries, risks of heavy metal pollution are scarcely measured in peri-urban areas. Some studies show the possibility of pollutant deposition for fields located at the very proximity of roads – within around 50 m (Petit et al. 2013). Recent research showed that crop samples from inner-city sites had higher metal traces than the samples from the supermarket that are supposed to have come from rural areas (Saümel et al. 2012).

The conquest of urban rooftops for market vegetable production is maybe one of the possible answers to reduce soil contamination in urban gardens. But the level of pollution on the roofs is for the moment poorly informed, although some experiments show that it could be very low (Grard et al. 2013).

In addition to heavy metals, air pollution too can contribute to crop toxicity. For instance, Agrawal et al. (2003) show that, in the polluted environment of Varnasi, India, some physiological characteristics of bean, palak, wheat and mustard are significantly affected by the SO_2, NO_2 and O_3 concentrations. These gases are very common in large cities in developing countries, especially with the fast growth of personal transport.

Pesticide residues

As in many forms of crop production, horticulture is confronted with pesticide residues in the plants and pesticide exportation to the environment. This can lead to major health problems for producers and/or consumers. The residues of pesticides and fertilizers originate not from agricultural inputs used by the producers alone. Cultivation in contaminated areas or irrigation with contaminated wastewater also contributes to increasing the residual levels in plants above the allowed limit. In Bangkok, a survey has shown residues of organo-chlorine and organo-phosphate in irrigation water (Eiumnoh and Parkpian 1998); these contaminants are adsorbed in soil and are characterized by a very long half-life. Most belong to families of products that are banned worldwide.

All levels of cropping intensity are encountered in urban areas, from the most extensive in developing countries and in allotment gardens, to the very intensive agriculture using large amounts of agrochemicals and expensive equipment.

Vegetables containing pesticide residues above the maximum residue limit have been identified in markets for more than 20 years (Midmore 1998; Moustier 2000; Diop Gueye and Sy 2001). A review (de Bon et al. 2014) and some recent works confirmed this trend. Bempah et al. (2012) have shown that the percentage of higher pesticides residues (over the LMR) in plants is 31.5% of the samples in Accra Region, Ghana. In France the samples show a rate of around 2.8% pesticide residues over the LMR. This occurs often, in spite of the fact that regulations for the use of pesticides and recommendations for the protection of human health are in place.

Awareness of the risks caused by excessive use of chemical pesticides exists among all stakeholders, ranging from producers, consumers and public authorities to agrochemical companies. The urban horticulture sector is more sensitive to this problem because of the proximity of consumer and producer. More negotiation between all players in the commodity chain might be one solution. The development of new technologies, such as integrated pest management, agro-ecology and biological control, can help in reducing pesticide use.

Nitrates

Nitrates deserve mention in pollution related to agricultural inputs. They can cause health problems in very young babies and pregnant women. Nitrates are also an indicator of good or bad agricultural practices. Nitrates cause eutrophication of water in combination with phosphorus. Nitrates are brought by organic and inorganic fertilizers. In African cities, the quantities brought in the gardens are higher than in the fields (Abdulkadir et al. 2014). The over-fertilizations of the crops seem to be rather frequent (Sangare et al. 2012), but in some cases N and P leakages are low as in Niamey (Predotova et al. 2011). In Europe there are standards regulating the nitrate content in crops and water. In urban horticulture systems, nitrates stem from fertilization and from irrigation water. Some quick tests, such as Nitracheck®, appear to help producers manage nitrogen. Still, many of the methods available need to be validated for the specific intra- and peri-urban leafy vegetables grown in developing countries. Moreover, with the aim of making better use of organic matter obtained from urban wastes in mind, specific tools need to be developed that take into account the problem of the irregular and slow release of nitrogen. If the source of pollution is close to the water resource, as is often the case with urban horticulture, the risk of pollution of water by nitrates is enhanced. This is particularly true in developing countries that do not have a good network of water supply and where many people depend on the local water resources for their supply.

Biological contaminants

In horticultural systems, solid wastes are mainly used to improve the soil (household wastes, market refuse, sewerage, night soil, manure, fish wastes and agro-industrial wastes). Urban organic wastes are mainly composted; this process significantly reduces health risks. However, if the compost is not properly prepared (i.e., at too low temperatures), the organic wastes may still contain disease-causing pathogens such as bacteria and helminth eggs, particularly if organic materials are mixed with human excreta (Holmer and Itchon 2008). The use of domestic sewage for irrigating and fertilizing field crops, perennials and trees is widespread. A large part of the wastewater used is untreated or poorly treated and contains various bacteria, protozoan parasites, enteric viruses and helminths. Coliform bacteria are mainly transmitted to humans from wastewater via the contamination of crops irrigated with wastewater or through consumption of contaminated meat from domestic animals that have ingested tapeworm eggs from faeces in untreated sewage.

The contamination of crops with pathogenic organisms by reuse of urban wastewater and organic solid wastes is an important issue associated with food safety, especially in the context of urban horticulture (Karanja et al. 2010; see Chapter 7). These diseases may affect the producers who handle the contaminated material, as well as the consumers who may eat contaminated fruits or vegetables. This is particularly a health risk in case the crops will not be cooked before consumption such as salads and herbs that may be eaten raw (Petterson et al. 2001). In Antananarivo (Madagascar), the watercress supply of more than 90% of the urban consumers is coming from intra-urban specialized farms cultivating mostly with urban wastewater. The watercress produced presents high levels of bacteria like *Escherichia coli*. Knowing this risk, the consumers adapted to this situation by cooking watercress (Dabat et al. 2010).

Based on a scientific consensus of the best available evidence, the World Health Organization has established guidelines for the safe use of wastewater, excreta and grey water in agriculture, including minimum procedures and specific health-based targets, and how those requirements are intended to be used (WHO 2007). However, there is still a dire need to translate these guidelines into local protocols that best suit the agronomic requirements of the crops grown as well as the specific socio-economic, cultural and environmental realities of many developing countries (Seidu et al. 2008). See Chapter 7 for more details.

Pollution by horticultural practices

Horticultural systems may also pose a risk to their environments, and especially so in an urban context because of the proximity to people. Additional conflicts may arise between urban gardeners and city dwellers, especially when horticultural systems cause odours or improperly use large amounts of pesticides or fertilizers – artificial or otherwise – that urban dwellers fear may cause pollution. Although it is a general rule that inputs that affect human and environmental health must be used with care, this is more so in urban areas. The intensive use of agrochemicals (fertilizers, pesticides) may lead to residues in crops, surface water or groundwater, and cause negative effects to the health of agricultural workers.

Recommendations for safe urban horticulture

De Zeeuw and Lock (2000) suggest a number of prevention and control measures that can be applied in urban horticulture systems to help produce safe and healthy products. Such measures should help reduce risk of pollution of crops by heavy metals, agrochemical residues, pathogens and diseases. The general principle of these "good practices" is often based on good communication between health sector actors and urban farmers, ensuring the latter is educated to respect rules to limit/stop contamination of the horticultural products. A summary of the major recommendations is presented below (see Box 9.1).

BOX 9.1 MAJOR RECOMMENDATIONS FOR REDUCING RISKS IN URBAN HORTICULTURE

Heavy metals

- Define norms regarding crop restrictions according to type and level of contamination of agricultural soils; test agricultural soils and irrigation water for heavy metals.
- Establish minimum distance between fields and main roads and/or boundary crops to be planted beside them.
- Treat soil to immobilize heavy metals: application of lime increases pH and thus decreases the availability of metals, except for selenium; application of farmyard manure reduces the heavy metal content of nickel, zinc and copper (but may increase cadmium levels); iron oxides (like red mud) and zeolites are also known to absorb heavy metals such as cadmium and arsenic.
- Wash and process contaminated crops to effectively reduce heavy metal content.

Agrochemical residues

- Train gardeners in proper management of agrochemicals.

- Promote ecological farming practices and replacement of chemical control of pests and diseases by integrated pest and disease management techniques.
- Establish better control on sales of banned pesticides.
- Introduce cheap protective clothing and equipment.
- Monitor residues of agrochemicals in groundwater.

Use of organic wastes and wastewater

- Improve inter-sectoral linkages between health, agriculture, waste and environmental management.
- Separate waste at source; collect organic refuse regularly; establish decentralised composting sites; ensure the application of proper composting methods (temperature, duration) to kill pathogens; identify quality standards for municipal waste streams and composts produced from them.
- Monitor quality of composts and irrigation water from rivers and wastewater outlets; certify safe production areas; restrict crop choice in areas where wastewater is used but water quality cannot be guaranteed.
- Establish adequate wastewater-treatment facilities with appropriate technologies.
- Train gardeners in managing health risks (for workers and consumers) associated with reuse of waste in agriculture.
- Educate consumers (scraping and washing of fresh salads; eating only well-cooked food).

Diseases

- Maintain cooperation between the health sector and the natural resource management sector (solid waste management, water storage, sewerage, agriculture and irrigation).
- Ensure water tanks and irrigation systems (especially in peri-urban areas) properly designed to prevent malaria.
- Apply slow-release floating formulations to control the malarial vector; use expanded polystyrene balls to effectively control mosquito breeding in latrines and stagnant polluted water.

Source: based on De Zeeuw and Lock 2000.

Agronomic techniques

Greenhouses and plastic tunnels

Horticulture in urban areas will continue to be adapted to specific circumstances, as determined by the opportunities and constraints, and specific techniques will be developed, including combinations of practices from traditional horticulture and more modern, innovative practices (see later). Horticulture is practised in various agro-ecological and climatic zones, from dry areas to tropical and equatorial climates, in areas with cold seasons and in those without. Urban producers strive to grow crops year-round, to be able to better regulate delivery. However, in different parts of the world, certain periods of the year are too cold or too hot to produce crops. The producer may also face drought in arid zones and excess of water in wet tropical areas, mainly in the rainy season. Temperatures and water can be regulated by using greenhouses and plastic covers. In developing countries, the two main difficulties encountered are excess and lack of water.

In tropical areas, the distribution of rainfall often varies greatly between the dry and the wet season. In the wet season, heavy rains, often in combination with strong winds, may stop horticultural activities even though the consumer demand is high. In addressing this problem, producers in some areas, such as Martinique (French West Indies) and Mayotte, use shelters as "umbrellas" to prevent excess of water for the crops. In some areas, despite the tropical location (e.g., Réunion, Vietnam, Kenya), closed shelters have to be used during winter when the temperatures are low.

In some other cases, an insect-proof greenhouse has to be used to protect the crops (at least in their early stage of growth) from a virus frequently transmitted by insects. This is the case of tomatoes, which can be infected by Potato Yellow

FIGURE 9.1 Horticulture in low plastic tunnels near Beijing, China
Source: IGSNRR.

Mosaic Virus (PYMV) and Tomato Yellow Leaf Curl Virus (TYLCV) through the white fly *(Bemisia tabaci)*. These shelters help increase yields but require significant investment and may lead to side effects, such as the soil becoming too poor to further sustain production. Producers may need to turn to new techniques as described in the next section (organoponics or hydroponics). Producers, whether rural or urban, are often willing to adapt and improve their practices based on their own experiences and new information. Most of the new techniques, however, require access to capital for investments and to specific knowledge.

Low tunnel nets

Low tunnel nets can be applied as physical barriers against pest species (Weintraub 2009). This technique has been applied for cabbage production in Africa against *Plutella xylostella* (Martin et al. 2006). A combination of a visual barrier with a repellent product would reduce the rate of *Bemisia tabaci* crossing through the net, thereby reducing the risk of virus transmission such as the TYLCV. Thus, the protection of vegetables with nets seems to be an economically viable method because it can be reused several times, in addition to its environmental benefits (Martin et al. 2014). The only difficulty with this is that the resource-poor farmers in Benin (and possibly elsewhere) will have to face the initial investment in material. Using nets to protect vegetables has the additional advantage that this technique can be easily combined with other integrated pest management (IPM) techniques.

Irrigation systems

Water requirements are related to climatic conditions and plant species. Generally, water availability in cities has been showing a decreasing trend and the forecasts predict it will continue at least in the next 30 years. In most capital cities of developing countries located in tropical and subtropical areas, the quantities needed vary from 0.1 to 8–10 l/m^2/day in very dry and hot weather. For a crop of 30 days, the quantity of water needed by a leafy vegetable during the dry season is around 15–90 l/m^2. Depending on the climate and the yields, producing 1 kg of a crop such as tomato requires 60–140 litres of water. Table 9.5 presents the water consumption of some horticultural crops observed in Bobo-Dioulasso.

TABLE 9.5 Water consumption of some horticultural crops in Bobo-Dioulasso (Burkina Faso)

	Cycle length without nursery	*Yield (fresh weight, kg/m²)*	*Water consumption (l/m²)*
Tomato	2.1–3.5	2.8–5.8	5.0–8.9
Cabbage	2.3–2.9	4.9–5.2	4.5–8.6
Carrot	2.6–3.1	4.6–5.0	4.1–4.8
Lettuce	1.0–1.5	3.6–7.7	2.4–7.2

Source: Sangaré et al. 2012.

Different techniques are used for irrigation. Water is applied by overhead irrigation using watering cans, and also through sprinklers or perforated pipes from wells, ponds or the sewer.

Vegetables, especially leafy ones such as lettuce and cabbage, need to be watered twice a day, every day or at least every other day to obtain a good quality (freshness, tenderness) for marketing. There are three steps in watering: (1) lifting the water from the well or the irrigation canal, (2) bringing it to the plots, and (3) applying the water to the plants. These steps may be merged or kept separate. For urban horticulture in developing countries, the watering can is the most commonly used system. Each can holds 8–15 litres; one worker usually carries two cans. The water is taken from shallow wells, deep wells, "céanes" in Senegal, small cement reservoirs, drums (Ghana), etc. Reservoirs are filled by hand using small buckets, or with treadle, electric or motorised pumps. Crops could also be irrigated by submersing of the field. The manual system is efficient because, most of the time, the gardener applies the exact quantity of water needed by the crop. It is, however, labour intensive, and in Senegal this operation takes 60% of the total labour requirement for vegetable production.

Drip or trickle irrigation is another irrigation technique that has been promoted for nearly 30 years (Holmer and Schnitzler 1997). It saves water by 20–30% compared with overhead irrigation, but requires clean water in order to avoid blocking of the emitters. The fully-fledged system includes filters, pumps, a pressure regulator and plastic tubes, which low-income vegetable growers cannot usually afford. The advantage of this technique is that water is not in contact with the fruits and leaves. It will not, however, avoid contamination of the soil and roots of vegetables with biological pathogens.

Some simple drip-irrigation systems have been developed, in different locations, functioning with low gravity, e.g., Niger (ICRISAT TIPA), Vietnam (International Development Enterprises) and in South Africa. This system consists of a 210-litre drum, which is connected via a tap to a set of five polyethylene dripper lines, each with a length of 6 m. The drippers are constructed by perforating the polyethylene pipe with a heated nail. A piece of string is threaded through these perforations by means of a bag-needle. Knots on both ends of the string prevent it from slipping out of the pipe. When the perforations get clogged, pulling the string from side to side usually unblocks the openings. Clogging of the drippers is reduced by placing a stone and sand filter at the bottom of the drum. The filter prevents coarse particles, which may be present in the irrigation water, from entering the pipes and blocking the drippers (Khosa et al. 2003). Such a system of micro-irrigation is particularly suitable for small farms in urban areas, because it does not require a high capital investment and because it uses rainwater collected from roofs.

Underground irrigation provides water to the plant by capillary action. Such an underground system can limit the transmission of pathogens to the vegetables thanks to the filtrating effect of the soil. A simple system based on a vertical plastic tube filled with soil has been developed in Senegal (IRRIGASC).

Fertilization

Crops require nutrients: macro-elements such as nitrogen, phosphorus, potassium, calcium; and micro-elements such as manganese, copper, etc. Intensive cropping systems on very small areas, using only solid and liquid urban wastes, are not always optimal for crops.

Two main groups of fertilizers are used: organic fertilizers and chemical (or inorganic) fertilizers. There has always been a heavy use of organic fertilizers in intensive production such as vegetables and ornamental flowers. The quantity varies from a few tons/ha/year to 50 or even 100 tons/ha/year. Organic fertilizers provide most of the micronutrients and, in addition, improve the structure of the soil. Organic fertilizers can be manure from livestock or poultry, compost from vegetable wastes or wastes from urban activities including sewage sludge, night soils, and household wastes. Over many centuries, intra- and peri-urban farmers have managed and recycled urban wastes (Fleury and Moustier 1999). In South-East Asia, use of fresh night soil is a common practice even though it disseminates human pathogens. These practices may cause some risks to the environment – pollution of soils with heavy metals from sewage sludge, pollution of water with nitrates due to large quantities of organic manure – and also to the health of the consumer.

Solid organic fertilizers have the disadvantage that they release nutrients, especially nitrogen, slowly. Liquid fertilizers act faster. This explains why liquid organic fertilizers are often used on short-cycle leafy vegetables like amaranth and mustard. In Hanoi (Vietnam), liquid organic fertilizer, e.g., pig urine, is used to supply nitrogen during crop growth. Research has often focused on combining organic and inorganic fertilizers to enhance their efficacy. The use of organic wastes as fertilizer can lead to a different form of pollution as discussed earlier. This problem is strongly linked to recycling of wastes in the cities (see also Chapter 7).

Inorganic fertilizers are easier to use and allow for application of the right dose of nutrients. However, there are risks of over-application and contamination of soils and water by nitrates and phosphates, which is especially relevant in the city. Also, they could be a source of heavy metals. In Thailand, it has been shown that ammonium phosphate can release cadmium, zinc and chromium into the environment in excessive quantities (Tran Khac Thi 1999). Urea is the main inorganic fertilizer used in horticulture, especially for vegetables. There is often a lack of phosphorus and potash, and this can lead to an imbalance in the proportion of nutrients in the soil. However, the physical and financial access to fertilizers in general and inorganic fertilizers in particular is still a challenge for farmers in most developing countries.

Pesticides

Chemical pesticides have contributed to yield increases in agriculture in general for more than 50 years. Especially in peri-urban horticulture, easy access to pesticides (via national and international companies, retailers and wholesalers) and technical information has increased its use. However, this has also increased the negative perception of agricultural production in and around the cities. There are three major risks involved: (1) health risks for consumers; (2) risks of polluting the environment (mainly water sources); and (3) risks for users. Surveys have been conducted regularly on the use of chemicals, their rate of application and the period between the last application and the harvest for marketing. The application of pesticides on crops also endangers workers if little information is available on how to use them and when no protective measures are taken. This mainly affects low-income gardeners who cannot afford to buy proper protective clothing and equipment or are not aware of the importance of doing so.

In Vietnam, low-cost pesticides (organo-phosphates, pyrethroids, carbamates) with high toxicity (classes I and II) are very commonly used with little information about how to use them. Surveys show that application rates are much higher than the recommended rates for most of the pesticides used. This and the high spraying frequency are the causes for high pesticide residues in the marketed vegetables. But, in Hanoi districts, Huong et al. (2013) have shown that pesticide use was positively related to growth duration and profit. We must therefore continually insist on the application of Good Agricultural Practices (GAP) or compliance with current standards, and that research should find solutions as effective and less polluting for horticulture, especially in urban systems.

New trends in urban horticultural systems

Rural horticulture adapted to urban situations

Horticulture in urban areas requires some specific adaptations, as discussed in the previous sections. In this section we present some discussion on general cropping systems and their adaptation to the urban context.

Kessler (2002) describes the different farming systems in four West Africa capitals (Lomé, Cotonou, Bamako and Ouagadougou). In this study, the farming systems are characterized by the crops grown by farmers. The study reveals that differences in crops and inputs of the different farming systems are due to different economic strategies adopted by the farmers. Mixed vegetable farming with watering cans and/or with pumps to cultivate short- and long-cycle vegetables like lettuce, cabbage, carrots, onions, etc. is an example. Robineau (2013) in Bobo-Dioulasso described four types of farmers growing vegetables: small-scale urban gardeners with high diversification of crops, specialists in two vegetable crops; gardeners on public urban allotments and peri-urban vegetable farmers. Differences are based on number of crops, marketing and irrigation systems.

Similar systems are also described in Asia. Farming systems in the peri-urban areas of Hubli-Dharward (India) comprise vegetable production, agroforestry systems, Napier grass (fodder) production and small-scale livestock production (Bradford et al. 2002). In Hyderabad (India), the predominant system is paragrass production, which like Napier grass is used as fodder (especially in intra-urban zero-grazing dairy production). Green leafy vegetables are grown here on small sections for subsistence needs and for sale. Other crops include rice, fruit trees and flowers. There is also coconut and banana as well as livestock (water buffalo) keeping (Buechler et al. 2002). In Cagayan de Oro (Philippines), urban types of agriculture are characterized by home gardens as well as aquaculture and other specialized food crops (banana, cereals, vegetables, etc.). Production can be for home consumption as well as for market sale. Peri-urban agriculture is often dominated by irrigated vegetable production, as is the case in Vietnam or Malaysia. Other systems that can be encountered are commercial and domestic livestock production, flowers and seldom agroforestry (Potutan et al. 2000; own observations). Major systems mentioned for Shanghai are cereals, vegetable and livestock production (Yi-Zhang and Zhangen 2000).

Many additional types could be named using the major crops grown or animals raised as a criterion. A study under the Urban Harvest Programme in Cameroon identified three major types of cropping systems:

1 Mixed crop systems dominated by open-pollinated varieties (OPVs) of improved maize in the upland areas (vacant lots, unused municipal lands).
2 Mono-cropping systems of OPVs of improved maize grown in valley bottoms.
3 Intensive horticultural systems in valley bottoms, primarily for the production of traditional leafy vegetables (TLVs).

In addition, they observed that there is widespread use of small home garden plots for growing leafy vegetables and stands of banana, plantain, avocado, African

FIGURE 9.2 Watering plants close to Accra, Ghana
Source: IWMI (Image: Nana Kofi Acquah).

plum and other fruit trees around homesteads. Within these cropping systems, the research identified two types of agricultural units: "commercial" and "household food" producers based on the criterion of producing for sale, at least, half of the output from one of their products. The study found that women are the main producers of both household food and food for sale, accounting for 87% of the total sample (see also the case of Yaoundé).

Moustier (1999a) summarized the different descriptions found in literature of cropping and farming systems in five major types of urban agriculture based on a few traits: subsistence, family-based commercial or entrepreneurs activities; intra- or peri-urban locations; and number of crops grown. In Montpellier, Lenoble (2013) added the trait: cultivated area. In some cases, animal production may be associated with vegetables production as dairy in Meknes (Morocco), fishing in the Philippines or piggery around Bobo-Dioulasso.

So we observe in all these typologies a large diversity of systems that represent a continuum between rural and urban areas, including or not, plant and animal production, with different crops of different types as mentioned above.

Impact of food sanitary crisis

In Europe, food sanitary crises (dioxin, BSE, avian influenza, *Escherichia coli*) at the end of the 20th century had a lot of consequences for consumers and producers, and the "globalized agri-food system" is being considered as the main causing agent. As a consequence, different food movements and new forms of short supply chains between producers and consumers have emerged to redevelop the trust in the food supply: from Community Supported Agriculture (CSA) in North America, their French version being the AMAP (Associations for the maintenance of peasant agriculture), to Internet sales, going through different box schemes, direct selling on the farm, urban market places, and even direct selling to the large food distributors. In Europe these movements relate mainly, but not exclusively, with peri-urban market-gardeners that – due to the decreasing of vegetable prices in the wholesale market – were encouraged to change their production and marketing systems and to engage themselves in short supply chains to urban consumers in the region (see Chapter 5 for more details).

The interaction with the consumers involved in these short chain systems results in a trend to more environmental-friendly production practices and an increase in the number of horticulture farms producing organically or applying similar practices, such as biodynamic horticulture or permaculture, while many other horticulture farms seek to reduce the use of pesticides and agrochemicals.

In the city environment, new horticultural practices, such as organoponics, hydroponics, and permaculture, have emerged that maximize the use of space, optimize the use of inputs and minimize the impacts of horticulture on human and environmental health. Such practices will be described below. Crops are also grown on vacant open spaces of the city, such as brownfields, overgrown lots, abandoned properties and rooftops. The social organization of the horticultural use of these spaces can be individual, communal or mixed forms.

Community gardens

Community gardens have emerged in many cities in response to urban poverty and food insecurity, as a way to get access to culturally preferred, fresh and healthy food products and/or as a recreational and social activity. Community gardens may be worked collectively or split up in small plots that are assigned to individual households (then in Europe called "allotment gardens"), or a combination of both. Community gardens are established on land leased by the community group or association of allotment gardeners from the municipality, a school, church or hospital, from a private owner, or on vacant public or private land that is informally occupied.

Allotment gardens have been very popular in Europe for more than 150 years, although their functions have shifted over the years. The history of the allotment gardens is closely connected with the period of industrialization and urbanization during the 19th century, when a large number of people migrated from the rural areas to the cities to find employment and a better life. Very often, these families were living under extremely poor conditions, suffering from inappropriate housing, malnutrition and other forms of social neglect. To improve their overall situation and to allow them to grow their own food, the city administrations, the churches or their employers provided open spaces for garden purposes.

At the beginning of this century community gardens have re-emerged as a phenomenon of urban horticulture in different cities of North America and Europe, as well as in Latin America, Africa and Asia.

FIGURE 9.3 Eora Summerhill Community Garden, Ashfield
Source: Ashfield Council.

In developing countries this was mainly in response to the growing urban poverty and urban food insecurity and malnutrition. Many cities in the South run programmes nowadays providing (often temporal) access to vacant public land to groups of urban poor and underprivileged as well as basic training, seed and tools for community gardening. Next to access to nutritious food, generation of complimentary income and group- and self-confidence building are often also important impacts of the community gardens (see also Chapter 6).

The functions of community and allotment gardens in USA and Europe have gradually shifted from enhancing food security to semi-public green spaces with recreational, social, environmental and educational functions (Holmer and Drescher 2005; PUVeP 2008; Holmer 2010). Duchemin and Wegmuller (2010) have underlined their multifunctionality to reconnect social links, to have more nature in the city, to contribute to education as well as to a healthier urban life. However, Alaimo et al. (2008) and Litt et al. (2011) have showed that also in Europe and USA, participating in a community garden significantly increased intake of fruits and vegetables compared to non-gardeners and even to home-garden owners, even if the production in itself is low. A recent work underlines the variability of the food supply function among other ones in Paris and Montréal (Pourias 2014). In Eastern European countries community gardens still have an important weight in the urban food supply (Boukharaeva and Marloie 2010). The economic and financial crisis in south-western European countries leads to a new interest for these forms of self-made horticulture.

Permaculture

Due to the limited area for cultivation and the constraints this poses, agricultural activities within the city have to be efficient and have minimal impacts on the environment. Some integrated systems called "permaculture" have been developed to meet these requirements. They combine growing fruits, vegetables or grains with keeping livestock by creating a symbiotic ecosystem, with an ethical foundation in sustainability and copying nature, and a scientific basis in ecology. Permaculture (for permanent agriculture) is particularly relevant in the context of urban horticulture because it is a flexible option that suits city conditions due to the local recycling of energy and resources. The variety of production limits the risk and gives financial security. It is well suited to the developing countries because external inputs (chemical fertilizers, pesticides, etc.) are limited or absent.

Permaculture can be considered as one ultimate cropping system concept that uses a wide range of techniques and concepts: rainwater collection, excrement composting, reusing and recycling of wastewater and organic wastes, saving energy, green building and planning, and developing the local economy. For Holmgren (2013), who developed the principles of permaculture, urban agriculture will be a possibility to integrate the human material construction (the city) and the agriculture by renewing the place of the man in the

FIGURE 9.4 Permaculture garden
Source: Chriss Southall.

ecosystems. For example, in London (UK), Becontree Organic Growers in Dagenham develop the local economy through a local exchange trading scheme (Sherriff and Howe, pers. comm.). In Havana (Cuba), permaculture has been encouraged (Lazo and Barada, pers. comm.), where it has not only permitted the production of food, medicinal plants, spices and ornamental plants, but also resulted in a knowledge network by including a range of interested actors through periodic workshops, courses and conferences in environmental education and other related topics.

Organoponics

The term "organoponics" had its origin in Cuba where so-called *organopónicos* were organized as a response to the oil crisis in Cuba after the collapse of the Soviet Union in 1991. A shift to urban agriculture applying ecological principles seemed an appropriate response with minimized transportation costs and reduced need for machinery and petrochemical-based fertilizers and pesticides, which were no longer available (Bourque and Cañizares 2000). The organoponics are a labour-intensive form of urban gardens that often consist of low-level concrete walls filled with organic matter (e.g., wastes from the sugar plantations, composted household organic wastes) and soil, with lines of drip irrigation laid on the surface of the growing media and crops being sown or transplanted in holes or furrows (Novo 2003).

Organoponics can be constructed on all types of surfaces (even contaminated soils or former parking places) and as such it is well suited for vegetable production in intra-urban and peri-urban areas because it maximizes the use of space and water. Linking horticultural organoponic systems with ecological sanitation, as discussed by Arroyo (2003), may be an option appropriate to increase the productivity of organoponic systems if acceptability of the produce by the consumers can be assured.

FIGURE 9.5 Organopics Havana
Source: RUAF, courtesy of Martin Bourke.

Hydroponics

Hydroponics (or water culture) is a technology characterized by the absence of soil: roots suspended in moving water absorb food and oxygen. It needs less space, labour, external inputs and time, but needs proper management and often higher investments. As mentioned earlier, it is often difficult to control or quantify nutrient availability in the soil. Hydroponic systems provide a convenient means to control plant uptake of nutrients. An additional advantage of water culture is that the accumulation of soil toxins and some soil-borne diseases are likely to be reduced (Lissner et al. 2003).

When oxygen in the water is insufficient, plant growth will be retarded. This is a point to look carefully in warm climates. The grower's task is to balance the combination of water, nutrients and oxygen with the plants' needs in order to maximize yield and quality. The use of water and inputs is optimized: the exact amount needed by the plants is provided. For the best results, a few important parameters need to be taken into account: temperature, humidity, CO_2 levels, light intensity, ventilation and the plant's genetic make-up. In order to fix the crop roots in the required position, some inert substrata may be used (sponges, artificial mineral marbles, rock wool, etc.).

Hydroponics allows production in abundance of healthy fresh vegetables, ornamentals, and aromatic and medicinal plants, and suits the requirements of poor urban farmers. When the technique is well controlled, the productivity generated by hydroponic systems is greater than that from traditional gardening systems. It is

FIGURE 9.6 Hydroponic production of tomatoes in greenhouse, Gabon
Source: Hubert de Bon.

a technology adapted to the conditions where the soil is poor or polluted. In many countries of South America, hydroponics is a technique that is fast gaining importance (Tabares 2003).

Small hydroponic units can be operated by families. This may help in meeting their food needs and in getting an additional income. Some special hydroponic techniques have been developed, especially for limited spaces and to suit people in developing countries. Such simplified hydroponic systems often use recycled materials and are easier to understand, learn and implement (Caldeyro-Stajano 2004; Fecondini et al. 2009). Simplified hydroponics is a technology incorporating soilless culture techniques without using mechanical devices or testing equipment. This technology was developed in the early 1980s in Colombia and is propagated by FAO. It is accessible to people with limited resources and is optimized to use minimal inputs of land space, water, nutrients and grower infrastructure (see Box 9.2). A Family Economical Unit (FEU) of 20 bed-growers of 2 m^2 each (40 m^2) is designed to produce crops that bring an income estimated at USD 3.33 per day in Colombia (year 2000 figures). Simplified hydroponics is well suited for fresh vegetables and fruits (with a high water content) such as lettuces, tomato, bell pepper, basil, celery and radish.

BOX 9.2 COST ESTIMATION OF A SIMPLIFIED HYDROPONIC SYSTEM

In data gathered from the Colombia project, the results of garden productivity were averaged and the commercial values were estimated. The cost of building 20 bed-growers for the FEU from recycled wood is estimated to be USD 12.84 (6.42 m^2). The annual costs for operating a garden, using the same crops as in the Colombia project, will average about USD 355. This includes costs for medium replacement, seeds, nutrients and water. The annual net income from this garden is estimated to be about USD 1,210.00 (USD 101/month). Water is applied to the bed-growers and the excess water is collected underneath them and recycled to the growers the next day. The average water use for a grower is 2–4 litres/day/m^2 or at most 160 litres per day. The annual water requirement for each garden is estimated to be 60,000–120,000 litres.

Source: Bradley and Marulanda 2001.

Another interesting process is hydroponics with floaters, where plants are fixed on polystyrene beds that float over a tank. The water surface is completely covered by the floating bed, which permits a very limited growth of algae. The tank's nutritive solution is oxygenated, e.g. by a pump. This hydroponic system is characterized by a large volume of nutritive solution, no losses of water, minimal evaporation and the possibility to use the solution for many crop cycles. It is a low-cost method needing little maintenance. It is used in Martinique (French West Indies), an island with high constraints of space in peri-urban areas, for production of lettuce or onion (Langlais, CIRAD, pers. comm.). Hydroponic systems also present interesting solutions in combination with the recycling of water, and has been studied in water hyacinth, reed and flower (roses) production systems. Another possible future development of hydroponics is the production of bioenergy crops using wastewater as a nutrient solution (Mavrogianopoulos et al. 2002).

Water quantity and quality are key factors in hydroponic systems. Water quality depends mainly on the source used. Growers use water from different sources, such as surface water (lakes, natural and artificial ponds), groundwater (wells), municipal tap water, rainwater and combinations of these. Rainwater has a low ionic strength and usually low micro-organism and algal densities; it conforms to water-quality guidelines and is often better than other sources. A common practice is to collect rainwater from greenhouse roofs into ponds. However, as these ponds are fed by atmospheric precipitation, they are vulnerable to changes in the environment, e.g., eutrophication and acidification. Rainwater is not always available for use in irrigation because of technical problems in collection and storage. Therefore, the grower must find other water sources, e.g. rivers or lakes, but, in many cases, such sources are polluted (Schwarz et al. 2005).

The Gravel Bed Hydroponic (GBH) system developed by the University of Portsmouth, UK, includes a rock filter in gabions for primary treatment, GBH beds for secondary treatment and a pond for tertiary treatment. It reduced the biochemical oxygen demand (from 350 to less than 20 mg/l) of the output water in a bed planted with narrow-leaf cattail *(Typha angustifolia)* in Colombia (Stott et al. 1999). The use of plants is also a technique to improve the quality of the water for hydroponics (Vymazal 2011).

Urban horticulture in or on top of buildings

Will urban horticulture in the future be inside the cities, in and on urban buildings? This question is not at all an imaginary one, while urban agriculture, and chiefly (but not exclusively) urban horticulture is reaching the heart of the cities, with the conquest of indoors and more frequently of rooftops and walls. The "Z-farming" (for Zero Acreage farming) is now studied in its interests and functions to produce food and also for other non-food and non-market functions (Calkins 2005; Specht et al. 2014).

Some commercial farms, for the moment chiefly in North America (Brooklyn Grange or Eagle Farm in New York, Lufa farm in Montréal) and Asia (Sky Greens in Singapore) were born some years ago, with different technical systems: open-air rooftop production (with substrates like translated soils and/or organic ones), or on-the-roof greenhouses, generally with hydroponic production systems.

FIGURE 9.7 Rooftop greenhouse Arbor House in New York, USA
Source: Nexus.

In developing countries, horticulture on rooftops using either hydroponics or organoponics (often in containers, boxes, pots or other containers) is gaining in importance and allows production of various leafy vegetables and aromatics, often tomatoes, but could also be more diverse and include tubers and small fruits. For instance, in Senegal, rooftop gardening, based on bricks or wooden box beds filled with compost, allows growing a wide variety of crops, including fibrous roots crops, tomato, hot pepper, eggplant, etc. (Deesohu Saydee and Ujereh 2003). Such cultivation is characterized by its high level of intensity due to the small spaces available on the roof of buildings. Due to being located outdoors, these systems face natural attacks, e.g., of insects and birds, and some crops would therefore need protection, e.g., with nets.

Some forms of rooftop gardening are not commercial or not commercial alone. Rooftop gardens may be established to reduce storm water runoff and energy use of the buildings and/or to increase urban green spaces with various social, environmental and/or educational functions (like is promoted in New York and Singapore; the "Santropol Roulant" project in Montréal).

Another variation comprises the so-called vertical gardens or "green walls", which is a system where plants can be grown on, up or against the wall of a building such as a vine, as part of a window shade or in a vertical hydroponic system. Typically, they consist of indoor/outdoor modular planters with multiple levels of vertically spaced pots or planters. Using the vertical space instead of

FIGURE 9.8 Rooftop garden, Uncommon Ground Restaurant, Chicago
Source: Lauren Mandel, EAT UP.

horizontal space is an important feature for urban dwellers that lack space for growing horticultural crops, such as those living in apartments with small balconies. The system is also water saving, since it flows from the top plants, passing to all the lower pots.

A more artificial system that is proposed now is the plant factory (Kozai 2013): a closed space in a closed insulated building or other structure where plants are grown on tiered shelves under artificial light. In the factory, the concentration of CO_2, temperature, humidity, light intensity, light-versus-dark hours, and other conditions are controlled to help the plants grow faster. Plant factories vary in scale from large ones for commercial use, extending over 1,000 to 2,000 m^2 with 10 to 20 tiers of shelving, to smaller ones for households that can fit on a table top. Mainly leafy vegetables (lettuce, mizuna) are grown but experiments are ongoing with various other crops (including dwarf varieties of rice). The irrigation water of the hydroponic systems is recycled. Hypotheses are that in such an environment the risks due to pest and diseases will be almost zero, the contents in biological contaminants and heavy metals will disappear, and the development time of the plants will be shorter. This system could be used also for nursery, aromatic plants, herbs and all plants with short life cycles. Some large industrial companies have invested in these prototypes.

FIGURE 9.9 Plant factory at Chiba University Kashiwa-no-ha Campus, Chiba, Japan, operated by Mirai Co. Ltd.

Source: Prof. Toyoki Kozai.

As rooftop open-air farms, green houses and indoor plant factories are new forms of urban horticulture, a lot of research questions are emerging. Some are technical: What is the productivity of the open-air rooftop systems? How to apply urban organic wastes as crop substrates?

Are the available references for production in classic greenhouses valuable for these new intra-urban ones (Sanyé-Mengual et al. 2012)? What adaptations are needed in the design of buildings to integrate well rooftop green houses or indoor plant factories (strength of floors, dimensions/number of elevators, etc.? How to reduce the energy use in plant factories (improved LED lighting, solar panels, use of excess CO_2/heat/energy/water of neighbouring industry or bio-digesters at landfills; interactions with the zero or plus energy building programmes will be required). Will these "ultra short" supply chains permit to improve the taste and nutritive qualities of fruits and vegetables as they can be harvested at maturity, or will these qualities deteriorate (due to industrial production in plant factories)?

The issue of the movement of inputs, crops and crop residues produced by rooftop systems is also a consideration in the urban context and could be a limiting factor in the development of this form of agriculture if not accounted for in urban planning.

The environmental effects of cultivated rooftops on reduction of "urban heat islands", on reducing and slowing down of storm water runoff, and on urban biodiversity began to be studied sometime back (Eumorphopoulos and Aravantinos 1998; Bass et al. 2003; Oberndofer et al. 2007; Hitchmough 2010; Kowarik 2011). The effect of rooftop gardens on reducing the energy consumption of commercial buildings was measured to be up to 14.5% in Singapore (Wong et al. 2003; see also Chapter 8).

Some work also has started on the question of investments in relation to the energy cost and the value of the production, which raise the necessity of further technical improvements (Wilson 2002; Oberndofer et al. 2007; Bojaca and Schrevens 2010).

Conclusion

In many expanding cities in developing countries, urban horticulture is already a large contributor in supplying fresh produce to city markets and is expected to remain so in the near future. On the one hand, the available land will decrease because of the need for industrial development and urban housing. On the other, the demand for fruit, vegetables and flowers will increase with rising standards of living and growing populations. Horticultural production units will evolve and adapt to new environments as cities continue to develop. In the future, vegetable production will remain essential as a source of high income and healthy food for growing cities.

To answer consumers' demand and to produce healthy fruits and vegetable in a manner that respects the environment and producers, it will be necessary to combine agro-technical solutions with urban planning. In urban agriculture there will be a choice between (or combination of?): (1) anthropised agro-systems as proposed by permaculture with a "natural" use of some parts of the intra- and peri-urban lands, or (2) totally artificial city plant and animal production in buildings (plant factories). It is therefore important to undertake agro-technical studies that could provide more in-depth information on the conditions required for obtaining good-quality vegetables. Urban planning should help to provide optimal conditions for urban gardeners. Supply of inputs and materials, management of crop residues and linkage between activities are key points that need to be taken into account early in the urban planning process. It involves all aspects of a city's organization and requires commitment to provide goods and services to agricultural activities and people (Pinderhughes 2004).

Urban horticulture is nowadays in a state of deep, rapid and multiform renewal. Some cities like New York are facing a real boom of different forms of urban agriculture chiefly concerning vegetables and fruit productions (Cohen et al. 2012). Non-professional, professional and hybrid systems are emerging generally without real urban planning, or at the best with a partial one (Mansfield and Mendes 2012), changing directly or indirectly the way urban dwellers may have access to food production.

A lot of technical systems are also emerging in a double objective to produce tastier and more diversified vegetables than before, and to produce them in more environmental-friendly ways than "traditional" long chain supplying and industrial forms of horticulture. Research is needed to have more information on the advantages, possible disadvantages, complementarities and eventually competitions of these multiple forms or urban horticulture.

Various functions of urban horticulture have been mentioned in this chapter. The food supply function remains the most important, even though economic, social (labour), cultural, living environmental, environmental (recycling) and security (food and natural risks) functions appear to be essential too. More than any other agricultural system, urban horticulture has a multifunctional role that should be taken into account by researchers and policy makers. Implementation of an urban planning policy that includes the sustainability of this form of agriculture is a necessity for well-balanced urban development. Urban horticulture plays a substantial role in the development of local (micro)enterprises, including input supply, processing and marketing. It also reduces the distance that fresh food needs to travel from producer to consumer.

If well managed, urban horticulture can play an important role in reducing socio-economic and environmental problems in cities. Planners and policy makers should develop and support community-wide plans to improve poor people's incomes using urban organic waste, to improve urban food safety and to create sustainable food systems.

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10

URBAN LIVESTOCK KEEPING

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Introduction

For the first time in history, more people are living in towns and cities than in the countryside and at least one billion intra- and peri-urban dwellers are estimated to practise agriculture. Their farming varies from growing herbs on a windowsill, to cultivating a vegetable allotment, to raising poultry under their bed, to running a dairy.

Urban livestock keeping is an interesting aspect of urban agriculture. Compared to crops, livestock produce foods that bring more profits and have a higher nutrient content, but that are more expensive to produce and buy. Livestock products are highly perishable, a strong driver for producing them around cities; also, livestock products are more prone to spoilage and contamination with disease-causing organisms. Livestock require little room and can better share spaces with human beings, but they also create more nuisance, waste and injuries than plants. Hence maintaining livestock in ways that minimize risks and maximize benefits is a powerful indicator that urban agriculture is thriving.

This chapter considers the past, present and future of urban livestock keeping and discusses the benefits and risks and their management. We first review keeping of livestock in cities: nearly ubiquitous in historical times, gradually evicted from 'modern cities' over the last century, and their comeback in recent decades. The second section discusses the different types of livestock keeping in cities and provides up-to-date information on the extent of livestock keeping and its motivation. We then discuss benefits and risks of livestock keeping in cities and suggest ways to maximize the former while reducing the latter. Finally, conclusions are drawn and a way forward offered. The chapter as a whole revisits the earlier synthesis by Schiere et al. (2007).

History of livestock and cities

In the beginning was livestock, and then came cities

Livestock are older than cities. Bezoars, ancestral to goats, were probably the first animals to be domesticated around 11,000 years ago (Pereira and Amorim 2010), followed by cattle, whose ancestors were so large and savage they were almost not domesticated at all; the world's 1.3 billion head of cattle are descendants from an original population of just 80 aurochs (Bollongino et al. 2012). More peaceable jungle fowl have been domesticated on multiple occasions, starting at least 5,400 years ago (Miao et al. 2013).

Cities probably arose after the invention of agriculture (although some argue the other way round). Ancient cities often had only modest populations and archaeology suggests livestock mingled with citizens. With time, cities and civilizations grew, and by the year AD 100 the world's three most populous cities (Rome, Luoyang and Seleucia) had more than a million human inhabitants among them, and likely many more productive animals and peri-domestic pests. Animals were kept in biblical towns, in ancient and medieval European cities, in Mayan and Aztec city-states, as well as in Chinese civilizations (Schiere et al. 2007). In pre-colonial Nigeria, the edges of cities consisted of intensively farmed land where the majority of the urban population worked each day (Winters 1983), while in eastern and central African cities, the quarters of these cities were separated and the spaces between them used for farming. As one observer said of Kampala, "it was less of a city than an immense garden" (Gutkind 1963).

Up to the last century, equids, camelids, ruminants and canids transported people and goods into, out of and around cities. As late as the 1960s, citizens in Europe and America got dairy products delivered to their door by horse and wagon. In England, rag and bone carts did rounds to buy sellable discards, while dustcarts removed refuse for a fee. In America, urban dairying grew rapidly after the 1850s when breast-feeding fell out of favour for cultural reasons (Du Puis 2002). In the mid-nineteenth century New York, many dairies were attached to breweries and distilleries where as many as 2,000 cows could be maintained in one giant stable feeding on brewers' wastes, hot from the still.

Some cities owe their origins to livestock. The American stockyard cities such as Chicago, Kansas City, Fort Worth and "Porkopolis" (Cincinnati) depended on the livestock and meat-packing trade during their establishment and growth. By 1900, the Chicago stockyards employed more than 25,000 people and produced 82% of the meat consumed in the United States. They also provided the backdrop for Upton Sinclair's novel *The Jungle*. This book was intended to draw attention to appalling workers' conditions, but ended up becoming a *cause celebre* for food safety, eventually leading to the establishment of the US Food and Drug Administration.

> All day long the blazing midsummer sun beat down upon that square mile of abominations: upon tens of thousands of cattle crowded into pens whose

> wooden floors stank and steamed contagion; upon bare, blistering, cinder-strewn railroad tracks and huge blocks of dingy meat factories, whose labyrinthine passages defied a breath of fresh air to penetrate them; and there are not merely rivers of hot blood and carloads of moist flesh, and rendering-vats and soup cauldrons, glue-factories and fertilizer tanks, that smelt like the craters of hell – there are also tons of garbage festering in the sun, and the greasy laundry of the workers hung out to dry and dining rooms littered with food black with flies, and toilet rooms that are open sewers.
>
> *(Sinclair 1906: 8)*

Livestock leave (some) cities

The first half of the last century saw a striking decline in the number of productive animals in cities in North America, Europe and Australia. Some authors trace this de-urbanization of animals to attitudes emerging in the nineteenth century whereby animals were increasingly seen as "impure, polluting, disruptive, and discomforting occupants of city spaces" (Philo 1995). A belief which the quotation from Upton Sinclair suggests was not wholly unwarranted.

These developed country cities could throw off their agriculture because of the invention of fertilizers, refrigeration, and steam and motorized transport, which together created the modern food system. Agriculture became increasingly industrialized, large-scale, dependent on specialized and expensive inputs, and located far from urban consumers. In parallel, urban areas stopped being seen as spaces for food production (Bellows 2010), at least in the countries where agriculture intensified first.

Several well-documented case studies show how livestock left cities. Perhaps surprisingly, the temperance (no alcohol) movement had a major role in the de-urbanization of livestock in the United States. Feed has always been the most expensive input for intensive livestock keeping, and at the time, urban dairies were heavily dependent on by-products of city breweries and distilleries. Temperance leagues joined with physicians to campaign against filthy conditions of urban dairies and the resultant "white poison"; instead, they called for "pure country milk" to replace beer and gin (Shaftel 1978). These campaigns, along with the decline of the distillery industry, rising land values and 'standards of propriety', led to the expulsion of dairies from Brooklyn by the twentieth century (Tremante 2000).

Gaynor (2007) describes how livestock went from ever-present to almost-absent in Australia's cities. In 1895 metropolitan Sydney recorded no less than 8,246 sheep and goats, 7,318 dairy cows and 5,560 swine. By the late twentieth century, almost no productive animals remained. The decline resulted from an increasing intolerance to animals in residential areas, leading to zoning restrictions, prohibitive license fees and regulations that made keeping of livestock increasingly difficult. This was not an uncontested eviction and many people, especially women and the working class, resisted the re-imagining of cities as livestock free.

Many of the regulatory mechanisms to exclude livestock from cities were adopted by cities in Africa and Asia but their application was generally much less successful. A review of laws of southern Africa published in 1999 found that regulations on land use in urban areas were present in most countries but little enforced and corruption was regularly reported (Briscoe 1999). Although livestock were kept out of some residential and commercial areas, their presence was widely visible and indeed has been considered a characteristic of developing-country cities.

Livestock comeback

The eviction of livestock from cities, never total, was soon to prove transitory. The last 50 years have witnessed a remarkable resurgence of interest in urban agriculture, and with this keeping of livestock in cities. In Africa and Asia, where urban agriculture remained an important subsistence and economic activity, it was the focus for sporadic civic action and research from the 1960s on, but this failed to persuade international organizations or governments to take urban agriculture seriously (Lee-Smith 2010). But, around the same time, there was a blossoming of community farms in the UK, Europe, USA and Australia, probably linked to increasing environmental concerns and more leisure, and these movements had more influence in the policy arena.

As urban agriculture became popular, it started to attract the attention of development agencies and donors. In 1991 the United Nations Development Programme commissioned an assessment of the relatively unknown field of urban agriculture. Canada's International Development Research Centre (IDRC) later played a leading role in forging this new discipline. IDRC and other partners supported the creation of a key global network, the RUAF Foundation (International network of Resource centres on Urban Agriculture and Food security) (Mougeot 2011). The CGIAR launched a decade-long program on health and resource recovery dimensions of urban agriculture in selected cities.

In developed countries, attitudes and policies have gradually become more positive to urban agriculture. A survey of urban agriculture regulation in 16 US cities, including Washington, DC, Detroit and Boston found that most cities supported community gardens. Keeping chickens was permitted in many cities but fewer allowed keeping of other livestock or bees. Moreover, regulations regarding the keeping of animals were stricter than those for gardens and restrictions on where animals were kept and the number that could be kept were nearly always in place (Goldstein et al. 2011). In the UK, up to 50 household chickens can be kept without the need to register.

The same trends are seen in developing countries. The Food and Agriculture Organization of the United Nations (FAO) reports that in the past decade, governments in 20 countries have sought their assistance in removing barriers and providing incentives, inputs and training to low-income city farmers (FAO 2010).

But paradoxically, although developing-country cities were slower to eject livestock from cities, they have also been slower to accept them. A case study on urban policy-makers in Dharwad, India, observed that there was no official recognition of urban agriculture or policies to support it. Especially, urban livestock keeping was viewed by city officials as a major obstacle to fulfilling their responsibility of providing water and sanitation and the apex court had adopted regressive laws which ban 'stray' cattle and aims to phase out all cattle within cities of a population larger than 500,000 (Nunan 2000b).

Livestock in cities today

Why are livestock kept in and around cities?

In 2008, for the first time the majority of the world's population lived in cities, around one-third of them in informal settlements or slums. Over 90% of urbanization is occurring in poor countries and the urban population is expected to double from 3.3 billion in 2007 to 6.4 billion in 2050. Increasing urban populations create increasing demands for food products (Yeung 1988), as urbanization

FIGURE 10.1 Transporting live pigs by motorbike in Vietnam
Source: ILRI.

is associated with higher consumption of meat and other animal-source food products (Rae 1998; Delgado 2003) and greater reliance on ready-to-eat foods.

The massive increase in demand for livestock products over the past few decades has created equally significant opportunities for smallholders who raise animals to meet that demand (Herrero et al. 2010). In urbanized economies, there may be fewer opportunities for smallholder provision of livestock commodities; but this also varies, with smallholders being far more competitive, for example, in the dairy sector, but far less likely to prosper for monogastric production (Tarawali et al. 2011).

In many developing countries, transport infrastructure is inadequate and expensive and it is difficult or impossible to maintain a cold chain. Hence, growing demands for perishable products can best be met by nearby production: it is most efficient to produce milk and eggs and slaughter livestock for food as near to the point of consumption as possible (Schiere and Hoek 2001; Veenhuizen and Danso 2007). Figure 10.1 shows some of the challenges of transporting pigs without a cold chain in Vietnam and, partly as a result, 97% of the pork consumed in Vietnam is sold in wet markets. By bringing live pigs to cities, and reducing times between slaughter, sale and consumption, large amounts of pork can be cheaply delivered to millions of urban consumers (Fahrion et al. 2014).

In some countries, policy-makers have actively encouraged farming within city limits. In China, making cities self-sufficient in food is a policy objective. Within Beijing, intra-urban agriculture supplies 70% of non-staple food to city inhabitants (consisting mainly of milk and vegetables) (FAO 2011). In developed countries, livestock are often kept for reasons other than production or work: mainly leisure and community development.

Where are livestock kept in cities?

Animals can be kept almost anywhere in and around cities and towns. There is a tendency for livestock density to decrease as human density increases, and for livestock to be less present in slum and central business areas (Lindahl et al. 2012). However, this is not absolute. For example, a study in a Vietnamese city found that pig-farming can persist at even high human density and in many cities livestock may pass through highly populated areas, either providing transport or looking for food. In densely populated slums, livestock are less common and small stock, such as poultry and rabbits, which have minimal space requirement, predominate (Figure 10.2).

The suburbs and outer areas of cities typically have more space and available biomass for feeding animals. In these areas, dairies are common (Figure 10.3) and so are multi-species enterprises, which may include poultry, dogs, cats and rabbits. The specialized sheep- and goat-fattening systems, which are a feature of semiarid systems, are also typical of suburban farming.

Outside the city bounds there are often fewer regulations that restrict livestock keeping while access to the large city markets is still good. Unsurprisingly, peri-urban production is characterized by larger farms, more animals and a greater

FIGURE 10.2 Pigeons in Burkina Faso require little space or housing costs
Source: ILRI.

FIGURE 10.3 Peri-urban dairy in Bamako, Mali
Source: ILRI.

business orientation. Peri-urban production is predominantly based on pigs and poultry because these are most suited to intensive production. Commercial peri-urban production of livestock is an extremely fast-growing sector, representing 34% of total meat production and nearly 70% of egg production worldwide (FAO 1999).

The importance and character of urban livestock also vary by region:

- **Asia:** More than half of the world's urban population live in Asia, and more than 60% of them are estimated as poor (Mougeot 2005; Satterthwaite 2010). Urban livestock keeping includes rearing of dairy cattle and buffaloes, small ruminants (sheep, goat), pigs, poultry (chicken, ducks, turkey) and small animals like guinea pigs, rabbits and pigeons. They are reared in intensive systems or backyard, scavenging systems. As in other parts of the world, the species present in the urban livestock keeping are reflections of the species commonly kept and consumed in the area. Whereas India has a large number of urban dairy cows, Vietnam and China have higher proportions of urban pigs and Indonesia of poultry.
- **Africa:** Today, about 40% of the African population live in urban areas. Over the next four decades, Africa's urban population is likely to triple in size. In many cities of sub-Saharan Africa, slums account for three-quarters of urban residents. Studies show that livestock keeping is common in African cities and that smaller livestock (poultry, rabbits) are most common, but keeping of sheep and goats (called shoats in East Africa) and dairy cattle is also prevalent (Kang'ethe et al. 2007). Cities in South Africa have tended to have fewer livestock and those of West Africa the most (Heilig 2012).
- **South America:** Three-quarters of the population and half of the poor in Latin America live in cities (Fay 2005). Swine and poultry are the two more common species raised in urban areas in Latin America, although rabbits are becoming more popular. Guinea pigs have been historically domesticated and raised for food in the Andean region of South America. In the periphery of the cities, small ruminants in small to medium-size herds are common. These animals are walked to public lands for foraging during the day and brought back at night to be housed in patios adjacent to houses (Correa and Grace 2014).
- **Europe and North America:** In developed countries, livestock are often kept as part of community development or as a leisure enterprise. Livestock are kept in petting zoos, children's farms, rare breed farms, science museums and residential care homes for the disabled (LeJeune and Davis 2004). Currently, there are around 136 million international migrants living in developed countries, with numbers continuing to rise (OECD 2013). Many immigrants come from a rural background or developing-country cities where livestock keeping is ubiquitous and they often choose to keep city livestock in their new home.

Who keeps livestock in cities?

The rapid growth of cities has led to previously rural areas being incorporated in cities. Many of the original inhabitants were farmers, and have continued their occupation as cities engulfed them. At the same time, many poor people have left the countryside to seek new opportunities in cities, and brought their livestock or their habits of livestock keeping with them. Livestock keeping is widespread among poor people. Recent estimates suggest nearly 1 billion people living on less than two dollars a day are dependent to some extent on livestock (Staal et al. 2009), so it is not surprising that the influx of poor people to cities has led to increases in urban livestock keeping.

Livestock keeping in cities can be very profitable and has attracted entrepreneurs, sometimes with no background in livestock keeping. Many of these are young people with tertiary education but who cannot find jobs in the formal sector.

How common is livestock keeping in cities?

Obtaining accurate information about the extent of urban livestock keeping is not easy. The largest urban populations live in the informal settlements of rapidly growing cities in developing countries. But in these areas there is little reliable information on human demography, let alone animal populations; additionally, the ambiguous legal position of livestock keeping also hinders reporting.

Schiere et al. (2007) summarized some earlier studies and reports on livestock in cities: over one-third of households surveyed in Harare, Zimbabwe, kept chickens, rabbits, pigeons, ducks and turkeys. In Cairo, Egypt, 5% of households kept small animals like chickens and pigeons. Some 41% of the households in Hue City, Vietnam, had livestock and 80% of Dhaka's (Bangladesh) inhabitants kept animals. However, many of these earlier reports lacked sufficient rigour to accurately estimate livestock populations. Moreover, as livestock keeping in cities has long been controversial, estimates by interest groups are prone to an upwards or downwards bias. Box 10.1 describes a study, which overcame the challenges of gaining information of livestock in cities to develop an accurate estimate of actual numbers along with an estimate of uncertainty.

BOX 10.1 ESTIMATING THE NUMBER OF LIVESTOCK KEEPERS IN CITIES

As part of an IDRC supported study, the International Livestock Research Institute (ILRI) undertook the first statistically rigorous survey of livestock keeping in two cities in Nigeria. As there was no reliable census for households or livestock keepers, households were selected by random sampling from a spatial grid. Nearly 2,000 households were involved with 985 detailed questionnaires. In Ibadan and Kaduna, with a combined human population of approximately 1.7 million, around 2 million livestock are kept. Chicken predominated (1.7 million), and sheep and goats (shoats) were also common (200,000). Cattle were comparably infrequent (15,000), but around 200,000 from a wide range of niche species were kept (turkey, guinea fowl, quail, snail, grass-cutter, camel, etc.) Two-thirds of households reported keeping livestock on the compound in the last year. Poultry keeping was most common (46% of households), followed by small ruminants (31% of households), while cattle and pig keeping was rare (2% and 1%, respectively). Herd size was generally small, but a small number of households kept substantial numbers of animals (3% of households had more than 100 animals on the compound). Livestock contributed most to food (purchase or direct consumption) and to a lesser extent to general expenses, school fees and medical fees.

Source: ILRI project report.

In 2007, in India, the Ministry of Agriculture estimated there were 67 million livestock in Indian cities (6% of the total livestock in India) or one livestock for every five persons in cities (Singh et al. 2013). Numbers were dominated by poultry but cattle made up 85% of the livestock biomass. Numbers of poultry and cross-bred cattle were increasing rapidly and goats slowly: sheep, pigs, equids and indigenous cattle were declining. This implies the dairy and poultry, which can best supply rapidly increasing demand, are increasing while less-productive animals are declining and transport animals are being replaced by motor vehicles.

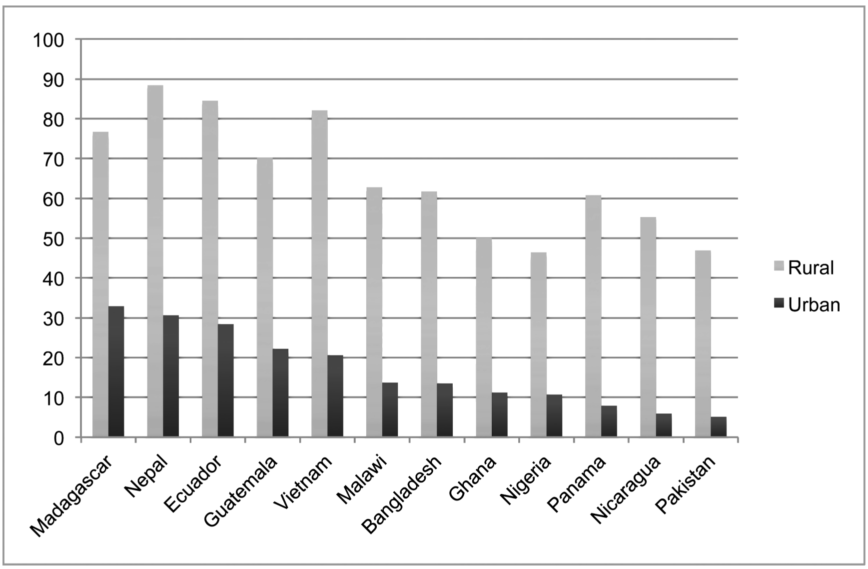

FIGURE 10.4 Livestock keeping by rural and urban households in 12 developing countries

Source: Data from Pica Ciamarra et al. 2011 (Image: ILRI).

A recent study provides solid information on livestock keeping in 12 other developing countries between the years 1995 and 2004 (Pica-ciamarra et al. 2011). Across the 12 countries, 65% of rural households and 17% of urban households kept livestock. If this proportion is extrapolated across the 2.5 billion people who currently live in developing-country cities, it implies there are 450 million people in urban livestock keeping households in poor countries. The study also found that, in cities, poor people were much more likely to keep livestock, whereas in rural areas, it was often the rich who had more and higher-value livestock. Although little information is available, it is probable that in developed countries a much lower proportion of households keep livestock. In developed countries, a far lower proportion of households keep livestock, although the trend has been upwards, probably less than 5%.

How are livestock kept in cities?

Livestock keeping in cities is highly diverse (Table 10.1). Systems may be categorized according to location (slum, urban, suburban, peri-urban); species (from guinea pigs to camels); farming system (intensive or semi-intensive predominate); production objective (food, money, draft power, financial services, assets and psycho-social well-being); and stage in the value chain (supplying young stock, males for breeding, livestock products).

Livestock as well as other animals are often kept for production or work. Most common are dogs and geese for guarding houses and compounds, and cats for pest control. In South East Asia, songbirds and fighting cocks are also common. In West and Central Africa, wild-caught deer and monkeys may be kept as curiosities. Table 10.1 summarizes some of the characteristics of urban livestock diversity.

In developing countries, the most common urban livestock keeping systems are backyard poultry, urban dairying, pig-keeping and fattening of sheep and goats.

Backyard poultry: Poultry are probably the most common type of livestock kept in urban areas. It is likely that poultry are present in all developing-country cities and towns in Africa, South Asia and South East Asia. A study from Kampala reveals a typical system. The household contained on average 8 persons and 17 local chickens. Women were most commonly in charge of chickens. The main reason for keeping poultry was income, and additional reasons were for food for the household and manure. Neighbours were positive about urban chicken production, 70% saying they benefited directly. One respondent stated, "Friendship is formed because chickens scavenge on my land" (Dimoulas et al. 2008). In India, large-scale poultry farms exist near every big city. In North America, poultry are the most commonly kept backyard livestock and seem to be increasing. A 2010 US Department of Agriculture study in four urban areas (Los Angeles, Denver, Miami and New York) found that 4% of the households planned to get chickens within the next five years, compared to less than 1% who had backyard poultry at the time of the survey (USDA 2013).

TABLE 10.1 Typologies of urban livestock keeping diversity

Diversity in scale	*Diversity in species*	*Diversity in management*
Small-scale predominates but medium- and even large-scale are found. In Nairobi, a crowded city with a population of 2 million, there are 1,350 commercial pig and poultry farms linked to national chains. Farmers with 3,000 birds or 50 breeding sows can earn USD $1,000 per month.	Small stock (poultry, sheep and goats) predominate but dairying and feedlots are found in most cities. Niche and unusual species are common. These include rabbits, snails, grass-cutters (greater cane rat), cattle, dogs and even camels. Often, a mix of species is kept.	Backyard systems where animals are confined to premises but allowed to roam freely for part of the day are most common. Permanent housing (zero-grazing) is a high input, high output system. The poorest often let animals scavenge freely or illegally use common spaces (roadsides, open areas, rubbish heaps).
Diversity in production objective	Diversity in input level and capitalization	Diversity in farmers
Unlike other urban agricultural activities, production for sale is usually the most important objective. Self-consumption usually ranks second. Other functions are: - Financial - Converting by-products - Social (status, presents) - Pleasure (the enjoyment of living things, hobby)	Businesses generating high profits such as dairying and fattening male sheep for Ramadan and Eid are usually high input. Most livestock kept by the poor are in low external input systems.	Women have a high involvement in livestock keeping. The poor have a high involvement. The poor generally keep a wider mix of lower-value animals (indigenous species and small stock) than do richer farmers.

Sources: based on UNDP 1996; Waters-Bayer 1996; Schiere and van der Hoek 2001; Schiere et al. 2007.

Dairying: Dairying is probably the second most important urban livestock system. It is common in cities and towns inhabited by milk-drinking cultures. These are mainly found in East Africa (especially Kenya and Ethiopia), Sahelian cities of West Africa and South Asia. Studies in Nairobi and Addis found one in 100 urban households kept cattle and in Indian cities there was one bovine for every 20 persons. These cultures have rich traditions around cattle.

There are also emerging dairies in cities without a tradition of milk-drinking, such as South East Asia. These are much less numerous and, in some cases, interesting new systems have evolved. A study in Greater Beijing found that approximately one-quarter (26%) of farmers checked into cow hotels after the Milk Scandal, increasing from 2% before the crisis (Mo et al. 2012).

Pig-keeping: Urban pig-keeping is most common in South East Asia and North East India. Pork-China is often compared to Dairy-India, because pork has the same central role in China as dairy products do in India. Pigs are reared near and inside every city of China. Estimates suggest around 500 million pigs are kept, with 60% in intensive systems which are generally urban or peri-urban. In the Philippines, 30% of pigs are kept in commercial herds and 65% of these are near the major urban market of Metro Manila (one pig per three persons).

Small ruminant-fattening: Sheep- and goat-fattening is common in towns and cities of arid and semiarid regions of West and East Africa and the Middle East. In these systems, sheep and goats are born in rural areas and reared in extensive, low-input systems and then taken to cities for intensive fattening before slaughter. However, free range sheep and goats are found at lower densities in Asia and southern Africa. In the Sahel and Middle East, fattening is linked to the Islamic festival of Eid-al-Kabir (Tabas ki) (Ayantunde et al. 2008). In Ethiopia, it is common to see sheep and goats in urban areas, including the capital, Addis Ababa. Feed resources are usually household wastes, market area wastes, mill left-overs, by-products and roadside grazing (particularly in the peri-urban system (Abegaz et al. 2002)).

What other activities do urban livestock keeping necessitate?

The entire livestock value chain is compressed into urban areas. Figure 10.5 shows some of the different stakeholders involved in the urban livestock chain. These include:

- Input suppliers: Feed, fodder, housing material, equipment, drugs, animals, utilities.
- Service suppliers: Extension, health and breeding advice.
- Producers: Ranging from small to large scale.
- Transporters: Inputs, animals, livestock products.
- Processors: Abattoirs, dairy cooperatives, food processing.
- Retail: Door-to-door hawkers, street sellers, kiosks, milk bars, restaurants, shops, supermarkets.
- Consumers: household, institutions (schools, hospitals), restaurant consumers.

All of these stakeholders are present in many or most developing-country cities. In the developed world, large-scale processing operations (abattoirs, dairy cooperatives) and larger farms have been mainly moved outside cities. In some developing countries there has been a dramatic increase in farmers' markets. According to USDA-AMS-Marketing Services Division, in the USA, the number of markets nearly doubled from 5,000 in 2008 to 8,144 in 2013. These typically sell livestock products, but not live animals.

Live animal markets: Live animal markets for cattle, sheep and goat are often found in, or close to, cities. These are often referred to as terminal or tertiary markets, as large numbers of animals are brought from smaller markets or other countries for distribution or sale. In many cases animals are sold to butchers for slaughter, but other animals may be bought for fattening, breeding or work. For example, the Niamana market in Bamako, Mali, is the largest in the country. Around 25,000 animals are sold each month. Live markets are dominated by cattle,

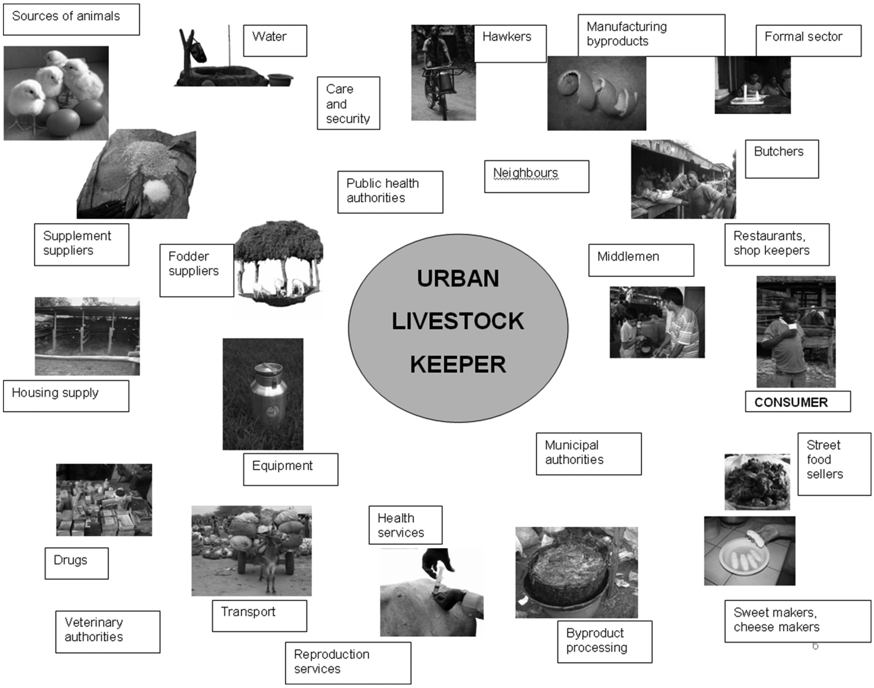

FIGURE 10.5 Different stakeholders involved in providing inputs to and taking up products from urban livestock keepers

Source: ILRI.

sheep and goats. Pigs are typically sold from the farm to the butcher or slaughterhouse, and poultry and eggs are sold alongside other perishable products in wet markets.

Slaughterhouses: Many of the cattle, goats and sheep bought in terminal markets will be slaughtered in urban abattoirs. Urban slaughterhouses have typically poor conditions but the lack of a cold chain makes it imperative that animals are killed close to the point of consumption. For example, a typical abattoir in a West African city may kill 300–400 animals a day. Slaughter is done without stunning on a concrete slab. The lack of infrastructure leads to filthy and unpleasant conditions. Many animals are not inspected and even when problems are found veterinarians find it difficult to ensure condemned meat is discarded. If an animal is condemned by veterinarians as unfit for human consumption, middlemen lose their entire days' earnings, so they strongly resist attempts to condemn meat.

Wet markets: Most of the livestock products produced in and outside developing-country cities is sold in wet markets. These exist in many different forms across Africa and Asia but have common characteristics: food escapes effective health and safety regulation; many retailers do not pay tax and some are not licensed;

traditional processing, products and retail practices predominate; infrastructure, including water, electricity, sanitation and refrigeration, is lacking; and little support is provided from the public or the non-governmental sector. Unsurprisingly, women and the poor have much greater involvement in informal markets. In addition to their meat and eggs, poultry and rabbits, animals are most commonly sold live to be slaughtered in the household or by the producer of ready-to-eat food.

Hawkers and retailers: Eggs and dairy products are often sold directly to neighbours: a very short value chain. In addition, traders may buy eggs and milk to sell directly to consumers or to other users. Especially in India, hawkers often have an established round whereby they deliver milk direct to the doorstep. Figure 10.5 illustrates some of the different ways peri-urban milk makes its way to consumers in India.

Street food: Many livestock products end up as street food (FAO/WHO 2005). Street food is a source of inexpensive, convenient and nutritious food and is especially important for the poor, who lack resources to prepare meals at home (Riet et al. 2001). In Ghana, for example, a study found that among the poorest quintile almost 40% of the total food budget goes to purchasing street food, compared to just 2% in high-income households (Maxwell et al. 2000). Lower-cost livestock products are popular types of street food. In Kenya, vendors sell sausages as a franchise business. In South Africa, 'walky talkies' are chicken feet and heads sold ready cooked. In most African countries, the majority of street-food processors and vendors are women (Canet and N'Diaye 1996), while the majority of customers are men (Nago 2005), and animal source food is often sold alongside alcohol in roadside eateries (the pork joints of Uganda, pubs in Tanzania and dietaries in Senegal).

Benefits and risks associated with urban livestock keeping

Food and nutrition security

Urban livestock keeping contributes directly to food security by providing food for consumption and contributes indirectly to food security by providing income to buy food. Animal-source foods (ASF) are nutritionally dense sources of energy, protein and essential micronutrients. Micronutrients tend to be more bio-available in animal-source foods, and some, such as vitamin B12, are found naturally only in animal-source foods (Smith et al. 2013).

Cross-country evidence consistently shows children in urban areas are better nourished than those in rural areas. For example, in 82 out of 95 developing countries for which evidence is available, the proportion of underweight children is less in urban areas (UNICEF 2013). Moreover, livestock products benefit not just the poor but also middle-income households, who prefer fresh products and pay a premium for fresh milk (Nunan 2000b).

Yet, despite the obvious connection between producing food and consuming food, recent reviews agree that there is little evidence that farming benefits nutrition (Leroy et al. 2008; Webb et al. 2008). This is partly because many evaluations of agricultural interventions have not looked at nutritional outcomes, but it is also possible that direct access to livestock products is offset by the need to obtain income. For example, experience from India shows that poorer households keeping buffaloes sell more of the milk produced and keep back less for home consumption (Nunan 2000b).

Income, assets and financial instruments

Production and processing of livestock may be the main or a subsidiary source of livelihood. Animals contribute to income sources in a household and, therefore, agriculture improves the ability to spread livelihood risks in a largely informal economy where the majority of the urban poor are daily-wage earners (Lupindu et al. 2012). Employment in intensive urban-rearing systems also forms a ready poverty alleviation pathway for those who are recently migrated from rural agricultural systems.

In countries with poor performing financial markets and weak credit systems, livestock act as savings, insurance and collateral. They are critical assets available even to disadvantaged groups that are not entertained by the formal credit suppliers. They reduce vulnerability of households to unplanned expenditures and act as collateral for quick loans (Randolph et al. 2007).

There are few formal studies on the economics of urban livestock keeping, with most studies on nutrition and livelihood benefits or health impacts.

Health impacts

By providing nutritious foods and by generating income that can be used for health care, urban livestock keeping makes important although indirect contributions to health. Negative impacts of overconsumption of ASF are increasingly contributing to chronic diseases, such as cardiac disease, even in developing nations plagued by malnutrition (Randolph et al. 2007).

A direct health advantage of urban livestock keeping is zooprophylaxis, or the reduction of transmission of diseases by using animals to attract disease-transmitting insects away from people. Recommended by the WHO as a management strategy for malaria since 1982, it has been found to be effective if (but only if) epidemiological factors are favourable. For example, pigs have been associated with a greater risk of Japanese encephalitis viral transmission in urban areas, but the presence of livestock like cattle may be a protection as they divert mosquitoes away from human beings or pigs by providing alternative food sources (Lindahl et al. 2012).

However, urban livestock keeping is also an important source of health risks in the urban environment. These may be categorized as occupational risks encountered by people working in livestock value chains and public health risks that affect the wider urban population.

Occupational hazards include:

- Mechanical injuries and ergonomic morbidity resulting from close proximity to animals as well as repetitive tasks associated with urban livestock keeping often carried out in confined spaces.
- Bio aerosols include biological agents, endotoxins, gaseous irritants as well as allergenic factors like dust, fungi and mites. This increases the risk for immunotoxic occupational diseases of the respiratory organ (bronchitis, occupational asthma and inflammation of the mucous membrane), especially in vulnerable groups such as children and the elderly, as well as manure handlers and poultry farm workers (Myers 2011).
- Biological agents include viruses, bacteria, fungi, microbial toxins and various particles of plant and animal origin. Many of these include zoonotic diseases. Value chain actors other than farmers are also susceptible, especially abattoir workers. Exposure to *Brucella* was found to be 22% among abattoir workers in Abbottabad, Pakistan, and as high as 35% in endemic regions in Saudi Arabia (Mukhtar and Kokab 2008).
- Bacterial resistance factors may be more common in the micro-flora of urban animals as antimicrobial agents are more accessible, and may be more used. These can transfer to humans. It is also interesting to note study findings that have identified resistant bacteria in the nasal, throat and faecal microflora of pig farmers (Aubry-Damon et al. 2004).
- Chemicals are often used in urban livestock keeping including pesticides, fungicides, antibiotics, and cleaning and disinfection agents. In addition, water used in urban livestock keeping may include agricultural or industrial chemicals.
- Allergens produced by microscopic fungi pose an occupational hazard (Dutkiewicz et al. 2011).

Close proximity to livestock and waste management practices create not only zoonotic risk to livestock keepers but also public health risk to urban populations. These diseases can be categorized by their transmission routes:

- **Direct transmission:** Crowding and high density of population constitute a contributing factor in direct transmission of pathogens where pigs, poultry and livestock act as intermediary hosts (De Haan 2013).
- **Vector-borne:** Cities without a proper sewage and waste disposal system favour vectors such as mosquitoes and rodents that transmit malaria, and viral diseases like dengue, Rift Valley fever, Hanta virus and West Nile Virus (Baumgartner and Belevi 2001). A study in Can Tho City, Vietnam, showed that urban pig-rearing increased the number of mosquitoes competent as vectors for JEV (Lindahl et al. 2012).
- **Water-borne:** In addition to vector-borne diseases, open sewage and untreated urban waste also aid in transmission of zoonotic parasitism. Important water-borne zoonoses include salmonellosis and cryptosporidiosis.

- **Urine-borne:** Diseases like leptospirosis are re-emerging as a public health problem in urban centres. This is attributed to increased exposure of humans, especially children to playgrounds, and recreational spaces contaminated with the urine of reservoir hosts (Dutkiewicz et al. 2011).
- **Food-borne:** There is evidence from major cities in Nigeria, India, Brazil and Saudi Arabia on human brucellosis infection and echinococcosis transmitted by domestic livestock through food (Satterthwaite et al. 2010). Brucellosis can spread to humans by drinking unpasteurized milk. Food-borne pathogens not only cause active infections or toxin-related symptoms, but also endanger intra-uterine foetuses (Listeria and Toxoplasma) causing death or serious malformations (Birley and Lock 1998).

In addition to zoonotic diseases, urban livestock keeping can threaten human health by antibiotic resistance and exposing people to agro-chemicals and livestock waste.

- Emergence of antibiotic resistance has been linked to the higher disease burden and higher production costs in urban farms. These drive farmers to over-use antibiotics. Leaching, improper waste disposal and contaminated animal faeces can introduce these antibiotic-resistant pathogens into the food chain. Antibiotic resistance in human pathogens may also result when people eat products that contain high residues (Birley and Lock 1998).
- Chronic illness has also been associated with agro-chemicals in the food chain in urban ecosystems (Birley and Lock 1998).
- Livestock waste generates as many as 60 volatile and non-volatile compounds. This can cause nausea, headaches, breathing problems, sleep interruption, appetite loss and irritation of the eyes, ears and throat. The urban poor, residing closer to open dumps, appear to be more exposed to this environment.

Increased animal transportation increases the spread and distribution of disease pathogens. This transitioning epidemiology is further influenced by persisting rural and pastoral practices in urban areas (Flynn 1999). As mentioned earlier, pastoral practices like open grazing, and scavenging practised for ruminants, poultry and pigs magnify the zoonotic risk in crowded urban and peri-urban spaces. One example is the increased prevalence of echinococcosis. What was essentially a rural disease is fast establishing itself as an urban menace. Despite a lower prevalence in urban canine population when compared to rural population, risk of transmission to humans is higher in urban areas due to greater human–animal contact. This situation is further aggravated in policy environments where food security takes precedence over food safety (Randolph et al. 2007). The non-adaptation of husbandry practices in response to urbanization and related changes increases the risk of urban population to zoonoses.

FIGURE 10.6 Urban food is often prepared under unsanitary conditions
Source: ILRI.

Direct environmental impacts

Urban livestock keeping can contribute to the reuse of urban solid and liquid waste. Easy and cheap access to by-products of the food processing industry (bran, oilseed cakes), hotel refuse and kitchen waste in urban spaces is one of the main reasons why urban livestock keeping flourishes and remains profitable in urban ecosystems. Along with better management of urban waste, organic manure from the livestock industry helps in maintaining soil fertility for gardens and recreational spaces (Randolph et al. 2007).

However, urban waste is considered one of the most serious and pressing urban environmental problems, and urban livestock keeping contributes to this. Abattoir effluent containing blood, fat, solid waste (intestines, hair, horns, etc.) and rumen content are often discharged into nearby rivers and reused for crop irrigation and as drinking water for cattle. Dumping solid wastes from livestock production or abattoirs is common. Nitrates from feedlots percolate to groundwater, and runoff into water sources is said to contribute to water contamination. Urban livestock keeping increases the competition for resources such as water and land. This can exacerbate prevailing shortages for household and industrial use.

Environmental impacts can be mitigated if farms in peri-urban spaces can develop better waste management practices. Some farmers generate a substantial part of their income from the sale of organic waste. Other farmers install biogas plants or dry manure for direct usage as cooking fuel (Ishagi et al. 2002). The latter use is less beneficial as biomass fuels form the largest source of indoor air pollution, causing acute respiratory disease in children and chronic obstructive lung disease in adults (Birley and Lock 1998).

Greenhouse gases and contribution to global warming

Ruminant livestock are a major contributor (18%) of global anthropogenic greenhouse gas emissions (Gill et al. 2010), and may cause up to 2% of global warming in the next 50 to 100 years (Johnson and Johnson 1995). The negative impact of global warming is also felt by peri-urban farmers through major floods and landslides as well as degradation of grazing land (Deka et al. 2009).

However, intensification of livestock can reduce the emission of methane and other greenhouse gases per unit weight of livestock product produced, as intensive agriculture produces more outputs per animal. In developing countries, most intensive livestock systems are urban or peri-urban. For example, 80% of the Chinese operations related to large intensive livestock are located around Beijing and Shanghai. Similarly, almost all intensive pig farms in Kenya are located around Nairobi (Burney et al. 2010; De Haan 2013; Havlík et al. 2014). Urban agriculture also reduces carbon footprint of cities by reducing the traffic flow of food and manure from distant rural areas and by substituting non-renewable fuels with biogas or biomass (Nunan 2000b).

Equity

Overall, men have more ownership of livestock and their products. Typically, men have ownership and responsibility for larger and more valuable animals, and as farms become more intensive and highly capitalized, male participation tends to increase. In backyard farms, women and children are often responsible for care-giving tasks (feeding and cleaning), thus making them more prone to health risks from occupational exposure. However, smaller ruminants and poultry are women's most important assets and income (Niamir-Fuller 1994; Deka et al. 2009; Smith et al. 2013). In addition, women are often involved in dairying, traditional processing of foods, and foods in wet markets and streets.

In rural areas, livestock keeping tends to increase with wealth but in cities the reverse is the case and the poor keep more livestock. In general, urbanization is often associated with worsening equity. For example, poor children in urban areas are at up to ten times higher risk for childhood stunting than the wealthiest group, differences which are not so marked in rural areas (Menon et al. 2000; Smith and Aduayom 2003). Urban livestock keeping could help improve nutritional and income equity in urban areas.

Social impacts

Urban livestock keeping also aids in increasing social cohesion and improving the social position of farmers in urban communities. Urban farmers in India sell milk directly to hotels and households in exchange for kitchen waste. Some farmers milk their cows in front of consumers to assure clean and unadulterated produce (Nunan 2000a). Trust in the community improves social security of farmers and aids social cohesion. In low-income urban districts of Bissau, urban farmers contribute to community welfare and funeral groups and gift their home produce as a reciprocation of social support, especially in times of distress and natural calamity (Mougeot 2000).

However, urban livestock value chain actors can be in conflict amongst themselves as well as with other groups such as non-rearing neighbours and civic authorities. In cities with shortage of water resources, livestock farmers compete with other industries for these resources and thus may face a hostile neighbourhood. Livestock farmers have been in conflict with non-rearing neighbours on the detrimental effect of the surrounding aesthetics caused by organic waste and pests. While farmers following the intensive system of rearing have conflicts regarding waste disposal, those involved in backyard farming and scavenging system can have conflicts associated with damage to neighbourhood gardens, theft, accidents on road traffic as well as injury from aggressive livestock (Ishagi et al. 2002). A study in Nigeria found that urban farmers suffered higher losses from pilfering of livestock than from rural farmers. Moreover, they were more likely to report emotional distress and discouragement as a result of pilfering (Anongoku et al. 2008).

Municipal authorities and public health researchers often see urban livestock keeping as a public health risk, pollution hazard and an impingement on urban aesthetics. Since urban agriculture is taken up usually by the urban poor and vulnerable groups, they lack a supporter or champion for urban agriculture in the policy space. Legislation and law enforcement therefore work against urban and peri-urban livestock keeping (Flynn 1999; Ishagi et al. 2002; De Haan 2013).

Maximizing the benefits and minimizing the risks of urban livestock keeping

The fact that most studies of hazards in urban livestock keeping find the presence of high levels of hazards demonstrates that current risk management is not very effective. Indeed command- and control-based regulation may actually make things worse. A study in Kampala found that dairy farmers who had more harassment from public authorities had fewer good practices (Grace et al. 2012).

When tackling hazards in urban livestock keeping, the best way can be the enemy of the good. For example, in Lusaka, Zambia, street sellers were moved to a new ultra-modern market funded by a USD $3 million grant from the European Union. The process involved careful consultation with vendors and other stakeholders. Yet many vendors returned to selling on the streets as they found they made more money by being closer to consumers (Ndhlovu 2011). During the bird flu epidemic, there were many attempts to close or upgrade wet markets. However, most were unsuccessful in improving hygiene or they covered only a tiny proportion of birds sold.

Approaches based on working with the existing situation and gradually improving it have been more successful. A well-documented initiative working with butchers in wet markets of Ibadan used positive deviants and peer-to-peer training. This led to 20% more meat samples meeting standards and cost USD $9 per butcher but resulted in saving USD $780 per butcher per year from reduced cost of human illness (Grace et al. 2012). This resulted in a very attractive benefit cost ratio of $87 benefit for every $1 invested.

In Kenya, authorities moved from harassing the informal milk vendors who distributed more than 80% of the milk consumed in Kenya, to supporting them. This included training on hygienic milk production and business management; provision of better technologies such as milk cans; and providing a license and certificate. The change in policy is shown to have improved the safety of milk and saved the Kenyan economy USD $26 million a year by lowering the cost of providing milk to consumers.

Effective strategies for risk mitigation include: education of farmers on hazards and prevention; quality labelling of products (Fall et al. 2001); education of consumers on hygiene (Sheth and Obrah 2004); animal health programmes to reduce the double burden of zoonoses (Lopetegui 2004); pollution assessment and zoning of areas (Kucharski et al. 1994); monitoring of fresh urban solid-waste treated soil and crops (Rao and Shantaram 1995); composting methods and variable sorting to control chemical and microbiological agents ('t Hart and Pluimers 1996); and programmes to eliminate schistosomiasis and occupational risks in freshwater fish farming (McCollough 1990). A project on the risks of livestock keeping in Nairobi, Kenya (Box 10.2), provides an example of a rational and effective approach to health risks associated with urban livestock.

BOX 10.2 SYSTEMATIC AND RISK-BASED APPROACHES TO MANAGING HEALTH HAZARDS IN URBAN DAIRYING IN NAIROBI.

With the objective of assessing and minimizing the risks of diseases spread from urban dairies, the project team applied an 'ecohealth' approach to its study. A multidisciplinary team was formed, which started by surveying and understanding dairying in Dagoretti, a district of Nairobi. Next, a systematic risk assessment was undertaken which covered a range of hazards: aflatoxins, brucellosis, cryptosporidiosis, brucellosis, coliosis, tuberculosis and antimicrobial residues. The study also looked at social and gender determinants of health. This identified cryptosporidiosis as the issue of greatest concern to be tackled first (on the grounds of its unexpectedly high prevalence, its emerging nature, and its riskiness to children and people living with HIV). The team of professionals, policy-makers and Dagoretti residents developed targeted messages for each high-risk group. They identified practices that were both good and uncommon and so had high potential for being more widely adopted. They incorporated social incentives (such as the desire to be seen as good parents) to help motivate behaviour change. The communication strategy included workshops, community champions, brochures and a television episode, and it involved policy-makers. Surveys showed a significant improvement in knowledge and practice and a reduction in the risk of cryptosporidiosis and other pathogens transmitted through the faecal route. The research findings were published in 17 multidisciplinary papers in two special editions *(East African Medical Journal* and *Tropical Animal Health and Production)*.

Source: Kang'ethe et al. 2012.

Conclusions

Much attention has been paid to the role of urban livestock keeping in maintaining and transmitting diseases and contaminating the environment but little to the role of urban livestock keeping in supporting livelihoods and nutrition. Urban livestock keeping supplies livestock products for household consumption and sale. The informal markets where most urban farmers sell their products offer benefits to poor farmers, traders and consumers. They often sell food at lower prices than the formal sector and the food sold often has other desired attributes including freshness, preferred taste and convenience, and the food originates from local breeds.

Because of the perishable nature of livestock products, there are strong incentives to produce livestock for city markets in cities and their surroundings. However, city farming is often banned or restricted by city by-laws. Considered to be dirty, smelly, noisy, disruptive, disease-ridden and a symptom of backwardness, city livestock are ignored or underestimated in official records. In Mexico City, authorities denied that pigs were kept on urban rooftops until they were dislodged by an earthquake and found walking the streets. By-laws are often based on precedent or on arbitrary decisions and rarely on evidence or logic. For example, in Tanzania it is legal to keep four cows in urban areas but illegal to keep five. Much of the opposition to keeping livestock in cities and selling livestock products in informal markets is based on the strongly held but poorly evidenced belief that city livestock and their products are a risk to human health.

Undoubtedly hazards can be found in urban livestock and their products, but this is also true for the rural counterparts. As a rule of thumb, most studies that look for hazards find them. Food-borne illnesses and animal diseases are of growing concern to consumers and policy-makers alike. Consumers respond to scares by stopping or reducing purchases with knock-on effects on smallholder production and wet market retail. Policy-makers often respond to perceived health risks by favouring industrialization and reducing smallholder access to markets. These changes are often based on fear and not on facts. Without evidence of the risk to human health posed by informally marketed foods or the best way to manage risks while retaining benefits, the food eaten in poor countries is neither safe nor fair (Grace 2011).

Urban and peri-urban livestock also plays an important, and in some cases increasing, role in supporting livelihoods and nutrition. Recent studies suggest there are 450 million people in urban livestock keeping homes and most of the 2.5 billion people who live in developing-country cities depend on urban live animal markets, wet markets, slaughterhouses and vendors to obtain their animal sources of food.

Although the potential harm of urban livestock keeping is well documented, there is surprisingly little evidence on quantified impacts (e.g., the number of people who fall sick from eating street food) or the relative importance of the risks versus the benefits of urban livestock keeping (which have been much less well documented). Better evidence is needed on the costs and benefits of urban livestock keeping to help decision makers and others to identify its most appropriate role. Encouragingly, the last decade has given many examples of how risks can be mitigated and livestock can contribute to a green and resilient urban environment. This offers a roadmap for future development of urban livestock keeping.

Keeping of animals has always been part of the city, and a link between the countryside and cities. After decades of neglect, urban livestock keeping is back on the development and political agendas. Urban livestock keeping has always been vulnerable to fears around disease and environmental contamination; fortunately, we now have the evidence and tools to ensure that it is not only productive and profitable but can be safe, fair and environmentally friendly.

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11

URBAN FORESTRY AND AGROFORESTRY

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Introduction

Today, cities already house almost 4 billion people (United Nations 2014). As the world continues to urbanize, sustainable development challenges will be increasingly concentrated in cities, particularly in lower- and middle-income countries where urbanization is faster.

While cities occupy less than 4% of the global terrestrial surface, they account for 80% of carbon emissions, 60% of residential water use and over 75% of wood use for industrial and domestic purposes. Urbanization is increasingly regarded as a critical process in the frame of global change and integrated policies to improve the lives of both urban and rural dwellers, which are urgently needed.

The expansion of cities leads to the "urbanization of poverty" (Baker 2008). Twenty-five percent of the world's total poor live in cities (Ravallion et al. 2007). Many of them live in small cities and towns where the incidence of poverty tends to be higher than in big cities (Baker 2008). Urban poverty and vulnerability, i.e., the risk of falling into poverty, is related to three characteristics of urban life: access to resources and commodities, environmental hazards and social fragmentation (Alkire et al. 2014).

This urbanization of poverty is an increasing concern for decision-makers: *nutrition, water* and *energy security* are essential for the livelihood and quality of life of citizens: urban (agro-) foresters are looking for new solutions and more efficient actions. However, urban forestry can also contribute to the quality of life and environment of existing and future cities by addressing other challenges that have emerged during the last decade: *climate change, soil sealing, human health* and *well-being* and *integrated environmental governance.*

In 2005, Konijnendijk and Gauthier (2006) prepared an overview of the status of urban forestry research and development, policy-making, implementation and education. This chapter provides an overview of the developments in the last decade and the current status of (intra- and peri-) urban forestry research and development, policy-making, implementation and education, and aims to demonstrate the dynamic status of the discipline and highlight emerging experiences and issues.

Growing attention for urban forestry

One of the most interesting facts of the 2005–2014 decade concerning urban forestry and agroforestry issues is the exponential growth of knowledge, action research and practice on *green infrastructure* and *ecosystem services* approaches as means to enhance the quality of life in cities and towns. A lot of work has gone into methodologies, technical issues, communication and education, multidisciplinary approaches and synergies.

The volume of studies focusing on urban forestry has grown substantially: over the past 15 years (1998 to 2014), the scientific contributions containing the keyword *urban forest* have increased more than four times (Figure 11.1) and include studies from all continents.

Three international journals mainly cover urban forestry: *Urban Forestry and Urban Greening; Arboricultural Journal;* and *Arboriculture and Urban Forestry*. Research findings are also published in other journals, e.g., *Landscape and Urban Planning.*

The International Union of Forestry Research Organisation (IUFRO) promotes conferences and sessions on urban forestry. At the last IUFRO World Conference in October 2014 in Salt Lake City, 38 papers and posters on urban landscape and

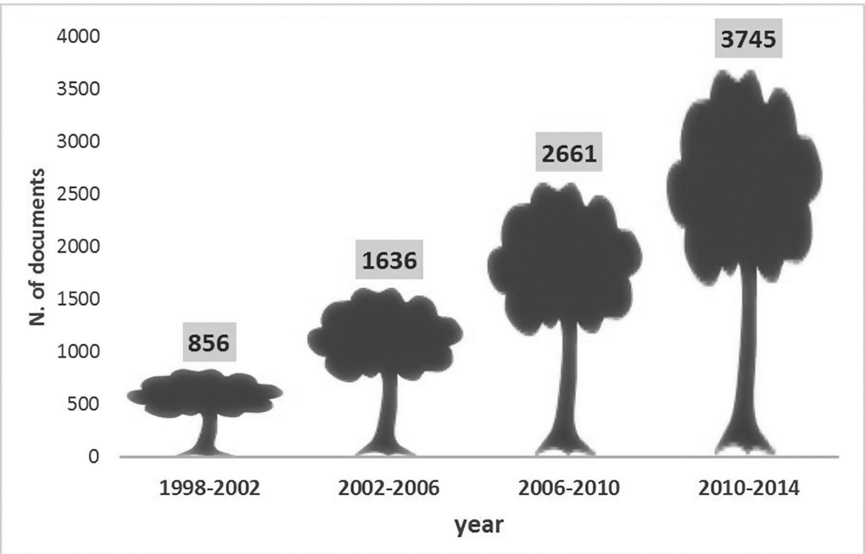

FIGURE 11.1 Number of documents on urban forestry and related issues in scientific publications from 1998 to 2014

Source: www.scopus.com.

urban forest issues were presented. Many other conferences, workshops and research projects at different levels refer to urban forests and urban green infrastructure.

Indeed, urban forestry and agroforestry are no longer only domains for experts but are now well rooted in the knowledge of many urban communities and in the capacity of technical and institutional boards. In the last ten years, urban forestry has become more and more attractive for investments and for urban policy and strategic frameworks.

The 2007 *State of the World Forests* (FAO 2007) selected urban forestry as one of the key issues related to restoration of the forest landscape and reported that 46 countries have stepped up afforestation efforts around towns with the primary objective of environmental protection, to a level of nearly 400,000 hectares per year.

The *State of the World Cities* 2013 report (UN-Habitat 2013) on "Sustainability and the Prosperity of Cities" clearly points out the important role of urban green spaces as a provider of ecosystem services and a fundamental resource for the citizens' livelihoods.

The World Health Report of 2013 (WHO 2013) highlights the positive role of green economy and green investments on the status of health in urban contexts. Since 1960, the World Health Organization (WHO) has promoted the adoption of a set of indicators and guidelines for Healthy Urban Environments. The WHO Note of Secretariat of 1967 on "The challenge to public health of urbanization" reports the need of setting minimum standards for healthy urban environments. Among them is the need of indicators for the density of, and accessibility to, urban green spaces. Although no official records of WHO ever mention a minimum green space area per resident, the figure of 9 m^2 per resident is generally accepted as being proposed by WHO (Singh et al. 2010 quoting Kuchelmeister 1998), and many national laws have adopted the square meters per urban resident as a criterion for urban development. That is the case of the Italian law on new urban development (D.M. 2 April 1968, n. 1444), which adopted 9 m^2 of green space as a standard.

Several international institutions, such as FAO, UN-HABITAT and UNEP, have promoted and sustained institutional as well as informal partnership and networking on urban forestry at global, regional and national levels. The FAO Multidisciplinary Action Group "Food for the Cities" also includes an action area on "Forests and trees – improving livelihoods through healthy green cities".

Since the late nineties, the RUAF Foundation (the International network of Resource centres on Urban Agriculture and Food security) is actively promoting and sustaining actions and guidelines for development at global (www.ruaf.org/topics/urban-agro-forestry) and regional levels.

ICLEI-Local Governments for Sustainability and United Cities and Local Governments (UCLG) have been very active at regional and local levels to support the dialogue and the partnerships on urban forestry and green infrastructure. ICLEI and UCLG-Africa supported UN-Habitat in the preparation of the *State of African Cities 2014* (UN-Habitat 2014), which included various aspects of urban forests and green infrastructure. According to this review, there is a strong need for building solid partnerships among African cities to build capacity and exchange knowledge as well as to attract financial support for the implementation of urban forestry.

The European Forum of Urban Forestry, launched in 1998, constitutes a robust example of regional networking and partnership. There are proposals to build similar experiences in Asia (FAO 2014b) and Latin America (FAO 2014a).

In 2012, Silva Mediterranea, FAO's statutory body on the forests of the Mediterranean, launched a working group on Urban and Peri-urban Forest (www.fao.org/forestry/80480/en/) that now is operating to create networking, partnership, knowledge and research/education opportunities in the region.

City twinning programmes, implemented in many different contexts, are other tools for networking and capacity building. The Lombardy Region (Italy), one of the most urbanized areas in Europe, and the Osrednjeslovenska – Ljubljana urban region in Slovenia – twinned their efforts and experiences to monitor intra- and peri-urban forests and the goods and services they provide (www.emonfur.eu/). In May 2014, the "50 Municipal Climate Partnerships by 2015" project was launched. Fifty German municipalities and their partner municipalities in the Global South will develop joint action programmes on climate change mitigation and adaptation in city regions including resilience, biodiversity, reforestation, energy supply, solid waste management, water management, awareness raising and education (www.service-eine-welt.de/en/climatepartnerships/climatepartnerships-start.html).

The development and institutionalization of urban forestry in the United States gained force as a result of major lobbying efforts by NGOs such as American Forests, Tree Link and ICLEI-USA. The "Urban Forests Create Vibrant Cities" programme (www.icleiusa.org/blog/urban-forests-make-vibrant-cities) was a very successful initiative towards creating partnership around urban forest issues. Great Britain's National Urban Forestry Unit (NUFU), an independent organization, has provided assistance to many local and regional urban forestry initiatives.

Several guidelines on urban forestry and agroforestry at global, regional and national levels were recently produced to support decision-makers and practitioners (FAO 2013; de Foresta et al. 2013) in improving urban life and environmental conditions through urban forestry strategies. In the last decade, indicators and approaches have been designed to assess the contribution of urban forestry in terms of ecosystem services (Nowak et al. 2007, 2008). Natural England, an advisory body to the British government that provides practical scientific advice on how to preserve England's landscapes, has developed *Green Infrastructure Guidance* (http://publications.naturalengland.org.uk/publication/35033).

ICLEI developed a technical guide for practitioners and decision-makers, *Talking Trees, an Urban Forestry Toolkit for Local Governments* (ICLEI 2006), aimed at supporting local environmental governance of resilient cities and strengthening integrated technical, institutional and community capacities.

Assessment of urban forest resources

In order to promote and develop urban forests, it is essential to know their status and understand the challenges they face as well as their potential contribution in term of ecosystem services. The characterization of the urban forest and the assessment of their condition are challenging tasks (Pauleit et al. 2005; Konijnendijk and Gauthier 2006).

Singh et al. (2010) provided a synthetic overview on the global extent of urban forests in the world. According to their analysis, cities in developed countries, in general, have more trees compared to cities in developing countries, which often fall below 9 m^2 of green open space per city dweller.

Large-scale international and national inventories and monitoring of urban forests are still scarce or fragmentary (Corona et al. 2011). However, there are a number of cases where National Forest Inventories (NFIs) also include urban forests (Table 11.1).

TABLE 11.1 Urban forests in National Forest Inventories

Data collected/methods applied	*Source*
USA: Urban tree canopy and impervious surface cover maps for 48 States by US Forest Service (2007) from 2001 Landsat satellite imagery to assess urban forest data including carbon storage and sequestration rates and air pollution removal estimates	Nowak and Greenfield 2010
Europe: An outlook study on the status of urban forests in 26 countries in Europe	EU COST action FP1204 GreeninUrbs
France: Data on the extent and characteristics of the forest in and around towns since 2006	National Forest Inventory of France
England: a survey of urban trees and their condition and management	Britt and Johnston 2008
Germany (Berlin): combining airborne LiDAR and QuickBird derived data to assess carbon stored in urban trees and to identify differences between urban structure types	Schreyer et al. 2014
Morocco: Basic inventory of 154 intra- and peri-urban forests (2006): location, area and status	HCEFLD 2010
China: application of airborne LiDAR data and hyperspectral imagery to generate species-level maps of urban forests with high spatial heterogeneity	Zhang and Qi 2012
China: Information on the average green cover of 439 cities	Wang 2009
Turkey: General Directorate of Forestry (OGM) collected information on the status of 112 urban forests: physical aspects of the forests, management issues, functions and ecosystem services	Atmiş et al. 2012
India: No national inventory but case studies on Chadingarh and Delhi using satellite imageries	Nagendra and Gopal 2010; FSI 2009 respectively
West and Central Asia: Basic information on urban forests	Åkerlund (2006)
Mapping the extents of urban tree canopy using aerial or satellite imagery	MacFaden et al. 2012; McGee et al. 2012
Use of airborne LiDar for measuring and mapping urban forest and trees	MacFaden et al. 2012; McGee et al. 2012; He et al. 2013; Alonzo et al. 2014

Source: authors.

Urban forest inventories are numerous. The case studies on Bogota (Tovar-Corzo 2013) and Montpellier (Besse et al. 2014) are excellent examples of two different approaches on the assessment of urban forests and green areas in cities.

The issue of "trees outside forests" (ToF) is also an important challenge for urban forest assessment. The ToF assessment by de Foresta et al. (2013) includes a specific chapter on the sound assessment of trees in cities.

Finally, an emerging aspect in implementing inventories of urban forests and trees is related to communication and involvement of the public. In the last few years, the use of information technologies was decisive in the implementation of community-based surveys and interactive inventory tools (Abd-Elrahman et al. 2010).

Green infrastructure and ecosystem services for future sustainable cities

Green infrastructure

Urban green infrastructure is the interconnected network of green spaces that conserves natural ecosystem values and functions and provides associated benefits to human populations. Urban and peri-urban forests and trees, together with agroforestry

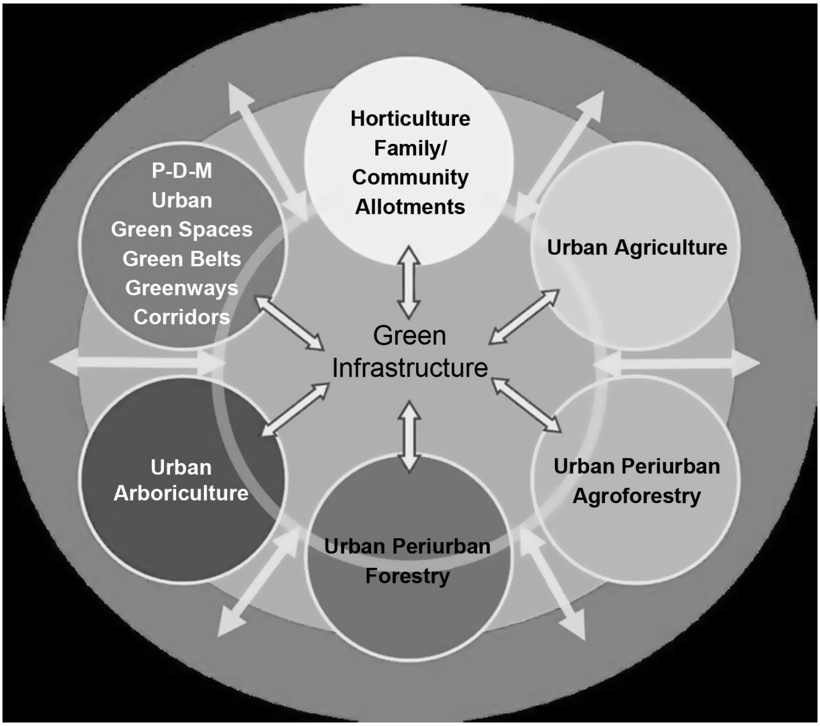

FIGURE 11.2 The green infrastructural framework
Source: authors.

systems, urban horticulture, green spaces, tree lines and hedges, parks, green roofs and walls, and riparian corridors form the physical and functional *green infrastructure* of the city region. They constitute the critical dynamic elements of urban and peri-urban landscapes, providing benefits as the structural component of the watershed, woodshed, foodshed, ecological network and nature protection areas.

Over the last decade, green infrastructure has developed as an approach to landscape planning that addresses the fragmented thinking associated with urban development. Green infrastructure is often viewed as an alternative to the so-called grey infrastructure, i.e., human-engineered solutions that often involve concrete and steel. The assumption of urban economists and town planners is that infrastructure is essential for economic growth. People often do not think of forests, wetlands, coral reefs and other natural ecosystems as forms of infrastructure. But they are. As such, "green infrastructure" can have an equivalent economic interest as "grey infrastructure".

Green infrastructure serves the interests of both people and nature, as quoted in the European Green Infrastructure Strategy (European Commission 2013). Green infrastructure enables citizens to benefit from the multiple services of the natural and semi-natural features of the landscape (Davies et al. 2006). This definition completely reverses the urban-centric vision of the 20th century by assuming that human activities and cities are hosted in the nature and not the opposite.

The green infrastructure planning agenda has brought together planners, ecologists, architects and developers, and proposed a holistic and functional understanding of the ecology of urban environments by proposing that natural resources should form the fundamental building blocks for landscape management and meeting a number of planning issues (Benedict and McMahon 2006; Mell 2007, 2010). In green infrastructural planning, local communities, landowners and organizations work together to identify, design and conserve the land cover diversity required for the maintenance of a healthy ecological functioning of the urban landscape (Benedict and McMahon 2006).

In the last decade, planning of strategic green infrastructure has been gaining momentum. In Europe, a multi-scale planning approach, ranging from the local community level through to regional, national and international platforms, is emerging. The European Green Belt (www.europeangreenbelt.org/), the Pan-European Ecological Network (Council of Europe 2000) and the European Green Infrastructure Strategy (European Commission 2013) are good examples of integrated directives, tools and actions oriented to implement multiple planning agreements and national/local legislation about urban forests and green infrastructure.

Ecosystem services

Urban forests and agroforestry systems are primary sources of *goods* and *ecosystem services* that are directly enjoyed, consumed, or used to produce specific, measurable environmental and human benefits, e.g., contributions to nutrition security as well as to health, well-being and quality of life of the citizens and particularly of the poor who need easily accessible resources and opportunities at low cost (Chen and Jim 2008; Dobbs et al. 2011). Intra- and peri-urban forests can buffer human settlements from extreme heat and cold, rain and wind, and provide fruit, timber, fuel and employment for a growing population.

Services provided by urban forestry and agroforestry can be categorized in four main types:

a *Provisioning* services are the products obtained from ecosystems such as food, freshwater, wood, fibre, genetic resources and medicines.
b *Regulating* services are defined as the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination or pest control.
c *Habitat* services highlight the importance of ecosystems to provide habitat for migratory species and to maintain the viability of gene-pools.
d *Cultural* services include non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation and aesthetic values.

Understanding and quantifying these benefits can raise citizen awareness of the value of their public resources, such as urban trees on publicly owned lands, as well as provide a basis for management to maximize benefits while controlling costs. As the amount, distribution and composition of urban forests vary from city to city, so do ecosystem functions and services and the resulting economic, social and ecological benefits.

Design, implementation, management and maintenance of urban forests, trees and public green spaces have always been seen as a cost to the community. However, during the last decade the awareness of the economic role of urban forest and green infrastructure has increased rapidly. Investing in urban forests can directly contribute to city revenues and citizens' incomes as well as being an affordable tool for savings and indirect economic benefits.

For instance, where there is an efficient green infrastructure in place, the impacts of extreme weather events (e.g., winds, floods, landslides and sand encroachment) are mitigated. Likewise, a well-managed watershed produces and supplies good-quality water and reduces the need for costly engineering works. The high and recurrent cost of rebuilding roads, housing and commercial infrastructure is greatly reduced, creating savings, while the maintenance of woodlands and trees generates green jobs and income through multipurpose management. Well-designed green infrastructure enhances physical activity and psychological restoration, contributing to save expenditures in the health system. Finally, farming and landscape systems that incorporate agroforestry and high-yielding plantations can supply nearby markets at competitive prices (FAO 2009).

The example of Toronto (Table 11.2) shows that urban forests provide the city with over USD80 million worth of environmental benefits. For the average single-family household, this works out to USD125 of savings per annum.

TABLE 11.2 Annual benefits provided by Toronto's forests

Benefit	*Quantity*	*Economic value*	
		(Millions Can $)	*Can $/tree*
Reduced wet-weather flow (less strain on water transportation and processing infrastructure)	25,112,500 m3	53.95	5.28
Absorbed air pollutants	1,905 tonnes	19.09	1.87
Energy savings (through shading and climate moderation)	41,200 MWH	6.42	0.63
Carbon sequestration	36,500 tonnes	1.24	0.12
Carbon emission avoided by climate moderation	17,000 tonnes	0.58	0.06
Total benefit		81.29	7.95
Benefits per $ investment in maintenance of urban forests: Can $ 1.35–3.20.			

Source: Alexander and McDonald 2014.

Cities and towns of different size, character, culture, income (e.g., Toronto, Canada; London, UK; Singapore; Curitiba, Brazil; Montpellier, France; Stara Zagora, Bulgaria) have decided to invest in green infrastructure for their future. For example, Bogotá, Colombia, is pursuing upstream landscape conservation and restoration as an alternative to more conventional water treatment technologies. Ho Chi Minh City, Vietnam, restored mangroves instead of building dikes in order to protect shorelines from storm damage. And a chemical facility in Texas, USA, built a wetland instead of using deep well injection to treat wastewater (www.greenbiz.com/blog/2012/06/22/green-vs-gray-infrastructure-when-nature-trumps-concrete).

The "Million Trees" programmes, started in the USA (e.g., New York City, Los Angeles, Miami) and then adopted in many other cities of the world, from Santa Cruz de la Sierra (Bolivia) to London (www.milliontrees.ca/), are excellent examples of merging the different potential ecosystem services provided by urban forests and getting back economic benefits as an added value for the future of the cities. The programme "ReForest London: Planting the Future Today" (http://reforestlondon.ca/) is emblematic of this approach.

Studies on specific ecosystem services provided by urban forestry are available for a number of cities around the world, e.g., on biodiversity (e.g., Sandström 2008), carbon storage (e.g., Escobedo et al. 2010; Schreyer et al. 2014) and wood energy supply (Drigo and Salbitano 2008; FAO 2009, 2012a). Chen and Jim (2008) provided a valuation of ecosystem services at the global level and Jim and Chen (2009) for Chinese urban forests identifying the emerging benefits and the regulating, provisional and social values.

However, the assessment of ecosystem services requires well-defined procedures and further development of a comprehensive set of good indicators for urban forest ecosystem services and the provision of goods (Dobbs et al. 2011, 2014). In the last decade, the *iTree* suite of software tools (www.itreetools.org) has been increasingly used as a ground-based method of assessing urban forest structure and ecosystem services and enabling scenario planning and land cover classification for planning purposes (Nowak et al. 2007, 2008).

Urban and peri-urban forestry: emerging issues

Nutrition, water and energy security: the contribution of urban and peri-urban forestry and agroforestry

Maintaining food and nutrition security for rapidly growing urban populations is one of the greatest challenges of the 21st century (Camhis 2006; Tanumihardjo et al. 2007; FAO 2011). The contribution of agroforestry systems to urban food security is one of the key issues highlighted in the global agroforestry guidelines prepared by FAO (FAO 2013). Intra- and peri-urban forests and trees are a source of fruits, seeds, leaves, mushrooms, berries, medicinal herbs, rattan, and fodder (leaves, sprouts, young shoots and seeds) for animal husbandry, while bush meat and edible insects are valuable sources of proteins in many areas of the world. In West Africa, for example, urban forestry practices such as the collection of wild edible plants, planting of fruit-bearing street trees and establishment of multifunctional public parks have contributed to an improvement in food security (Fuwape and Onyekwelu 2011; Dubbeling 2014). Also in Pacific Islands, the contribution of fruit and fodder urban trees is decisive for the daily consumption and the improvement of the nutritional values in vitamins and other key nutrients. Reliable estimates of the contribution of urban forestry and agroforestry to food and nutrition security of urban dwellers are still scarce. Income from forests and trees in urban farms can increase the food security of peri-urban households. A large number of women in West Africa earn a substantial income from the collection, processing and marketing of nuts harvested from naturally occurring shea trees, like for example the 300 women from the Alaffia Shea Butter Cooperative in Sokodé, Togo (Olowo-n'djo Tchala 2011). In India, *Jamun* trees alongside roads of Delhi yield about 500 MT of fruit each year (Singh et al. 2010), which is harvested and sold to pedestrians and motorists passing by these roads during the monsoonal season, when fruits are ripe. "A food-secure city" foresees productive tree systems for food production, as well as has an awareness of the environmental services that these systems also produce (Kyle and Kimberly 2013).

Forests and trees within and around cities and towns also help to maintain clean water supplies and to improve watershed health by decreasing the quantity of storm-water runoff, recharging groundwater, decreasing flooding and erosion and reducing the pollutants that are washed into streams from impervious surfaces (Gash et al. 2008; Brown and Farrelly 2009; Pearson et al. 2009). As forests are cleared for development in urbanizing watersheds, they are replaced with paved or compacted surfaces such as roads, driveways, parking lots and sidewalks that, together with rooftops, make up an impervious cover. In Rhode Island, the 14%

of land of the Narragansett Bay watershed is under impervious cover. The value ranges from 3 to 40% by municipality, with only 17 of 39 towns having less than 10% of the impervious cover. Impervious cover increased 43% between 1972 and 1999, six times faster than population growth in the area (Zhou and Wang 2007). Nowak and Greenfield (2010) analyzed the relationships between tree cover and impervious surface in 20 cities in the USA. All the sample cities had a reduction of tree cover and an increase in impervious cover from 2003 to 2009, excepting Syracuse, where the tree cover slightly increased while the impervious surfaces decreased.

The watershed of the valley of Mexico City has an area of 9,600 km^2. The conurbation area (60 municipalities) covers 7,815 km^2, i.e., 81% of the watershed. The urban sprawl of Mexico City in the last century is impressive (see Table 11.3). The water supply for the city has been in crisis for 20 years. The major problem is the inability of the watershed to meet the demands of drinking water (Breña Puyol and Breña Naranjo 2009).

TABLE 11.3 Urban growth in Mexico City and urban cover of Mexico Valley watershed

Year	*Dense urban area (km^2)*	*Urban population (million)*
1910	27	0.5
1960	382	5.6
1990	1209	15.6
2000	1350	18.4
2010	1475	20.1

Source: Breña Puyol and Breña Naranjo 2009.

The Impervious Cover Model (ICM) developed by the Center for Watershed Protection (CWP) predicts that most stream quality indicators decline when the watershed impervious cover exceeds 10%, with severe degradation expected beyond 25% (Cappiella et al. 2005). The CWP developed an *Urban Forestry Watershed Manual* (Cappiella et al. 2005, 2006a, 2006b), a working tool to plan, design and manage trees and forests to protect watersheds from floods and runoff, as well as to enhance the quality of water in hydrological systems serving cities. They introduced the concept of *urban watershed forestry* as an integration of urban and community forestry and watershed planning.

Urban watershed forestry sets watershed-based goals for managing urban forests as a whole rather than managing them on a site-by-site or jurisdictional basis, and provides strategies for incorporating forests into urban watershed management. Reforestation programmes constitute the pillars of integrated strategies and alliances oriented to reduce the devastating effects of floods caused by extreme climate events. The example of the Marikina Watershed Integrated Resource Development Alliance (Box 11.1) in the Manila region represents a way of incorporating urban forestry actions in the strategic watershed plan devoted to reduce future dramatic floods.

BOX 11.1 THE MARIKINA WATERSHED INTEGRATED RESOURCE DEVELOPMENT ALLIANCE: BUILDING PARTNERSHIPS FOR DISASTER RISK REDUCTION IN URBAN CENTRES OF METRO MANILA (THE PHILIPPINES)

The Marikina Watershed, located in the wider metropolitan area of Manila, the city capital, spans 28,000 hectares of what used to be rainforests and cuts across three main townships (Antipolo, San Mateo and Rodriguez). Only roughly 20% of the rainforest remains.

Late in 2009, the Philippines was battered by tropical storm Ondoy and typhoon Pepeng, leaving nearly a thousand dead and thousands homeless, with total damage and losses estimated at USD4.38 billion. The intensity of flash floods that devastated the Metro Manila region was attributed to the degradation of the Marikina Watershed.

Local government leaders – led by Marikina city mayor and the mayors of Pasig City, Antipolo City, Cainta City, Quezon City, Rodriguez and San Mateo – also known as the "Alliance of Seven" – signed a Memorandum of Agreement, in September 2010, and committed to work together to rehabilitate and sustainably develop the Marikina Watershed under the framework of disaster risk reduction and enhancing urban resilience. Proposed actions include rehabilitation and reforestation of the Marikina Watershed, including a review of existing policies, resettlement plan for high-risk communities and possible in-city relocation and livelihood assistance, as well as the development of harmonized mechanisms within a sustainable and climate-sensitive plan for the Marikina Watershed. Emphasis is also placed on building partnerships not only between the seven city governments but also with other key stakeholders across the seven municipalities, including civil society and the private sector. The Alliance of Seven is working with citizens' groups and local NGOs, and will also build on previous reforestation efforts by the United Coconut Planters Bank, a private bank, which started in the 1990s to rehabilitate the Marikina Watershed.

Source: Tuaño and Sescon 2013.

In many parts of the world, wood is by far the most affordable source of energy, very often the only one available to the urban poor. Timber and non-timber products are considered the first and very likely the most important tangible benefits that urban forests can provide to African citizens: wood for energy, among them, plays a leading role (Fuwape and Onyekwelu 2011). Marien prepared a complete outlook study on the interconnected urban forestry–wood fuel system for African cities (Marien 2009; FAO 2012d) as part of a series of studies and actions promoted by FAO in Central Africa to establish and improve the use of urban forestry as a strategic tool for the future of the cities.

In Bangui, Central African Republic (FAO 2009), wood fuel was one of the main issues around which an urban forestry action plan was developed. In N'Djaména, Tchad (FAO 2012a, 2012b, 2012c), and Kinshasa, Democratic Republic of the Congo (Schure et al. 2011), the wood energy component was studied and planned not only as part of urban forestry programmes but as a key determinant of strategic town planning.

A recurrent criticism to the wood fuel sector is that the unsustainable harvesting of wood fuel supplying large urban and industrial markets significantly contributes to forest degradation and to deforestation when coupled with other land-use changes (IPCC 2014). Sustainable harvesting and transformation techniques are almost well known in the traditional wood fuel supply rural zones while the intra- and peri-urban chain of production is informal and very often illegal. There is no recognition of the wood fuel harvesting needs and very little is done to grant these activities even in technical terms. However, recent technological advances suggest that energy production from biomass can also be an opportunity for facing the carbon sequestration challenge (Zeng et al. 2007; Fargione et al. 2008; Hoekman 2009; Azar et al. 2010). Especially in OECD (Organisation for Economic Co-operation and Development) countries, wood-efficient applications for wood energy are increasingly being used to produce cost-effective, high-quality energy services at various scales (Abd'razack et al. 2013).

The urban forest and trees as sources of bioenergy are mainly used by the urban poor. Urban trees can provide up to the 80% of their needs but the access is uncertain and risky (Drigo and Salbitano 2008). The major blockings are the lack of visibility, the absence of norms and regulations, and the failure of any investment on the sector of wood fuel and charcoal production and marketing in urban and peri-urban areas. In this sense, the contribution of intra- and peri-urban forestry can be decisive, at least for some component of the urban poor.

Therefore, the projections of significant growth in wood fuel demand, particularly in developing countries (Mwampamba 2007; Drigo and Salbitano 2008; Zulu 2010; Agyeman et al. 2012) make it vital that this sector is overhauled and modernized using new technologies and approaches, and that governance mechanisms, such as "WISDOM for cities", are highlighted (Drigo and Salbitano 2008).

Even if, from a strictly quantitative point of view, they cover only part of the urban wood fuel demand, urban forests play a fundamental role in planning a sustainable urban wood energy system. In collaboration with urban development agencies, (intra- and peri-) urban forestry may trigger a virtuous planning process and provide good management practices aimed at meeting urban needs through sustainable and responsible interaction with rural areas and communities well beyond the city boundaries.

In this perspective, urban planning should extend its responsibility to extra urban resources and socio-economic processes influenced by the urban footprint. The first task in this expanded role would be to disclose the nature, in terms of environmental and socio-economic sustainability and impacts, of the relation between growing urban needs, on the one hand, and the resources and processes that provide commodities and services, on the other.

In their study, Drigo and Salbitano (2008) called this expanded area of influence *urban woodshed* and adapted the WISDOM (Wood fuel Integrated Supply and Demand Overview Mapping) platform to the city scale, highlighting the proactive relationships with urban forestry.

Climate change and urban forestry

The fact that the Earth's climate has changed as a result of human activities has become increasingly clear over the last years, and there is strong evidence that we can expect further dramatic changes in the next decades. The 2014 report of the Intergovernmental Panel on Climate Change (IPCC 2014) refers to urban greening and green infrastructure as one of the major tools to reduce the effects of climate change at the urban scale, particularly in view of their potential to mitigate the urban warming and its associated effects.

The warming of the atmosphere leads to long-term changes in rain and snowfall patterns, wind and ocean currents, ice and snow accumulation, and other climatic aspects. It can increase the frequency of droughts, heat waves, heavy rainfall and snowfall, and other extreme weather events (Duryea et al. 2007). It is associated with a wide set of environmental and economic risks which, depending on the geographical context, can be desertification, floods, erosion, landslides and avalanches that could affect urban regions (Seppälä et al. 2009).

Trees and forests adjacent to cities and towns provide important ecosystem services by reducing the direct or indirect risks associated with climate change. Urban forests and agroforestry systems, especially if planned according to a green infrastructure approach, can substantially contribute to sequestering and storing greenhouse gases (Schreyer et al. 2014; Timilsina et al. 2014).

One of the most important characteristics of urban climate is the Urban Heat Island effect (UHI) that causes urban temperature to be higher in the city centre than in the peri-urban areas. Normally, heat island intensity is proportional to the population size and density of a city. Urban trees reduce UHI effects through shading and cooling through evapotranspiration (the evaporation of water trough foliage) thus reducing demand for air-conditioning in summer and the associated demand for fossil fuel energy and water. Joint studies by the Lawrence Berkeley National Laboratory (LBNL) and the Sacramento Municipal Utility District (SMUD) placed varying numbers of trees around houses to shade windows and then measured the buildings' energy use. The cooling energy savings ranged between 7% and 47% and were greatest when trees were planted to the west and southwest of buildings (www.epa.gov/heatislands/resources/pdf/TreesandVegCompendium.pdf). According to McPherson et al. (2005), the benefits of urban forestry in energy saving can vary considerably by community and tree species, but they are always higher than the costs. The five-city study found that, on a per-tree basis, the cities accrued benefits ranging from about USD1.50–USD3.00 for every dollar invested. These cities spent roughly USD15–USD65 annually per tree, with net annual benefits ranging from approximately USD30–USD90 per tree. The impacts of specific greening interventions on the wider urban area, and whether the effects are due to greening alone, have yet to be demonstrated. Nevertheless, the positive effects of urban forestry on UHI and thermal profiles have been assessed in several cities (Ruth and Cohelo 2007; Seppälä et al. 2009). The cooling effect of green areas is related to a range of variables, such as local urban morphology around the parks, land use around the parks, wind-flow, types of pavements, types of trees and landscape design (Tsiros 2010; Tuaño and Sescon 2013).

However, the climate change and urban forest literature has mostly focused on environmental services and climate mitigation (e.g., Lundholm and Marlin 2006; McPherson et al. 2008; Lawrence and Escobedo 2012) but little work has been done so far in the adaptive side. Urban forests and green spaces make important contributions to the cities in term of building resilience and adaptiveness to climate change stressors. The green infrastructure approach is considered a very promising conceptual framework in emphasizing the individual contribution of the different types of green spaces towards adaptive cities (Gill et al. 2007).

Climate change also affects the urban forests and these need to be adapted to an increase in stress variables including higher temperatures, precipitation changes (in both quantity and quality; i.e., snow to rain), air pollution increases, soil habitat alterations, among other stress variables (Li et al. 2007; Seppälä et al. 2009; Arnbjerg-Nielsen and Fleischer 2009).

While scientific knowledge, technical tools and guides to cope with urban forest adaptation to climate change have been developed in North America and Europe (Cullington and Gye 2010; Natural England and RSPB 2014) such contributions are almost absent in tropical regions and in low-income countries.

Urban soil sealing: new discussions on old problems

Soils provide a number of ecosystem services which make them environmentally, economically and socially crucial for human societies (Scalenghe and Marsan 2009). Soil sealing by impervious materials is, normally, detrimental to its ecological functions. Exchanges of energy, water and gases are restricted or hampered and increasing pressure is being exerted on adjacent, non-sealed areas. The negative effects range from loss of plant production and natural habitats to increased floods, pollution and health risks, and, consequently, higher social costs.

In the last century, urban sprawl has been the driving process of soil sealing. Unplanned or poorly planned urban development has transformed agricultural and forest land into the impervious, harsh cover of industrial, residential and commercial structures and infrastructures.

Well-designed green infrastructure can indeed avoid or reduce soil sealing but requires sound policies and a strategic commitment. The *European Green Infrastructure Strategy* (European Commission 2013), adopted at the beginning of 2014, is the first official document calling for strategic actions to limit soil sealing derived by urban sprawl. Understanding the relationships between soil sealing, urban forestry and green infrastructure in scientific and in policy terms is highly challenging, and researchers, practitioners and decision-makers in urban forestry and related issues will need to provide answers in the near future.

Urban forests, green spaces and human health and well-being

The WHO (1998) defines a healthy city as "the one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential." A green city, with a high availability of trees and forest, green and open spaces, is the best urban environment to meet these requirements and provide three types of functions related to health processes: prevention, therapy and recovery/restorativeness.

Urban forests and green spaces can be designed and managed to assist therapies for very different type of diseases (Weldon et al. 2007). Urban trees and forests provide shade and help cool the atmosphere and the soil. Thus, longer and more frequent visits to green spaces generate significant improvements in the real and perceived well-being of users (Guite et al. 2006; Lafortezza et al. 2009; de Vries et al. 2011) and alleviate discomfort from extreme heat (Shashua-Bar et al. 2010).

The contribution of urban forests to the reduction of pollution and contamination of atmosphere, water and soil is also the object of various studies (Escobedo et al. 2008; Escobedo et al. 2010; Escobedo et al. 2011). Urban forest and trees are excellent filters. They reduce harmful ultraviolet radiation and air pollution, noise and negative sensorial perception. This filtering function contributes to drastically decreasing some direct and indirect causes of non-communicable disease and urban stressors (Tiwary et al. 2009).

A sedentary lifestyle increases the overall risk of early mortality, cardiovascular diseases, obesity and some forms of cancer, including colon and breast cancer. The presence and access to open green spaces can also help promote more active lifestyles (Tzoulas et al. 2007), and it is well established that regular exercise, including walking, can reduce the negative effects of many major health threats (Bird 2015).

Another benefit of urban forests is the positive effect of green spaces on psychological well-being, including stress reduction and mental health improvements. Surgery patients who could see a grove of deciduous trees recuperated faster and required less pain-killing medicine than matched patients who viewed only brick walls (Ulrich 2002; Berto 2007; Heerwagen 2009; Grahn and Stigsdotter 2010).

In parallel, there are forests designed and managed to serve specific programmes of convalescence and restorativeness. The sense of well-being induced by relaxing or carrying out activities in urban forests and greening has deep significance in the restorativeness needs of urban populations (Carrus et al. 2013, 2014). The number of healing gardens is increasing and design styles emphasizing the psychological restorativeness potential of urban forests and parks are currently taught in landscape architecture and urban forestry courses worldwide. Indeed, informal activities in green spaces also have a positive effect on the treatment of depression (Townsend 2006).

On the other hand, it is necessary to be aware of the fact that urban trees and forests can cause problems to human health and well-being. Some tree species are allergogenic and urban forests can provide habitat for fungi and insects that are potential vectors of either epidemic or non-communicable diseases (Cariñanos et al. 2014).

Integrated environmental governance to achieve long-term sustainability

The need to integrate environmental concerns into city governance and planning represents a major shift in urban policy thinking in the last decades. The prevailing focus on built infrastructure of the 1970s moved gradually towards a landscape and territorial approach. Urban forest in its larger meaning (Konijnendijk and Gauthier 2006) is a public asset that must be protected, maintained and also improved over time. To achieve this, elected officials and planning agencies must balance regional and community growth with environmental quality. Urban forestry requires innovative approaches to working together with a range of stakeholders to plan and manage all the resources that constitute the "urban forest", so it is important to find clearer ways to learn from innovation and experience (Lawrence et al. 2013).

Over the last decade there has been an increasing interest in urban green space, trees and forests but it has focused largely on the benefits (social, environmental and economic), the distribution of those benefits, and technical aspects of tree and green space management (Lawrence and Carter 2009). Much less attention has been paid to the processes, interactions, organizations, and decisions which lead to the establishment and maintenance of such resources and the resulting benefits. This complex area of human organization and behaviour is referred to as governance (Lawrence and Ambrose-Oji 2010).

Urban forest governance is still a new concept, particularly in Europe (Bentsen et al. 2010). In the USA, individual aspects of urban forest governance have been widely discussed but the term *governance* has rarely been used. In other parts of the world it is virtually unknown.

Compared with traditional rural forest governance, urban forest governance involves a much wider range of stakeholders, interacting with state and non-governmental organizations operating at multiple scales. All levels of government can impact on urban forests, from national level (administrations and policies relating not only to forestry, environmental protection, natural resources, nature conservation, but also to transport or road works), to various scales of local government (Van Herzele et al. 2005; Trefon et al. 2007). Urban forests are intensively used for a wide range of purposes and to obtain a number of benefits and services.

As a result, interest groups and user demands play an important role in urban forest governance but differ from city to city, depending on which benefits and services are dominating.

One of the main difficulties in applying an integrated approach to urban forest policy at the local level is that in many countries the local authorities' responsibilities for trees and woodlands are split between different departments with different visions and mandates.

Urban forests are still frequently an afterthought in the process of developing comprehensive plans at local and national scales. Often, there is a fundamental disconnect between the community's vision of environmental quality and the ecosystem functions and services that constitute the cornerstone for achieving environmental quality and sustainable development (Schwab 2009). Good data and inclusive dialogue across disciplines, sectors and institutions are necessary components of any successful planning process. Both are currently lacking in nearly all regions and countries, but many local entities are compiling good data and instituting progressive practices to engage affected landowners and interest groups, and to develop a sustainable green vision for their communities.

The results of more comprehensive research on urban forestry are driving planners towards new models of urban management where social inclusion, cultural integration, water and food security and well-being are being adopted as core objectives. An integrated management style (Randrup 2006) is recommended as the best way to harmonize urban forests and green infrastructure in the frame of urban governance. The Urban Forest Management Plan of the city of Gresham, Oregon (USA), is one of the best examples of a working application of new concepts of integrated environmental governance (https://greshamoregon.gov/urbanforestryplan/).

An important development in recent years concerns the ongoing attempts to link urban forestry to wider urban development: the *urbanscape* approach and the policies based on *green infrastructure* represent a short medium-term perspective for city decision-making and planning and for urban environmental programmes.

Needs and perspectives: designing the future of urban forests and green infrastructure

Policy

The institutionalization of urban forestry has further progressed in North America, where the concept of urban forestry has become an integral part of policy and legislation. Asian countries and particularly China are rapidly developing policy and planning tools for urban forests. European countries refer to urban green space and peri-urban afforestation in their policies and legislation (Bentsen et al. 2010), but the concept of urban forestry is seldom used explicitly. This is particularly true in Mediterranean Europe as well as in northern African countries. Networking and exchange of experiences and ideas is growing and there is a promising perspective for a more effective policy approach to urban forestry in this region of the world.

Africa is still lacking specific policies on urban forestry except in a few cities. A policy framework is lacking (Conigliaro et al. 2014) and there is a concrete need to develop tools and reference experiences in a continent that has the fastest urban growth in the world.

In order to be successful, urban forestry requires a strategic perspective and the development of targeted, specific policies as well as of sufficient capacities. Guidelines and scientific/technical solutions are already available to some extent but there is a need to produce more effective as well as clear and simple tools to support the decision-making processes at various levels (from local to global).

Although positive perceptions are dominant, the potential negative aspects of forests and trees in urban and peri-urban contexts such as wildfires, diseases, crime (Sreetheran et al. 2014) and increased allergies still need to be properly explained and placed in the framework of active policies on urban forests and trees (Cariñanos et al. 2014).

Local communities should benefit from urban forests, and legal, economic and institutional arrangements should be in place to ensure this. In many countries, land tenure is still a major constraint to proactive community involvement in urban forestry and related activities. Moreover, planning, design and management of urban forest resources is even more complex than in the previous decade (Carreiro et al. 2008). In fact, the effects of urban forestry actions are becoming significant to a wider set of actors, while the number of individuals and groups involved is growing.

The perspective of integrated governance and collaborative programmes oriented towards involving an increasing number of stakeholders requires collaborative efforts among decision-makers, experts, researchers and the civil society.

Research needs and perspectives

Ongoing research on urban forestry shows a complex pattern of research lines and it is rather difficult to capture gaps in knowledge and the research needs within urban forestry.

Priority topics for research mentioned in different fora and publications include species selection, managing pests, diseases and abiotic stress caused, for instance, by air pollution, adaptation mechanisms to climate changes and eco-physiological constraints of trees growing in the urban environment. There is also a need for additional knowledge on the relationship between green infrastructure and soil sealing.

Other research needs relate to the development of environmentally sound adaptive management methods, studies of public preferences and changing demands for urban forest benefits, assessment of these ecosystem services and related payments, strategies for sustainable development, and the development of better information and public participation tools. Performance indicators for ecosystem services and the methods of balancing the payments of ecosystem services (PES) also need to be explored more in depth.

The development of expert systems to support planning and management has improved in the last decade but research is still needed on methodologies for capacity building and user-friendly solutions. Applied research to support decision-making processes and collaborative and public involvement processes is still rather poor. Efforts are required in activating multidisciplinary research to strengthen the knowledge base on green infrastructure at various levels, from the pattern and processes of urban ecosystems to inter-sectoral dialogue.

Research on urban forestry and green infrastructure needs to be supported and improved in several regions of the world. Africa, some countries of Latin America and the Caribbean, and southern and western Asia have huge gaps in basic knowledge in almost all the research sectors referring to urban forestry and green infrastructure. The need for technology transfer and information-sharing exists not only within countries, but also between countries and the world's regions. Calls for research networking, identification of centres of research excellence, and the establishment of demonstration urban forests and landscape laboratories are some of the potential tools for applied research in the domain of urban forestry and green infrastructure. In order to meet these calls and make sure that developing countries are not excluded, sustainable donor and other funding options need to be explored, as already pointed out by Konijnendijk and Gauthier (2006).

Educational needs and perspectives

In the last decade, the inclusion of urban forestry in education has advanced substantially in Europe, North America, central northern Asia and the Pacific. It is still in its early stages of development, or completely neglected in other parts of the world. One of the major challenges is to develop integrated educational programmes on green infrastructure. Programmes and courses should make an effort to focus on the strengths not only of urban forestry concepts and practices, but also of incorporating multiple perspectives and disciplines, and take a comprehensive view of the green infrastructure resources.

Initiatives taken in the direction of international cooperation in education should be encouraged. Life-long learning opportunities should be activated and promoted to update professionals on the current knowledge on urban forestry and green infrastructure. The work of the International Society of Arboriculture (ISA), the International Federation of Landscape Architects (IFA) and other organizations to enhance the professionalism of green space practitioners, for example through international certification and accreditation, should be supported and further developed. In parallel, there is a clear need for enhancing higher-education opportunities for designers, planners and policy advisors of green infrastructure and integrated environmental governance.

Urban forestry for development, and green infrastructure for the future cities

The experiences described above show the significant potential of urban forestry and green infrastructure for any city and town of the world, in low-income countries as well as in the so-called developed world. The concept of green infrastructure promotes inclusiveness in terms of involving experts, policy-makers and stakeholders from all walks of life. The need to join forces with other initiatives aimed at sustainable urban development is therefore crucial. Green infrastructure needs to dialogue and to find synergies with other comprehensive approaches for natural resource management and land use in intra-urban areas, at the urban fringe, and at the urban–rural interface, such as urban greening, green structure planning and landscape planning, nature conservation, forestry, agroforestry and agriculture. Green infrastructure is definitely a place where it is possible to provide urban livelihoods and help cities "farm for the future". The same piece of land should not have to accommodate conflicts between urban forestry, urban agriculture, urban agroforestry, and urban recreation but should host an integrated opportunity for providing significant benefits to urban dwellers.

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12

URBAN AQUACULTURE FOR RESILIENT FOOD SYSTEMS

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Introduction

Urban aquaculture has been defined in several ways. Clearly the location of aquacultural production within built-up areas of cities or within municipal administrative boundaries can be classified as such but the definition 'urban' has been attached to aquaculture outside this strictly literal definition (Little et al. 2012). Aquacultural practices established in conjunction with commercial, industrial and infrastructural developments – for example, power stations and dams for hydroelectric power generation – have previously been categorized as urban (Bunting and Little 2003, 2005; Leschen et al. 2005; Bunting et al. 2006). Aquaculture located on the edge of towns and cities *(peri-urban)* that makes use of nutrient-enriched drainage and sewerage water for producing food and at the same time treats the waste is often termed urban (Edwards 2003). The city as a source of nutrients and other key inputs, as well as being the major demand driver for the outputs, explains the location of much traditional or emergent aquaculture being located close to urban settlements. The very nature of 'urban' in densely populated, dynamic economies that are increasingly well networked is subject to redefinition (Leschen et al. 2005; Little and Bunting 2005). Aquacultural practices developed in rural areas but inspired by examples operated in urban areas or based on knowledge derived from urban-rural migrants and returning students or intended to supply demand from urban markets may be regarded as urban from a socio-cultural or social-psychological perspective (Iaquinta and Drescher 2000; Bunting and Little 2005).

A range of physical systems with different technical attributes are used in urban aquaculture. These range from shallow irrigated ricefields modified to allow alternate or continuous production of aquatic vegetables, fish or crustacea through, to adapted natural lakes or man-made reservoirs, to extensive natural or modified wetlands. A key requirement is that water quality is maintained through balancing inputs (feeds, fertilizers) with management to ensure adequate dissolved oxygen and other water quality parameters (e.g., low concentrations of toxic compounds and optimal nutrient levels for in situ primary production). In *extensive* systems, in which productivity is based solely on natural run-off, this is mainly achieved through maintaining a low stocking density with regular stocking and harvesting of multiple species, whereas *intensive* systems such as tanks and cages usually involve a monoculture and require provision of complete formulated diets and careful water exchange. Compared to aquaculture in general, which is globally still dominated by *semi-intensive* aquaculture, urban production is more likely to be either *extensive* or *intensive,* reflecting the different risk and opportunity cost profiles (Table 12.1).

TABLE 12.1 Urban aquaculture systems, prevailing management regimes and production risks

Aquaculture system	*Prevailing management regime*	*Production risks*
Tanks	Tanks can be constructed from brickwork and concrete or preformed from plastic and corrugated metal sheets. Aeration and filtration can be used to condition the culture water and water exchange used to remove waste.	Poor water quality and the accumulation of waste can impact on production and in severe cases cause mass mortalities. High stocking densities can lead to the rapid spread of diseases.
Ponds	Ponds ranging from tens of square meters to several hectares can be made by digging and forming embankments to make the best use of cut-and-fill options. Ponds can be static or flow-through depending on the prevailing hydrology and access to water sources.	Poorly designed and constructed ponds can suffer from erosion and collapse of embankments. Ponds sited on inappropriate soil types can be difficult to seal to avoid leaks. Optimizing the productive potential of ponds by stimulating in situ primary production and feed use is difficult.
Ponds in converted ricefields[1]	Peripheral areas of ricefields might be excavated to permit the combined culture of fish and rice, or ricefields might be excavated completely for the sole purpose of aquaculture.	Maintenance of combined ricefield-pond systems can be difficult depending on the prevailing soil type and hydrology. Production in ponds created in rice growing areas may suffer from pesticide drift and run-off.
Borrow pits	Borrow pits are formed as a result of extracting aggregates, clay and soil. The excavations are often deep to maximize the amount of material extracted. The depth of water may make it difficult to promote primary production through fertilizer application and feeding may be needed. Cages can be used in borrow pits to avoid problems with them being too deep.	Borrow pits are often much deeper than might be desirable for fish culture, making it difficult to catch the fish or drain completely for maintenance and pre-stocking preparations. Borrow pits in low-lying areas are prone to flooding.

(*Continued*)

TABLE 12.1 (Continued)

Aquaculture system	*Prevailing management regime*	*Production risks*
Lakes and reservoirs	Fish can be stocked in lakes and reservoirs and supplementary feed given to increase production but catching them requires a significant effort. Cages can be used to contain the stocked fish and enhance feed conversion and husbandry.	Problems with poaching and harvesting fish from large water bodies can mean that financial returns are insufficient to cover associated costs. Fish released into lakes and reservoirs or stocked in cages are susceptible to pollution and poor water quality; excessive cage culture development can cause self-pollution.
Multifunctional wetlands[2]	Aquatic plants are often cultivated in peri-urban wetlands in southeast Asia and fertilizer and pesticides may be used to enhance production. Ponds can be constructed within wetlands and are typically managed semi-intensively.	Wetlands are prone to drying and flooding and rapid changes in water depth can cause problems for cultured animals and plants. Construction of ponds on acid-sulphate soils can lead to water quality problems affecting cultured animals.
Cages	Cages constructed with wood, plastic or steel frames and covered in netting typically range in size from 1–50 m^3 in freshwater situations and production depends on the provision of feed.	Free movement of water through cages can present problems when pollution is present if the prevailing quality is poor. Accidental or deliberate damage to cages can cause major stock losses.

Notes:

1 Areas of low-lying ricefields within peri-urban areas are often converted to ponds for aquaculture to enhance financial returns, but prevailing physical and hydrological conditions may not be ideal for pond culture.

2 Multifunctional wetlands are defined here as areas that are inundated with water for most of the year, dominated by emergent aquatic macrophytes and used for several purposes including food production, storm water discharge and wastewater treatment.

Source: authors.

Here we consider urban aquaculture from a geographical perspective as practices occurring within larger towns and cities (intra-urban) and at their edges in peri-urban areas. Aquaculture includes the production of any plant or animal in water and embraces finfish, shellfish (crustacea and molluscs) and a range of less orthodox species. Aquaculture production is globally centred on Asia and in freshwaters is dominated by finfish production; however, a very common type of aquaculture in Asia is the production of aquatic vegetables. Producers located in urban environments face similar challenges in terms of a) accessing space for production, often with insecure tenure arrangements and property rights, b) sourcing water of sufficient quality and quantity throughout the year to carry out aquaculture, and c) having limited access to institutional support, input and service providers and credit facilities.

An overview is provided below, regarding the different urban aquacultural production strategies that meet our geographical criteria, and the relevance of each to pro-poor and food security imperatives and sustainable urban development is described (Table 12.2). Risks associated with each, such as pollution and theft,

TABLE 12.2 Relevance of urban aquaculture to pro-poor action, food security and sustainable urban development and associated risks

Urban aquaculture production strategy	*Relevance to pro-poor and food security*	*Relevance to sustainable urban development*	*Risks*
Land-based culture systems	Market demand for cultured catfish presented new opportunities for underemployed youth to engage in rewarding livelihoods; small tank-based systems can provide homestead-based income generating opportunities for women.	Fish farming opportunities prompted investment in human capital that has contributed to social-economic development; aquaculture can facilitate integrated production of agricultural crops; visits to fish farms by school children foster learning and understanding amongst their families.	Institutional capacity is often lacking, especially the limited capacity of government extension services to support commercial aquaculture development; access to credit also presents a barrier to expansion and new entrants.
Ponds, borrow pits and lakes	Numerous ponds within larger towns and peri-urban areas of secondary cities and borrow pits left following clay and soil extraction for construction can make a notable but often overlooked contribution to supplying fish to urban markets. Multifunctional urban lakes can alleviate flooding in low-lying areas housing poor and marginal groups; fish produced in urban water-bodies can provide an affordable protein source.	Ponds in larger towns and peri-urban areas often receive combined flows of domestic wastewater and surface run-off and facilitate treatment processes that contribute towards environmental protection. Retaining urban lakes can provide capacity for storm water discharge to mitigate flooding and open spaces that are beneficial for psychological well-being and an environment to capitalize on recreation and tourist economies. Aquatic production can be a good functional bio-indicator of environmental health.	Stagnant water bodies can suffer from intermittent poor water quality leading to fish kills; standing water can harbour disease vectors and parasites; it is difficult for operators to monitor their ponds and therefore they are vulnerable to thefts. Urban lakes can be regarded as prime areas for commercial and residential development and appropriate controls are needed.
Multifunctional wetlands	Foraging in urban wetlands can yield animals and plants for human consumption or livestock feed; women engage in cultivating aquatic plants with minimal costs and risks. Large areas of fish and shrimp ponds downstream of cities in the tropics provide employment and income opportunities, both directly and in associated value chains.	Wetlands within urban and peri-urban areas provide storage for storm water, whilst observable food production increases the pressure on authorities to eliminate pollution. Nutrients discharged from urban areas are assimilated in extensively managed ponds and production of valuable fish and shrimp contributes to economic development.	Agrochemical use to combat plant diseases can raise public health risks and surface water pollution can constitute a hazard for producers, local communities and consumers. Mangrove removal and suppression of regeneration makes urban coastal communities vulnerable to storms and tidal surges and disrupts other vital ecosystem services.
Cages and culture-based fisheries	Cage culture can provide employment for poor and marginal groups; small cages can allow households to culture and fatten fish in common property water bodies. Action to increase fish stocks can enhance incomes for poor fishers and bolster food security locally.	Fortunes of cage culture can be a good functional bio-indicator of prevailing environmental health, which can be a proxy for the effectiveness of urban planning and governance. Increased surveillance by concerned authorities can help eliminate pollution, resulting in general public health benefits.	Excessive numbers of cages can overwhelm the capacity of the environment to support cage culture, resulting in self-pollution and environmental degradation. Stocking invasive non-native or native fish outside their range could damage indigenous fish populations and aquatic ecosystems.

Source: authors.

are summarized and recent research to address constraints is reviewed and opportunities to put research findings into use to capitalize on the potential of aquaculture to contribute to sustainable urban develop are discussed. As with other contributions to this volume, the focus is on cases from developing countries.

Land-based culture systems

Aquaculture in concrete tanks in peri-urban settings in Nigeria has emerged as a novel production practice able to generate employment for underemployed youth and produce fish for consumption locally (Miller and Atanda 2011). These systems are used to produce African catfish *(Clarias gariepinus)* to meet rapidly expanding market demand. Serviced by intensively managed hatcheries and with access to good-quality formulated feeds, investors are able to make a positive return on their money within one year of commencing production.

Cooperative management of several hundred tanks located together in fish farming villages or fish farm estates within peri-urban areas has become established as an effective production strategy. Trained staff employed to maintain and watch over the estates ensure that individual tanks are well managed and that poaching is reduced (Miller and Atanda 2011). The scale of production also means operators are able to secure credit based on professional business plans and credible documentation.

FIGURE 12.1 Fish growing in concrete tanks Azemor, Ibadan, Nigeria
Source: SARNISSA project, courtesy of V. Poumogne, 2009.

Aquaculture to produce ornamental fish was reported from Bhubaneswar, Odisha, and Kolkata, West Bengal in India, and it was noted that fish culture in small brick-built tanks within peri-urban settlements offered important livelihoods opportunities, especially for women (Mukherjee et al. 2004). Aquaponics[1] production systems have been established in peri-urban locations in Phnom Penh, Cambodia, and Kathmandu, Nepal, with the dual intention of producing fish and salad crops for food and income and of providing an educational resource (Mallapaty 2012; *Khmer Aquaponics* 2014). It is not clear, however, whether such systems would be financially viable based purely on the sale of crops produced, or to what extent their establishment depended upon external interventions and financial support.

Research into use

Calls to establish urban and peri-urban land-based aquacultural systems for enhanced food security and livelihoods and as a resource for learning and teaching and human capacity-building have come from authorities and social organizations in countries including Cuba, England and the United States (Bunting and Little 2005; Frederick 2005; Prain 2005; Roy 2005; The Able Project 2014). Proponents have developed technology packages, such as the 'fish farm in a container', a series of tanks in a modified shipping container that can enable the intensive production of fish in a small, secure space (Crone 2013). Discussing the evolution of peri-urban aquaculture in Nigeria, Miller and Atanda (2011: 281) noted that 'the industry was led by the establishment of intensive fish hatcheries and delivery of quality fish feeds through imports or greatly improved local production'. It was noted, however, that veterinary provision and disease and parasite identification and treatment were inadequate, as was environmental management. These authors also cautioned that continued expansion of the sector may be constrained by the availability of locations with 'adequate environmental capacity' to sustain production (281). Although clustering of enterprises close together and shared water use and effluent disposal can exacerbate the spread of pathogens, the co-location of hatchery and nursery enterprises undoubtedly results in faster social knowledge generation and exchange (Little et al. 2002).

Ponds, borrow pits and lakes

Farm and village ponds are often retained in peri-urban areas as a source of water and as part of the drainage system. As the population density increases, the water draining into these ponds can contain a significant proportion of domestic wastewater and the ponds can become important in treating this, although bathing and washing in such ponds would constitute a public health hazard. Elevated nutrient levels in peri-urban ponds as a result of waste inputs can enhance fish production, but excessive nutrient levels can cause water quality problems and affect the health and survival of the fish being cultured. Where towns and cities in Asia are

FIGURE 12.2 Fishponds Kakamega, Kenya
Source: SARNISSA project.

expanding into agricultural areas and in predominantly rice-growing regions in particular, conversion of land to growing aquatic vegetables and fish is a common strategy to generate higher financial returns. Such a transition has been reported in the cases of Mymensingh in Bangladesh and Hai Duong, Vietnam.

Rapidly expanding urban areas in many developing counties demand large amounts of soil or dredged material to fill low-lying areas and sand and bricks for construction. Borrow pits dug to extract clay and soil usually fill with water and although not ideal for fish culture as they are difficult to drain and maintain, entrepreneurs often commence aquaculture as the potential returns outweigh the challenges (Little et al. 2007). Both ponds and borrow pits in peri-urban areas are vulnerable to theft and contamination and it may be difficult for producers to monitor their ponds to counter such problems.

Large lakes in built-up areas are often protected from urban encroachment as they are considered important in enhancing the capacity of urban environments to absorb surge floodwaters, a key attribute in climate change mitigation. They also provide an open area for amenity and recreation and can be used to supply water and fish. Construction of multifunctional lakes can be included in urban development plans to avoid the problems of reclaiming and building on low-lying areas and to create green infrastructure to sustain the urban economy. Hoan Kiem Lake and West Lake in Hanoi, Vietnam, are managed principally for storm water drainage, amenity and fish production; they have particular cultural significance as the location for pagodas and the setting for mythical tales. New lakes have been constructed as part of the urban development projects in Thanh Tri District, Hanoi, Vietnam, and Rajarhat New Town, West Bengal, India, with the intention of creating multifunctional green spaces where fish culture is an intrinsic component.

Research into use

Retaining and creating lakes within urban and peri-urban areas can serve a number of purposes (Table 12.2), but an integrated urban landscape planning approach is needed to adequately value the benefits of large water bodies within built-up areas. Similarly, there may be tensions between stakeholders owing to economic returns that might be realized through filling in old borrow pits for redevelopment versus their continued use for urban floodwater mitigation and other uses including aquaculture. Ponds within peri-urban areas can perform multiple functions but fish culture may be regarded as vulnerable owing to fears over poaching and the composition of wastewater draining from local residential and commercial areas. Management strategies such as sharing a proportion of the fish harvest with local residents can foster community cohesion and lead to greater vigilance. Risks associated with wastewater entering ponds may not necessarily constitute a major health hazard if viewed from the perspective of a holistic risk assessment (WHO 2006a).

Multifunctional wetlands

Several cities in Southeast Asia have low-lying areas within their boundaries or at their periphery that are inundated with water for large parts of the year. Often, the seasonal nature of these wetlands and limited scope to establish perennial deep water areas or regulate water exchange mean they are only suited to cultivating aquatic plants. Extensive areas of aquatic plant production were noted in peri-urban areas such as Bin Chanh District and Thu Duc District, Ho Chi Minh City, Vietnam; Boeng Cheung Ek, Phnom Penh, Cambodia; Gia Lam and Thanh Tri, Hanoi, Vietnam; and Pathumthani, Bangkok, Thailand (Hung and Huy 2005; Khov et al. 2005; Nguyen and Pham 2005; Yoonpundh et al. 2005). Aquatic plants cultivated included water cress *(Rorippa nasturtium-aquaticum),* water dropwort *(Oenanthe stolonifera),* water mimosa *(Neptunia oleracea)* and water spinach *(Ipomoea aquatica),* and they were often harvested daily and sold at local markets. Frequent pesticide applications were found to be a major public health hazard.

Samples of water spinach analyzed from Boeng Cheung Ek contained thermotolerant coliforms (ranging from 10^5 to 10^7 g^{-1}), protozoan parasite (*Cryptosporidium* spp., *Cyclospora* oocysts and *Giardia* spp.) cysts (9.2 g^{-1}) and helminth (*Ascaris lumbricoides, Trichuris trichura* and hookworm) eggs (0.1 g^{-1}) (Vuong et al. 2007). Thermotolerant coliform concentration in the water used to cultivate the plants was 10^4–10^7 100 ml^{-1} and exceeded the World Health Organization guideline level of $\leq 10^3$ 100 ml^{-1} for water used for unrestricted irrigation of crops that are likely to

FIGURE 12.3 Fish grown in the East Kolkata Wetlands, India, going to market
Source: Bunting.

be consumed raw (WHO 2006a). These findings indicate that the cultivation and sale of aquatic plants grown in Boeng Cheung Ek constituted a public health hazard to both growers and consumers. A separate study noted that levels of potentially toxic elements (PTEs) were low and it was concluded that water spinach from the lake presented a low food safety risk with respect to PTEs (Marcussen et al. 2009).

Intra-urban and peri-urban aquaculture in wetlands has emerged in sub-Saharan Africa with examples described from Dar es Salaam, Tanzania, and Harare, Zimbabwe (Rana et al. 2005; Aquaculture Zimbabwe 2011). Tilapia culture dominated in Dar es Salaam and was practised in ponds ranging 10–10,000 m^2 and covered 50 ha in total. Urban aquaculture was promoted as part of the Aquaculture Zimbabwe initiative and focused on the sustainable use of peri-urban wetlands and integrated gardening activities for enhanced livelihoods outcomes and nutrition.

Extensive peri-urban wetlands were widely exploited for wastewater disposal and, in some cases, these wetlands were modified to optimize wastewater treatment and produce valuable fish, rice and vegetable crops. Extensive ponds stocked with fish in the East Kolkata Wetlands (EKW) occupy 3,900 ha, although a much larger area was designated a wetland of international importance in 2002 under the United Nations Ramsar Convention in respect of historical land-use practices and to establish a buffer to further urban encroachment. The Government of West Bengal made a significant commitment to safeguarding and enhancing the wise-use of these wetlands, passing 'The EKW (Conservation and Management) Act (2006)' and constituting the 'East Kolkata Wetlands Management Authority' (EKWMA). The EKW provides a living and working example of an alternative paradigm for solid and liquid waste management for towns and cities in India and worldwide.

The concept of wise-use embodied by the EKW and its associated environmental and biodiversity attributes was instrumental in the designation of this wetland area as a Ramsar Site. Research has demonstrated that farming fish, rice and vegetables in the EKW benefits local people and Kolkata residents in several ways:

- Direct employment for thousands of men and women, catching fish, weeding and harvesting and as casual labourers.
- Indirect employment in supply and distribution networks, e.g., seed traders and market vendors.
- Payment-in-kind for work undertaken on farms, e.g., weed clearing or carrying fish to market.
- Supplying affordable and fresh fish and vegetables to markets serving poor communities.
- Low-cost and natural wastewater treatment.
- Managed solid organic waste and wastewater use, mitigating environmental degradation and reducing health risks.
- Ecosystems services, including provisioning, regulatory, cultural and supporting services.
- Overall improvement in environmental quality due to the existence of peri-urban farming and wetlands.

Practices devised by farmers in the EKW to optimize production and the financial returns generated by the lakes under their jurisdiction were combined with engineering principles to formulate rational design criteria for wastewater reuse through aquaculture (Mara et al. 1993). Comparative benefits of adopting this rational design approach as opposed to a conventional one for lagoon-based wastewater treatment and use in the context of the EKW demonstrated that production could be potentially increased from 11,560 t to 45,500 t.yr^{-1}, but that this would require extensive reconfiguration of the existing system and modification of management practices (Bunting 2007). Use of wastewater and excreta in aquaculture was recognized as a legitimate means to achieve incremental improvements in sanitation provisions with the publication of the World Health Organization guidelines for such practices (WHO 2006b). Cities now constitute major driving forces leading to the relocation of significant water resources within river catchments and the concentration of nutrients in anthropogenic waste streams. Ecological processes within wetland agroecosystems constitute a low-cost and environmentally sound means to recover valuable nutrients entrained in waste streams and rehabilitate water resources for other purposes and to safeguard environmental flows that sustain receiving aquatic ecosystems (Bunting et al. 2010; Finlayson et al. 2013).

Cities have been traditionally located close to perennial water, usually on floodplains or close to estuaries, and consequently many cities have encroached into coastal wetlands. The EKW was initially a series of salt lakes, and further downstream where the main drainage canals discharge into the Kulti River estuary a vast area of fish and shrimp ponds has been constructed. Water used to fill these ponds contains wastewater from the city and this has been cited as benefiting producers as it stimulates primary production in the ponds. The animal, environmental and public health risks associated with this have yet to be assessed. Similar aggregations of shrimp ponds can be observed to the south of Bangkok, Thailand, and to the north of Jakarta, Indonesia.

Research into use

Research findings from the European Commission-sponsored PAPUSSA (Production in Aquatic Peri-Urban Systems in Southeast Asia) project were used to produce better management practices for aquatic plant growers to optimize production and minimize health risks for producers and consumers. The guidelines noted that in many cities 'aquatic vegetable growers have an almost non-existent voice in the urban planning process' and that national and local governments should 'target and incorporate aquatic production systems in their city development and land use plans' (PAPUSSA 2006). Considering the multifunctional wetlands observed in cities such as Bangkok and Phnom Penh, rapid economic growth and urban development have, however, resulted in wholesale programmes of in-filling and reclamation for construction purposes. The plight of families growing morning glory and living in Boeng Tompun, Phnom Penh, was covered in a national newspaper (*The Cambodia Daily* 2014) and described how in-filling 80% of this wetland with sand threatened the dual role of this area in treating wastewater from the city and producing aquatic vegetables.

Despite the benefits derived from the EKW, a number of problems threaten the system and the communities that depend upon its continued operation (Edwards 2005), including: deficiencies in managing and maintaining the system, notably siltation of canals and fish ponds; inadequate quantity and distribution of wastewater to farms; changing quality of waste resources; perceived threat of urban encroachment; limited access to alternative livelihoods and economic activities; and uneven and incomplete service and infrastructural coverage. Provisions within 'The East Kolkata Wetlands (Conservation and Management) Act, 2006' addressed the 'conservation and management of the East Kolkata wetlands' and a schedule of landholdings within the EKW was presented specifying their character and mode of use. Furthermore, the Act set out the functions and powers of the East Kolkata Wetlands Management Authority (EKWMA) and one of these functions was to prepare action plans and another to implement and monitor activities specified in the action plans.

Formulation of Environmental Management Plans (EMPs) addressing aquaculture management, wastewater management, waste recycling and best practices was carried out in consultation with various stakeholders associated with the EKW as part of an Asian Development Bank (ADB) sponsored programme of Technical Assistance (Bunting et al. 2011). Based on a wealth of knowledge derived from various studies and surveys in the EKW over the past 20 years, it was possible to prepare preliminary EMPs that addressed the major problems faced by different stakeholder groups associated with the system and highlighted some of the main ways in which management of the EKW could be improved. It was deemed essential that stakeholder groups associated with the EKW should have the opportunity to participate in jointly assessing the preliminary plans and suggesting amendments and additions making the plans more likely to find widespread support, contain important and worthwhile objectives, and lead to the desired enhancements in wise-use practices, environmental protection, biodiversity conservation and livelihoods. Following this review phase, the preliminary plans were amended where appropriate.

EMPs included several sections, covering management objectives, compliance to regulations, environmental and ecological objectives, social and economic objectives, educational objectives, principles of operational management, research objectives, monitoring controls and surveillance, consultation with stakeholders, post-harvest sector assessment, triggers for periodic review of the plans, institutional assessment, and legislative and regulatory assessment. Furthermore, there was provision within the EMPs for any stakeholders to propose new areas for inclusion in the plans, thus helping to guide an ongoing process of management plan review and improvement. The agreed plans were published in the *Environmental Management Manual East Kolkata Wetlands* (Bunting et al. 2011) along with a historical account of the systems development and contemporary challenges to support the EKWMA in formulating and implementing a comprehensive environmental management system.

The concept of exploiting wastewater flows to realize employment and income was adopted under the Ganges Action Plan and a series of lagoon-based treatment systems incorporating fish culture were constructed at several places in West Bengal (Mara 1997). It was envisaged that cooperatives would produce fish using these systems and the revenue generated would help pay for the operation and maintenance of the wastewater treatment lagoons. Use of wastewater for catfish culture in Ghana for income generation and to support wastewater treatment was described by Murray and Yeboah-Agyepong (2012), who extolled the virtues of a public-private business model to foster the adoption of this approach elsewhere in sub-Saharan Africa. Related and other 'Business Models for Resource Recovery & Reuse' were conceived as part of the CGIAR Research Programme on Water, Land and Ecosystems (IWMI 2014).

Cages and culture-based fisheries

Cage culture is a well-established practice that offers huge potential in terms of producing fish in water bodies where the capture of stocked fish would be difficult or in open-water areas such as large lakes and marine areas where securing exclusive rights to benefits associated with enhanced fish stocks and catches are problematic. Cages for the culture of tilapia were observed in rivers in peri-urban areas of Ho Chi Minh City, Vietnam. These cages were constructed from wood and incorporated accommodation and storage space at one end, reminiscent of traditional fish cage designs (Beveridge 2006). Cage culture is widely practised in peri-urban lakes

FIGURE 12.4 Cages in river downstream Ho Chi Minh, Vietnam
Source: Bunting.

and reservoirs in Southeast Asia but there is a tendency for the number of cages installed by multiple operators to exceed the carrying capacity of the ecosystem (Hart et al. 2002). Accumulation of wastes below cages and deteriorating water quality can result in self-pollution, leading to mass fish kills, meaning that the water is not fit for other purposes, for example, as a source of drinking water.

Widespread pollution from industrial and residential development and agricultural intensification had a severe impact on water quality in the Beijiang River running through Shaoguan City, Guangdong Province, China (Cai et al. 2010). This situation was compounded by the extensive construction of dams for hydroelectric power generation and to divert water for irrigation. Dredging of aggregates that accumulated on the bed of the impounded river has caused extensive damage to aquatic habitats. Consequently, the abundance and diversity of fish species declined significantly and households that engaged in fishing became more impoverished, with the younger generation forced to move away to seek urban-based employment (Punch and Sugden 2013).

Overfishing was implicated in the decline of wild fish stocks throughout the Pearl River Basin and consequently a no-fishing season was instigated to reduce this source of pressure. Declining catches combined with limited alternative livelihood opportunities for aging fishers on the Beijiang River has had negative impacts on their health and well-being. Subsidized fuel supplies helped fishers to a limited extent, but the authorities instigated a more drastic programme to relocate the fishers from living on their boats on the river to living in flats in urban areas. Authorities in Shaoguan City tried to control pollution and established a number of aquatic conservation zones in an attempt to regenerate aquatic habitats. Stocking of cultivated fish species was initiated to bolster fish stocks and supplement the catches of fishing households. Fish species stocked in the river included bighead carp *(Aristichthys nobillis),* black amur bream *(Megalobrama terminalis),* common carp *(Cyprinus carpio),* crucian carp *(Carassius auratus),* grass carp *(Ctenopharyngodon idellus),* silver carp *(Hypophthalmichthys molitrix)* and *Spinibarbus denticulatus*. Releases commenced in 1995 and by 2012 the estimated number of fry stocked was 8 million.yr^{-1}. Records from boats in a stretch of river 50 km downstream of the stocking point indicated that cultured fish accounted for 12–38% of the catch (Luo et al. 2013). Such programmes can be cost-effective if the ecological benefits of bolstering wild fish stocks and socioeconomic benefits of sustaining the livelihoods of poor fishers are considered.

Research into use

Considering the need to enhance the conservation of aquatic resources in Shaoguan City, integrated action planning was facilitated with stakeholders to better characterize the problems faced by resource users and threats to biodiversity. A number of short-, medium- and long-term actions were identified to enhance biodiversity conservation whilst ensuring that wise-use of aquatic resources was regarded as legitimate and actually beneficial in increasing the importance ascribed to conserving and restoring urban aquatic ecosystems. Activities included in the Integrated Action Plan (IAP) developed for the Beijiang River passing through Shaoguan City included changes to ongoing measures and new short- and long-term actions.

Formulation of IAPs jointly with authorities and other stakeholders led to improvements in the regulation of sand mining in the river and the establishment of clearer communication channels between fishers and the operators of the hydroelectricity dams. The interactive participation of multiple stakeholder groups in the integrated action planning process can be regarded as a notable outcome in its own right. Specific interventions proposed within the IAP for the Beijiang River included 'Improved regulations regarding water pollution', 'Compensation received from sand mining and hydropower to be used for conservation of aquatic resources', 'Setting up Aquatic Conservation Zone offices' and 'Increased numbers of fish fry released.' The potential impact of these was evaluated with bioeconomic modelling and indicated that stricter pollution control could increase net benefits accruing to fishers by 15.9% as well as benefiting other user groups and local communities and enhancing biodiversity and stocks and flows of ecosystem services. Adoption of an ecosystems approach to fisheries management is effective at balancing the capacity of the environment to supply ecosystem services that sustain social and economic activity. Pertinently, it was concluded that such an approach would be critical to rehabilitating the ecosystems and fisheries of the Old Brahmaputra River running through Mymensingh city in central Bangladesh (Ahmed et al. 2013). The evidence in Bangladesh is that the governance required to conserve such ecosystems is complex and unlikely to be effective in a context of such open access fisheries in which large numbers of poor people remain dependent. Concomitantly, there has been a large increase in dependence on farmed fish by poorer consumers (Tofique and Belton 2014).

Tools and approaches devised for integrated action planning were compiled in the Wetland Resources Action Planning (WRAP) toolkit (Bunting et al. 2013) to enable similarly integrated and multidisciplinary joint assessments with stakeholders. Integrated action planning to achieve biodiversity conservation founded on the wise-use of aquatic resources could make a significant contribution to achieving the United Nations' Convention on Biodiversity (CBD) Strategic Plan for Biodiversity, which included 20 targets, known as the Aichi Targets,[2] notably Targets 2 and 4 under Strategic Goal A: 'Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society', and Target 6 under Strategic Goal B: 'Reduce the direct pressures on biodiversity and promote sustainable use.'

Opportunities and challenges

Opportunities for (intra- and peri-) urban aquaculture development as a response to adverse conditions experienced by poor and marginal groups in urban areas were identified using the version of the DPSIR (Driving forces, Pressures, State, Impacts, Responses) (Maxim et al. 2009; Spangenberg et al. 2009) framework conceived within the EU-project HighARCS (Highland Aquatic Resources Conservation and Sustainable Development) (Bunting et al. 2013) (Table 12.3).

TABLE 12.3 DPSIR assessment of urban aquaculture in developing countries from a systems perspective

DPSIR elements	*Description*
Driving forces	- economic growth and industrialization - population growth and rapid urbanization - rural–urban migration - rapid expansion in physical extent of urban areas
Pressures	- population pressure results in in-filling of vacant land with buildings and informal settlements on any accessible areas - lakes, pond, wetlands and other low-lying areas in-filled, making them suitable for urban development - population growth and urban and industrial activities result in greater untreated wastewater flows and pollution
State	- proportion of global population living in urban areas surpassed 50% in 2007 and continues to grow - number of poor people living in urban areas is expected to reach 5 billion in 2030 - 750 million people in urban areas in developing countries in 2002 were living below the poverty line of $2 per day - several factors conspire making the urban poor particularly vulnerable (insecure living conditions, limited employment and income, inadequate infrastructure and services, insecure food supplies and lack of social-ecological resilience) - air and surface water quality in many urban environments is below acceptable international standards and extent of open and green spaces has declined significantly
Impacts	- poor and marginal urban populations suffer as a result of comparatively high food prices, compounded by the lack of access to health care and sanitation - pollution and untreated wastewater flows result in livestock, environmental and public health problems - residents suffer owing to the absence of urban ecosystem services, i.e., flooding due to limited infiltration; extreme temperatures owing to urban heat island effects; denial of psychological benefits associated with accessing green (and blue) spaces - participation in urban farmed seafood value chains appears a complementary component of livelihood portfolios for a proportion of poor people - urban areas disrupt ecological processes in rivers and their catchments and present insurmountable barriers in the migratory routes for several fish species, affecting food-chains and capture and recreational fisheries - urban food systems and populations are increasingly vulnerable to social-ecological shocks, notably civil unrest, global commodity price surges and worsening climate change impacts
Responses	- aquaculture as one element of multifunctional lakes and reservoirs in urban areas - culture-based fisheries enhancement to restore stocks decimated by pollution and habitat destruction - processes of urbanization enclose ponds and wetlands or transform peri-urban areas making them suitable for aquaculture but unsuited to other uses owing to water-logging or costs of reclaiming land for construction - entrepreneurs initiate intensive aquaculture in urban areas to capitalize on market access, transport links, access to services or other business opportunities - specialist activity such as seed production for restocking, holding seed at key distribution points or ornamental fish production

Source: authors.

Urban centres in many developing countries have undergone rapid change over the past decade with many of the more widely known examples of large urban and peri-urban aquaculture systems having been lost. The rapid pace of change has resulted in large numbers of poor people living in substandard accommodation with inadequate water supplies and sanitation coverage. Environmental conditions are bad as a result of air and surface water pollution and this situation is compounded by limited employment opportunities, elevated food prices, limited access to health care and insecure living conditions.

Where large lakes and remnants of extensive peri-urban wetlands remain, these can sustain a range of urban ecosystem services that can improve the environment, with notable benefits for poor and marginal groups (reduction of flood risks, improved quality of surface water, moderation of extreme heat events and enhanced psychological well-being). Cultured fish might also be used to supply local markets, and, depending on the quality and size of fish, these might be purchased by poor families contributing to their food security and nutrition.

Current and emerging challenges and opportunities to the development of urban aquaculture were critically reviewed using the SWOT (Strengths, Weaknesses, Opportunities, Threats) assessment framework (Table 12.4). Intra- and peri-urban aquaculture is an established practice in many larger towns and cities in Asian countries and this has demonstrated the potential range of benefits that could contribute to sustainable urban development. Compared to volumes of regional and national aquacultural production, those from urban and peri-urban systems may be modest. This may mean the demand for support services does not warrant

TABLE 12.4 SWOT assessment of urban aquaculture in developing countries

Strengths: existing or potential resources or capability	*Weaknesses: existing or potential internal force that could be a barrier to achieving objectives/results*
- strong demand for aquaculture products - broad range of aquaculture production systems and strategies suited to niches found in urban environments - urban aquaculture recognized in national and international policy and supported by donors and development agencies - aquaculture in urban areas can be a good indicator of environmental health and help restore degraded urban ecosystems - urban aquaculture provides income and employment opportunities in production phase and across associated value chains and produces fish and plants that can be an affordable and important source of protein and nutrients for the poor	- deficiencies with urban environmental management lead to widespread pollution of surface waters - insecurity of tenure constrains investment in urban aquaculture - difficulties in monitoring aquaculture systems in urban settings can lead to thefts and indiscriminate dumping and in-filling - dispersed and often transient nature of small-scale urban aquaculture means support from government institutions and access to service providers is lacking- urban authorities may not recognize aquaculture as a legitimate land-use practice – lack of information on extent of peri-urban aquaculture means its contribution to livelihoods, economic development and food security is overlooked

Opportunities: existing or potential factors in the external environment that, if exploited, could provide a competitive advantage	*Threats: existing or potential forces in the external environment that could inhibit maintenance or attainment of unique advantage*
- opportunities to access markets locally with fresh produce on a timely basis - increasing demand for high value aquatic products amongst burgeoning middle classes in many urban areas in developing countries - rising demand for affordable aquatic products for nutrition and food security amongst poor urban communities - underutilized resources (low-lying areas, nutrients in organic waste streams, wastewater flows) that urban aquaculture could exploit - international agreements and guidelines that support responsible aquaculture development and the use of waste resources - national policies that advocate and recognize urban agriculture (encompassing aquaculture) as a legitimate urban activity	- access to land and inputs (water and nutrient sources) denied or disrupted owing to competition or development plans that do not consider or recognize the claims of aquaculture producers - improved transport links and communications mean urban aquaculture must compete with production in rural areas with lower capital and operating costs - demand for fish from urban aquaculture systems declines owing to negative media coverage resulting from animal, environmental or public health concerns - inappropriate urban aquaculture development results in conflict with other resource users or local residents - excessive urban aquaculture development overwhelms capacity of supporting ecosystem areas, resulting in self-pollution and environmental degradation

Source: authors.

government attention and that the number of input suppliers is limited and producers do not benefit from competition for their custom. Broader benefits associated with urban and peri-urban aquaculture may be overlooked by authorities faced with more immediate and potentially controversial issues such as pollution, transport and waste disposal.

Deficiencies with pollution control and inadequate wastewater treatment can impact severely on aquacultural production, causing widespread fish-kills and resulting in public health risks for consumers. Aquaculture producers could garner broader support by highlighting their potential role as a component in integrated wastewater management and nutrient recovery strategies. This could reduce the costs for wastewater treatment that must be met from squeezed public spending budgets and alleviate environmental degradation caused by untreated discharges. Despite potential benefits, a number of threats must be considered; the pace of peri-urban land-use change means aquaculture producers with insecure tenure, minimal institutional support or contemplating more lucrative investment opportunities may only continue for a limited time.

With better transport links, increased access to formulated feed supplies and lower capital and operating costs, aquaculture producers in rural areas can out-compete urban and peri-urban producers. Despite this, urban and peri-urban aquaculture occurs in developed and developing counties and it is necessary to take account of the full range of values associated with such practices to explain why they persist and continue to be established.

Creating an enabling environment for development of urban aquaculture

Conditions required to enable and sustain development of urban aquaculture as part of resilient food systems were defined using the STEPS (Social, Technical, Environmental, Political, Sustainability) framework (Bunting et al. 2005; Lewins et al. 2007) (Table 12.5).

A critical issue for policy-makers, urban planners and implementing authorities is to prevent toxic compounds and those causing off-flavours from entering the aquatic environment. This constitutes a tall order, requiring the upgrade of urban waste management generally; otherwise the fish produced will only have distant, poor markets as an outlet and local urban people will buy 'imports'. An added benefit of modest and dispersed aquacultural systems operating in urban and peri-urban areas is that they could constitute functional bio-indicators of urban environmental health.

The role of burgeoning urban markets in many developing countries in governing development of aquaculture nationally is increasing (Toufique and Belton 2014) and arguably they constitute the main driving force for expansion of urban and peri-urban aquaculture. Proximity to markets is only one consideration, however, and an assessment of the needs, logistics and impacts of aquacultural production across the value chain, including input and service provision and marketing, consumption and waste disposal, is required.

As with the production of both urban agriculture and livestock (Ellis and Sumberg 1998) it is important not to overstate the current or potential future contribution of (intra- and peri-) urban aquaculture to supplying affordable fish to poor and marginal groups. Local initiatives, where circumstances permit, may be able to produce modest volumes of good-quality fish, but for the substantial amounts of affordable fish needed to meet the demand for burgeoning urban populations this requires large land areas that are not available in urban areas and would not be cost-effective to develop in peri-urban areas.

Peri-urban land prices are comparatively high as a consequence of the proximity to build up areas and expectations that such land will increase in value as development for commercial or residential purposes becomes more likely. Larger aquacultural systems that might make a notable contribution to fish supplies are more likely in low-lying and coastal peri-urban areas where the risk of flooding prohibits urban development and in areas where drainage and sewerage water from urban areas is discharged. Such hazardous situations may, however, require producers to adopt culture systems and practices that minimize the risks they face and the likelihood of damage and financial losses.

TABLE 12.5 STEPS assessment of conditions needed to support and promote urban aquaculture

STEPS elements	*Conditions*
Social	- acceptance and support for aquaculture as a legitimate and worthwhile urban activity - demand for products from urban aquaculture continues and grows - urban aquaculture is able to generate sufficient financial returns to make it viable and a continued and novel employment and income-generating activity
Technical	- access to appropriate spaces within urban environments is possible and sufficient periods of tenure guaranteed to safeguard investments made by producers - inputs to establish and sustain aquaculture are readily available - haulage providers and processing and marketing facilities willing and able to accept products from urban aquaculture - transaction costs and overheads are reasonable given the production volumes and financial returns generated by urban aquaculture systems
Environmental	- responsible authorities implement and enforce policies and laws that prevent pollution and environmental degradation in urban areas - city planning and infrastructure development (including green infrastructure) safeguards areas where urban aquaculture can be practiced against encroachment and shocks (floods, drought, disruption to electricity and water supplies) and includes provisions for aquaculture as potential element of multifunction urban water management plans - wastewater aquaculture included as a legitimate element in establishing and upgrading sewage treatment systems in accordance with WHO (2006b) guidelines to help protect receiving water bodies and facilitate productive reuse of waste resources
Political	- national and international polices explicitly support urban aquaculture for employment and income generation and associated ecosystem services and food security benefits - municipal authorities recognize and encourage aquaculture as a legitimate urban activity - land-use policy and tenure agreements provide sufficient security so as to encourage prospective producers and reassure investors and credit providers - government and private sector aquaculture support services cover aquaculture in urban environments
Sustainable (long-term viability)	- policies supporting urban aquaculture and production system management strategies are adaptable given the rapidly changing urban environment - urban aquaculture producers join forces to promote knowledge sharing, raise awareness and lobby for greater support, negotiate for cheaper inputs and coordinate sales and marketing - producers develop links with business advisors, development agencies and researchers to enhance efficiency and capitalize on accessible resources and income-generating opportunists

Source: authors.

Enabling policies and institutions are needed that recognize and support aquaculture as a legitimate and beneficial activity within urban and peri-urban environments (IWMI 2002). Policy-makers may call for evidence concerning the likely benefits associated with the development of urban and peri-urban aquaculture. Cost Benefit Analysis (CBA) carried out to evaluate the potential of the development of aquaculture should include the valuation of the full range of ecosystem services that it can sustain in urban and peri-urban environments. Similarly, application of CBA and complementary efficiency indicators (Murray et al. 2011) could demonstrate the advantages of urban and peri-urban aquacultural practices that incorporate the use and upgrading of wastewater as compared with conventional treatment plants. Regulatory authorities and practitioners may require appropriate hazard assessment and control frameworks to ensure that practices adopted locally do not pose unacceptable animal, environmental or public health risks.

Notes

1 Aquaponics is the integrated production of terrestrial plants (flowers, salad crops and vegetables) in an aquatic growing medium; also used to culture fish in unit where the water is recirculated to optimize nutrient uptake.

2 Aichi Target 2: By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.

Aichi Target 4: By 2020, at the latest, governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

Aichi Target 6: By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species, and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

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13

GENDERING URBAN FOOD STRATEGIES ACROSS MULTIPLE SCALES

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Introduction

Gender provides a powerful lens for analysing and addressing urban food insecurity (Hovorka et al. 2009). This chapter examines gender-related issues in urban food systems across multiple scales and offers strategies to integrate gender analysis in practice. The chapter builds on Hovorka and Lee-Smith's (2006) review of gender and urban agriculture literature in *Cities Farming for the Future: Urban Agriculture for Green and Productive Cities,* with two key differences in focal point. First, whereas the 2006 contribution focused on food production in urban areas, this chapter encompasses multiple aspects of urban food systems including food distribution, consumption, and livelihoods. Second, whereas the 2006 chapter was focused on cities in developing areas, this chapter draws together research from cities of the Global North and the Global South, using gender as a unifying concept to connect extremely diverse case studies.

In adopting a comprehensive and interdisciplinary scope, this chapter draws on the concept of a 'feminist foodscapes framework' (Hovorka 2013) to emphasise the social justice questions at the heart of urban food security. The feminist foodscapes framework highlights the power imbalances that create and sustain food insecurity in urban areas. These power imbalances are evident in the structural disadvantages faced by women relative to men at multiple scales, including: the distribution of resources at the household level, access to employment, education and health care, and the protection of women's human rights. These structural issues shape men's and women's food security status differently, while also intersecting with disempowering social categories and identities based on race, class, age, religion, and sexuality. The precise causes and effects of these differences differ by context, but the feminist perspective reveals the resonance of each case with a bigger picture of inequality and injustice. Hovorka (2013) argues that the ubiquity of food and gender difference in all societies makes the overlapping of food and gender studies particularly constructive for a social progress agenda.

The literature review provided in this chapter illuminates the ways in which gender is necessarily embedded within and across various scales of urban life: individual, household, neighbourhood, city, nation, and globe. Indeed, it exposes the ways in which gender roles, responsibilities, and expectations are normalised and often the root of inequality in terms of food access and security. In foregrounding the political economic dimensions of urban food systems, the feminist foodscapes framework resonates with the growing literature of critical food studies related to urban agriculture (McClintock 2014; Tornaghi 2014), urban food marketing and distribution (Lerner and Eakin 2011; Riley 2014), and the role of the global food system (Ruel et al. 2010). These increasingly prominent critical approaches draw on earlier work on the political economy of food (Sen 1981; Watts 1983), applied to the 'new food equation' of an increasingly integrated global food system, climate change, land grabs, and rapid urbanisation in the Global South (Morgan 2009).

The use of the feminist foodscapes framework as an analytical framework draws the chapter's examination of urban food systems in line with important literature on gender, poverty, and development. Feminists have been very influential in debates on how to address global poverty, particularly in the context of a post-2015 agenda to replace the Millennium Development Goals (MDGs) (Fukuda-Parr and Orr 2014; Sen and Mukherjee 2014). Feminist development scholars have long argued the need to approach research, policies, and development projects in a way that simultaneously targets practical (e.g., jobs, educational opportunities, and access to health care) and strategic (e.g., legal reforms, social protection, and recognition of human rights) needs (Moser 1993; Kabeer 1994). The feminist foodscapes framework applies this duality to the analysis of food security, recognising that the practical need for people to have food in the immediate term and the strategic need to ensure that the human right to food are equally important.

This chapter seeks to contribute to academic and policy-oriented discussions about urban food systems by connecting issues at multiple scales to provide a snapshot of the complex relationship between gender and urban food systems. The following section provides an overview of issues that tie together gender and urban food security. The examples mainly draw from literature published in the past decade and serve as an update to Hovorka and Lee-Smith's (2006) contribution to *Cities Farming for the Future: Urban Agriculture for Green and Productive Cities.* The following section discusses challenges in integrating these insights into policies, research programmes, and development interventions aimed at improving the food security benefits of urban food systems generally. Gender mainstreaming has been increasingly central to food security interventions in cities (Hovorka et al. 2009), and this chapter concludes with reflections on the practical benefits to food security programming, particularly in the longer term, that can result from a broad conceptualisation of the links between gender inequality and food insecurity in cities.

Gender and urban food systems at multiple scales of analysis

Food insecurity is increasingly widespread in cities of the Global North and South. It is a manifestation of urban poverty that links problems of income inequality, under employment, environmental degradation, and rights to urban space. In seeking to understand this problem in general terms, and from a feminist perspective, this section provides a multi-scaled examination of diverse issues drawn from interdisciplinary perspectives that convey the richness of gender-based analyses of urban food systems. Table 13.1 summarises the issues examined at each scale and provides a road map for the discussion in this section. The multi-scaled analysis facilitates the integration of women's and men's daily experiences of urban food systems with the broader structures and processes that shape ideas about urban food security as a global development issue.

TABLE 13.1 Gender and urban food system topics examined at multiple scales

Scale	*Topics*
Individuals	Gendered cultures of consumption Men and women as economic actors The mobility of women's and men's bodies in relation to food access
Households	Household livelihoods Urban household food security in southern Africa Gender relations within urban farming households
Cities	Food deserts Informal economies and informal food systems The provisioning of municipal services
States	National social protection schemes National agricultural and urbanisation policies Rural–urban connections and urban food security
Global	International trade and the global food system The effects of global climate change The Millennium Development Goals for 2015

Source: authors.

Individuals

At the smallest scale, that of individual men and women, many issues related to gender and urban food security are apparent. The body is a common scale of analysis in feminist scholarship because physiological difference is the starting point for the constellation of cultural, social, political, and economic implications of gender difference. Bodies are also at the core of food studies and the universal experience of eating to nourish and sustain bodies is at the core of food studies. This first of five scalar subsections examines three issues that elucidate the link between gender and urban food security at the scale of bodies: (1) gendered cultures of consumption, (2) men and women as economic actors, and (3) the mobility of women's and men's bodies in urban spaces.

The growing rates of obesity in cities in all parts of the world is evidence that food consumption choices are not purely practical, but situated within a cultural context that generates desire for certain types of food based on its meaning (Allen and Sachs 2007). Gender identities shape what foods are desirable and considered culturally appropriate for different people. Research in Blantyre, Malawi, for example, found that people associated some foods such as clay *(dothi)* and baobab fruit with maternity, and men's fertility was associated with other food such as fresh cassava and soaked rice (Riley 2013). These findings resonated with Hovorka's (2012) research in Botswana, where the association of men with cattle and women with chickens shaped food security strategies, including production and consumption.

Research in the Global North into gender consumption choices has shown that women's dominance in food purchasing and preparation has given them a prominent role in shaping alternative food networks (Little et al. 2009). Identification with a female ethic of care and community building was also reported in research on women food producers in American cities (Jarosz 2011; White 2011). These cultural dimensions of why urban women choose to produce food and why they choose to consume certain foods is less prevalent in studies based in the Global South, where economic necessity is presumed to be the main motivation. This perspective presents an exciting avenue for future research in more diverse settings.

Individual men and women have different economic opportunities and face different livelihood constraints in cities, which shape gendered outcomes for food security. In the Global South and the Global North, women face structural constraints in achieving the same economic status as men (Kabeer 2003). Women are more likely to be employed informally, which raises problems of income regularity and security, in addition to the higher likelihood that women's incomes will be insufficient to meet an urban household's basic needs. Interventions such as micro-finance projects are often targeted at women because of the structural impediments they face as independent economic actors, including: difficulty in accessing credit, lower rates of literacy, and time constraints due to domestic responsibilities (Kabeer 2003; Hovorka et al. 2009). An important structural barrier for women in many places is the gender discrimination embedded in property rights. While the issue of property could also be considered at the national scale of analysis where property laws are formulated and enforced, the differential *effects* of these laws and practices shape food security outcomes differently for men and women. Research on gender and urban agriculture has consistently found that tenure of farmland is more often a barrier face by women than by men (Hovorka et al. 2009). Additionally, lack of secure housing tenure constrains women's options for economic independence or to generate income through rentals.

The scale of individual bodies also raises the issue of mobility for food security, an issue increasingly recognised as part of the 'mobilities turn' in social sciences (Cresswell 2010; Hanson 2010). Accessing food entails going to places where nutritious and affordable food is available (Frayne 2010). In some places, this entails going to markets on the outskirts of cities where urban residents are buying directly from rural producers (Tacoli 2007). Mobility is gendered in that women

FIGURE 13.1 Ana Huamani is a single mother in Mala (near Lima) growing organic vegetables and fruits, which she sells in her own stall at a weekly farmers' market

Source: MESA-program.

are often less mobile than men for several contextually various reasons (Uteng and Cresswell 2008; Uteng 2011). Women's responsibilities in the home are onerous and time-consuming in many low-income urban households, which restricts the time they can spend to travel for work or food procurement (Riley and Dodson 2014). In some places, women's mobility is directly constricted by laws or customs that proscribe their presence in public spaces (Robson 2006). Public safety concerns also gender mobility, for example in places where urban violence can make it unsafe for women to travel at night. Women's movements in public space can also be the result of domestic violence in cases of husbands seeking to control their wives' movements (Uteng 2011). A focus on gendered mobilities and food security demonstrates the overlapping forces within and beyond households that influence the different possibilities for movement of women's and men's bodies in space.

Households

The household is the main social unit used in urban food security research. The household is a small social and economic unit that lends itself to comparisons across time and space. Most studies of household food security infer from the supply of food in the household and the needs of its members if the household is food secure or food insecure. Yet feminist scholars have argued that this inference is based on a false assumption that food is shared equitably within households (Agarwal 1997; Devereux 2001). A variety of context-specific factors shape the way in which resources (including food and the means to buy and produce it) and responsibilities (including the responsibility for feeding household members) are divided among household members according to gender. This subsection examines three topics of relevance to gender and urban food security at the household scale: (1) household livelihoods, (2) household food strategies, and (3) gender relations within urban farming households.

The question of how households, especially low-income households, function economically has been taken up by the literature on livelihoods framework (Rakodi and Lloyd-Jones 2002; Foeken and Owuor 2008). The livelihoods framework highlights the full range of contributions by household members, which may be in the form of labour, money, or other resources. In a household in which the husband is employed and is the primary income earner, his wife might also be producing food in the garden, earning income through petty trading, and providing labour in food preparation, cleaning, and childcare. Income-based models often obscure non-financial contributions and focus solely on income through formal employment, which in this scenario would overemphasise the husband's contribution. Notably, research on urban livelihoods has also shown that children also contribute to households in various ways (Porter et al. 2010). The livelihoods framework offers a fuller picture than income-focused measures of urban household economic status. It is crucial for capturing the value of subsistence food production, casual employment, informal training, and domestic labour within the household.

The food security status of different household types reflects the important role of gender in shaping urban food systems. The African Food Security Urban Network (AFSUN) survey of 6,453 households in eleven cities compared four household types: female-centred, male-centred, nuclear, and extended (Crush and Frayne 2010). A gender-focused analysis of the survey findings demonstrated that female-centred households were over-represented in the severely food insecure category relative to other types of households. Poverty was an important factor determining food security status, and while female-centred households were the most likely type to be poor and to be food insecure, the effect of poverty on food security status was less pronounced among female-centred households. This finding suggests that at lower levels of income, female-centred households are doing better at feeding their households. The explanation for this finding is unclear, but it is possible that female household heads dedicate a greater proportion of household resources to food relative to male household heads. This explanation aligns with research that has identified gendered differences in priorities for the use of household resources whereby women's greater control over the use of household resources can lead to greater food security status (Kennedy and Peters 1992; Haddad et al. 1997).

The household scale of analysis has been used extensively in research on food production in cities, particularly subsistence production (Hovorka et al. 2009;

Mkwambisi et al. 2011; Shillington 2013; Simiyu and Foeken 2013). In most urban food producing households, men and women are both highly engaged in farming-related activities, but in most households men make the final decision on what to produce and how to deploy women's labour. Simiyu and Foeken (2013) found that some women subverted this control by taking advantage of their husbands' frequent absences from home and hiding proceeds from the sale of farm products from their husbands. Shillington (2013) argued that gendered labour in backyard fruit tree cultivation in Managua, Nicaragua, was not only economic, but also served a cultural purpose of making a home in the city. Mkwambisi et al. (2011) identified many women household heads who were also farmers in their study of urban Malawi, but female-headed farming households produced less food per hectare than male-headed farming households. Reasons included relative lack of money for inputs like seeds and fertiliser, relatively less household labour, and less capacity to develop agricultural skills because of illiteracy. Household scale case studies provide a rich resource for understanding the nexus of power, culture, and food in cities.

Cities

At the city scale, questions about planning, governance, and the effects of different built environments on people's ability to access food come into focus. Urban food security is often discussed with reference to sustainability, which can refer to overlapping objectives, including: the long-term viability of the city's economy, the vulnerability of city structures to natural hazards, the health of the city's population, and the social cohesiveness of the city (Pieterse 2011). Until recently, food has been an invisible issue for urban planners thinking about sustainability (Morgan 2009). This is partly a result of the mainstream assumption that food was primarily an agricultural, and hence a rural issue. The past decade has seen a proliferation of interest among planners, municipalities, and researchers on the issue of urban food security. Box 13.1 further illustrates the importance of the city scale in practical terms, as it illustrates the important contributions municipal governments can make to food security programmes focused on gender equality. This subsection examines three issues pertinent to understanding gender and urban food security at the city scale: (1) food deserts, (2) informal economies and food systems, and (3) the provisioning of municipal services.

The concept of food deserts encapsulates widespread injustice in many post-industrial cities where the supermarket-based food distribution system does not adequately serve the needs of low-income communities (Shannon 2014). Food deserts are areas where safe and nutritious food is not readily available. As an issue arising primarily from research in cities in the Global North, it dovetails neatly with the nexus of mobilities, livelihoods, and food excess emerging from research in cities of the Global South. Its framing of urban food security as a social justice issue evident in the urban geography of the city offers lessons for understanding urban food security research in the Global South, just as the livelihoods approach offers insights that can enrich the understanding of urban food security in cities of the Global North (Battersby 2012). A focus on gender equality has the potential to serve as a connective thread between these lines of theorising urban food systems because of its unifying reference to gender difference as a core cause of hunger and poverty.

In many cities of the Global South, most work, services, trade, and production takes place informally. In spite of the near ubiquity of informality in cities in developing countries, planners, urban managers, and politicians often seek to put an end to these practices (Potts 2008; Riley 2014). Formality is associated with development because it is better suited to government regulation and taxation, as well as global trade and investment, and therefore to a particular ideal of urban development and urban food system (Riley and Legwegoh 2014). Yet from the perspective of many low-income urban residents and the needs of their household members, informal economies are critical for survival. This is particularly true of informal food systems, which provide flexibility and convenience to millions of consumers who are unable to access formal food sources (Porter et al. 2007). They also provide a vital source of livelihoods and income for people who cannot secure sufficient employment in the formal economic sector, the majority of whom are women (Roever 2014).

Municipal authorities can be partners rather than adversaries of informal economic actors (Tinker 1997). The construction of market facilities with piped water, sanitation facilities, and security services is one way of investing in informal sector workers and consumers (Porter et al. 2007). Partnering with traders and consumers, and ensuring that the women among them have a voice, can be an important step towards empowering low-income men and women economically and politically

FIGURE 13.2 Market on the outskirts of Blantyre, Malawi, where urban consumers buy low-cost food directly from producers

Source: Riley.

and promoting gender equity. A similar approach is needed to address problems associated with informal food production in cities. The benefits of using urban space for food production are increasingly recognised, and the idea of a city as an agricultural site is less alien to planners and urban managers now than it was a decade ago (Hovorka et al. 2009). The 13 case studies of gender-focused urban agriculture projects featured in *Women Feeding Cities* (Hovorka et al. 2009) attest to the multiple possibilities for improving urban livelihoods by building on diverse experiences of implementing gender-mainstreamed urban agriculture projects. Nonetheless, challenges remain in how to best 'mainstream' gender into urban agricultural projects, especially in regards to achieving the strategic goals related to gender equality in the long term (Hovorka 2006; Lessa and Rocha 2012).

A final point on the city scale of analysis is to note the importance of equitable provision of other urban services and amenities such as clean water, adequate housing, electricity, intra-urban transit, sanitation, schools, and hospitals. These basic necessities are increasingly difficult to provide in part because population growth usually outstrips municipal resources, but the stress on natural resources in and around cities means that environmental concerns at the city scale are central to understanding urban food systems. Inadequate or unaffordable provisioning of services and amenities can impact household food security in several ways, such as:

- Lack of affordable housing can divert scarce income to housing costs rather than food.
- Lack of clean water can compromise food safety and health.
- Inadequate transit can increase the time expense of livelihood activities.
- Poorly resourced schools and hospitals have long-term impacts on public health, economic development, and social cohesion.
- Poor environmental stewardship reduces the productivity of agriculture in and around cities.

These issues often have a greater impact on women than men, in some cases making domestic tasks more onerous and in other instances removing opportunities to close the gender gaps in health, education, and economic participation. The de-prioritisation of services and amenities that could make food provisioning and preparation less onerous for women often reflects women's lack of political influence in municipal decision-making.

Nations

At the national scale (or in some cases state or provincial scale), the ideals for the recognition of human rights and gender equality formulated in international agreements are translated into the local context and government action plans. The goal of representing women's voices equally in legislatures is a key feminist goal, which is also intrinsic to democratic values. Progress has been made worldwide and the proportion of parliamentary seats held by women increased from

14% in 2000 to 22% in 2014 (UN 2014: 23). While this value is nowhere near parity, and there are vast differences among countries, it suggests that women are having a greater influence in political affairs than they did in the past. This progress potentially bodes well for the formulation and implementation of laws, policies, and development objectives that prioritise social justice and gender equity. Box 13.2 illustrates the importance of these reforms based on direct experiences implementing gender-mainstreamed urban food security programmes in Kenya. This subsection examines three national scale topics related to the gendering of urban food systems: (1) national social protection schemes; (2) national agricultural and urbanisation policies, and (3) rural–urban connections and food security.

One area of direct relevance to gender and urban food security has been the policy of social protection schemes in low-income countries (Miller et al. 2011; Nino-Zarazua et al. 2012). The AFSUN survey finding that female-centred households benefited more than other types of households from South Africa's social grants scheme is strong evidence that social protection has a gender-positive effect on urban food security (Dodson et al. 2012). The comparison between the three South African cities surveyed, where social grants were available, and the eight cities in other countries without social grants is striking:

> The three South African cities tend to have lower LPI [Lived Poverty Index] scores than the other eight cities in the survey. The biggest gap is amongst female-centred households: in South African cities their LPI is 0.8, whereas in cities outside South Africa it is nearly double at 1.5. This almost certainly reflects the impact of social grants, and especially child grants, in South Africa.
>
> *(Dodson et al. 2012: 21)*

In targeting dependents including children and retired people, the social grants are able to support households with the highest ratio of mouths to feed relative to economically productive members, which are most likely to be households headed by women. For these economically marginalised households, the stability and reliability of the income source can be as critical as the sum itself, facilitating budgeting for household needs on a monthly basis.

In their study of the gendered effects of social protection schemes in eight diverse countries (Ghana, Peru, Bangladesh, Ethiopia, India, Indonesia, Mexico, Vietnam), Holmes and Jones (2010) demonstrated that social protection schemes are not a panacea for reducing women's poverty relative to men. Gender equality was not a primary objective of most programmes, and even in cases where gender was mainstreamed into the project, problems with implementation (including gender biases and stereotypes held by officials and participants) negated the effectiveness of the schemes for addressing gender needs. By failing to include an objective of transforming gender relations at all scales, most programmes operate with a 'narrow conceptualisation of gender vulnerabilities and focus on supporting

FIGURE 13.3 Women producers associated with the Harvest of Hope box home delivery scheme of Abalimi Bezekhaya in Cape Town ready to deliver their vegetables
Source: Abalimi Bezekhaya, courtesy Patrick West.

women's care and domestic roles and responsibilities in the household' (Holmes and Jones 2010: vii). In supporting women's care and domestic roles, gender inequality was often reinforced and the gendered division of labour at the heart of inequality was perpetuated rather than transformed.

The design and implementation of gender sensitive social protection programmes, whether they take the form of cash or asset transfers, public works, or food subsidies, hold the potential for national or state governments to directly intervene in urban poverty and food insecurity by setting a minimum standard of living. These programmes can simultaneously address gender inequality by lightening the burden of responsibility for feeding households from women's shoulders.

In the Global North, food and agricultural policies are increasingly central in debates over public health, environmental justice, and the nutritional appropriateness of food (Shannon 2014). Policies and development objectives formulated at the national level shape how cities are built, with consequences for gender relations and urban food systems. Urban policies in North America after World War II promoted the suburban sprawl of cities and the spatial division of male/urban/production from female/suburban/reproduction (Domosh and Seager 2001). The spread of suburban sprawl distanced people from food sources and created a new reliance on cars to access food. Doubts about the environmental sustainability of industrial agriculture and the corporate-dominated food distribution system have influenced the governments of major countries, including the US, to (slowly) start supporting alternative food networks through policies and investment (McClintock 2014). Eco-feminists have contributed to the debates by emphasising the social and cultural costs of urban consumers being alienated from the social and environmental processes of food production (White 2011). Their experiences of urban food systems are expressed in terms that link the personal need for healthy bodies and communities with the political need to re-envision the policy frameworks that create food deserts and perpetuate class and gender-based health inequalities.

National urbanisation policies in developing countries can play a key role in shaping settlement patterns, urban built environments, and the standard of living in cities (Parnell and Pieterse 2010). Many developing countries that experienced rapid population growth in the twentieth century also experienced rapid internal migration into cities at a pace that outstripped their governments' capacity to provide basic housing and municipal services (Davis 2006), such that the development of cohesive national urban food strategies was not feasible. The response by some governments was to attempt to curtail rural to urban migration, or to reserve the right to fully participate in urban civic life. China's *hukou* system, for example, prevents rural to urban migrants from accessing government services in the cities, thus preserving their 'rural' status and promoting temporary or circular migration (Fan 2008). Such policies preclude the political question of urban food security by *de jure* marginalising many of the would-be urban poor, particularly women who are more likely to face legal and economic barriers to establishing themselves formally in cities.

Circular forms of migration between rural and urban places are increasingly recognised as the norm in many developing countries (Lynch 2005). Rural–urban social and economic linkages that facilitate access to a variety of resources and opportunities at different times of the year are vital for livelihoods and urban food security (Tacoli 2007; Lerner and Eakin 2011; Agergaard et al. 2010). Progress on the re-theorisation of urban livelihoods as transgressing the rural–urban divide ties into the aforementioned benefits of personal mobilities, which facilitate 'straddling' multiple places and often benefit women disproportionally in giving them opportunities to diversify their informal economic activities in reaction to their marginalisation within urban formal economies (Flynn 2005; Riley and Dodson 2014). This research is instructive for planners, researchers, and development workers to broaden their geographical frame of reference when developing urban food system improvements.

Global

Political, economic, and environmental structures and processes functioning at the global scale shape urban food systems and vulnerability to hunger. It is increasingly important to integrate the global scale in studies of food security and gender equality because of the increasing role of international economic transactions, political agreements, and social development priorities on everyday life. This subsection examines three global scale topics in relation to the feminist foodscapes framework: (1) the role of international trade, (2) the effects of global climate change, and (3) the Millennium Development Goals for 2015.

The 2007–08 global price shocks of basic food commodities exposed the vulnerability of millions of urban residents to become food insecure as a result of global scaled events (Clapp 2009; Ruel et al. 2010; Hadley et al. 2012). In many countries, urban markets rely on geographically dispersed supply chains to make food available in cities. Households that rely on their incomes to purchase food for survival (rather than drawing on a variety of livelihood strategies) were the most directly impacted when financial speculation, droughts in key food producing areas, and a rapid rise in demand for biofuels caused food prices to spike (UN 2011). The hyper integration of the food system also impacts on rural (and urban) producers, many of whom fail to compete with the economies of scale and subsidies provided to the agriculture and food industries in the Global North (Weis 2007). The consequential decline of rural agricultural economies can lead to increases in rural to urban migration and more dependence on global markets for survival as domestic production declines. This trend can be particularly deleterious for women, many of whom are responsible for feeding their households even when food becomes suddenly unaffordable or unavailable. The challenges faced by migrants themselves are also gendered, and in most cases female migrants are more vulnerable to the economic marginalisation and social alienation that causes urban food insecurity.

The increasingly distantiated integration of consumers and producers in the global food system is fundamental to why the impact of global climate change is expected to be extremely profound and widespread. Local changes in temperature, water availability, the frequency of extreme weather events, and seasonality will not only have local impacts on food supplies: global integration means that production shortfalls in specific areas can reshape global supplies and trade patterns, with price shocks such as that experienced in 2007–08 becoming more frequent. In general, the negative consequences of global climate change will most severely impact people in the poorest and least developed countries. Urban residents in these countries will be among the most vulnerable to hunger in most climate change scenarios. These processes create new forms of environmental injustice that are starkly evident at the global scale where the people most severely affected are the least likely to have benefitted from industrialisation that caused global warming. The need for analysis that can support adaptive strategies for urban households is urgent (Frayne et al. 2012). Integrating strategic gender needs will be key to developing and implementing durable strategies for on-going livelihood adaptation as climate change leads to unpredictable and unprecedented new circumstances.

The MDGs represent a global consensus among governments and global civil society organisations on the priorities for social development. Hunger figures prominently in the first MDG, with the target of 'halving, between 1990 and

2015, the proportion of people who suffer from hunger' (UN 2014: 8). The prevalence of undernourishment has been reduced from 23.6% in 1990–92 to 14.3% in 2011–13, but with rapid population growth the absolute number of hungry people remains high at 842 million (UN 2014: 12). Furthermore, the most rapidly urbanising regions, sub-Saharan Africa (25%) and southern Asia (17%), have the highest portions of hungry people. Fukuda-Parr and Orr (2014) argued that the MDG hunger target has reduced the problem of hunger from one of food as a human right, as expressed in the 1996 FAO declaration, to food as a nutritional problem amenable to technological solutions of production and supply. Urban issues are under-represented in the MDGs, reduced to a conservative target for slum improvement (Cohen 2014). In light of the prolific body of research on urban food security produced in the past decade, and the rapidly growing urban populations in the Global South, the post-2015 agenda should recognise the distinct needs of urban food systems to meet the needs of urban residents. The goals for gender equality are also notably weak in the MDGs and key structural issues such as reproductive freedom and economic empowerment for women are understated relative to their importance for social development (Sen and Mukherjee 2014). Within a feminist foodscapes framework there is a discernible connection between the depoliticisation of food security and the depoliticisation of gender in the MDGs that needs to be redressed to make progress on both fronts. The global scale of analysis brings important discursive trends to the surface and highlights the pressing need to bring discourses and policies in line with the values associated with gender equality and the human right to food.

Action for gender-equitable urban food systems

The feminist foodscapes framework not only illuminates the ways in which gender is necessarily embedded within and across various scales of urban life, it also opens up exciting possibilities for action to improve the gender equity of urban foods systems. In reiterating the central importance of strategic goals related to achieving gender equality, the feminist foodscapes framework reinvigorates the political dimensions of food activism. Hunger continues to be a serious problem for nearly a billion people in their daily lives, while millions more are highly vulnerable. Furthermore, millions of people who are not at risk of hunger are unhealthy because the food they consume does not meet their nutritional or cultural needs. The people who have the least opportunities to influence the broad social, economic, and political structures that shape their urban food systems are mostly women constrained by economic marginalisation, access to fewer resources for their livelihoods, patriarchy within their households and communities, and unjust laws. Empowerment for women and men in urban communities can be conceived in terms of expanding these opportunities to change urban food systems at multiple scales.

BOX 13.1 THE ROLE OF MUNICIPAL GOVERNMENT IN THE MUSIKAVANHU URBAN AGRICULTURE PROJECT IN HARARE, ZIMBABWE

Development practitioners in the Global South have observed that gender inequality is a consistent challenge to implementing urban food security programmes that promote food production by urban households (Hovorka et al. 2009). The Musikavanhu Project in Harare, Zimbabwe, granted the use of vacant urban land to low-income households 'in order to maintain their food security, save money on food expenditures, and generate complementary income from regular sales' (Toriro 2009: 94). Although the project was not intended to target women farmers, 90% of farmers were women during the 2008 survey. The popularity of urban farming among women in Harare was partly a reflection of the gendered burden to feed household members during the political economic crisis taking place at the time of the survey.

An analysis of the challenges for the Musikavanhu Project to promote sustainable social change toward gender equality led Toriro (2009: 102–3) to list six ways in which the municipal government in Harare could support the project:

1. Creating a facilitating legal framework that recognises the economic and social contributions of urban farmers and provides rights and protections to male and female urban farmers equally.
2. Raising awareness of gender and urban agriculture through gender sensitivity training and public awareness campaigns.
3. Improving land tenure through the designation of zones for urban agriculture and giving ownership or leasehold lands to women rather than granting it only to their husbands.
4. Stimulating adequate support services by co-funding programmes with Non-Governmental Organisations to support female farmers and by implementing tax incentives for private enterprises to donate resources to such programmes.
5. Providing protection against theft of crops that women are not normally equipped to protect at night because of obligations at home and safety concerns.
6. Giving access to free medical support to reduce the burden of caring for relatives suffering from HIV/AIDS and other health problems, thus freeing up more of women's time for agricultural activities.

These lessons for the municipal government in Harare can be transferred to other cities as they implement policies aimed at achieving food security that also enhances gender equality. It emphasises the important role of politics at the 'city' scale.

Source: Toriro 2009.

The 'five elements of mainstreaming' presented in Hovorka and Lee-Smith (2006: 131–33) warrants repeating in this chapter in light of the multiple scales approach to gendering urban food systems. The five elements are: (1) conceptual clarity, (2) identifying practical and strategic needs, (3) political will and commitment, (4) capacity building and resource allocation, and (5) scientific research.

The first element speaks to the narrow understanding of gender among actors across multiple scales, from project participants and managers to World Bank and UN employees. The overuse and oversimplification of 'gender' in policy documents and strategic frameworks can reinforce the false impression that it is relevant only to women (Hovorka and Lee-Smith 2006: 131). The research above demonstrates the need to develop gender capacity at multiple scales in order to make the necessary connections between the power-laden fields of food and gender. For grassroots project implementation, this is a matter of engaging in critical dialogue with participants about the meaning of gender in their social context in order to make the core concept of gender equality accessible and relevant to their daily challenges. While the particular obstacles in this process will be different in different settings, for example in places with low literacy rates, different means of communication will be required (Cornwall and Scoones 2011), there is a perennial need to build and reinforce capacity in this regard and it should not be overlooked in projects based in the Global North. In like manner, reinforcement of the meaning of gender and its role in shaping hunger and vulnerability is consistently required among policymakers at all scales.

The second element, to identify practical and strategic needs, has been a major theme of this chapter. The process of articulating these needs in the local context should be allotted time in the planning process, and ideally be conducted using participative approaches that include participants. Hovorka and Lee-Smith (2006: 132) note that 'identifying the type and scale of intervention (be it through programmes, planning or policies) should rely on a solid understanding of the local context and structural factors that delineate opportunities and constraints for individual producers'. The feminist foodscapes framework highlights the interconnectedness of the 'local context' with structures and processes at multiple scales, such that 'understanding the local context' goes far beyond the spaces in which project participants' daily lives take place. The process of articulating practical and strategic needs should involve a dialogue between facilitators, who are more likely to be able to comment on big picture dynamics that shape gender and urban food systems, and participants, who have vital knowledge of urban food systems based on their daily experiences living in the city. Applying a feminist foodscapes framework therefore requires a balance between these types of needs, and their related action plans and objectives, to be at the forefront of planning, implementation, and assessment of project outcomes.

The third element is 'political will and commitment amongst key stakeholders at all scales' (Hovorka and Lee-Smith 2006: 132). This element emphasises the need for leadership in forging a cohesive commitment to the goal of gender equality as a central goal of efforts to ensure urban food security. In the policy realm, gender inequity should be addressed by first seeking to understand the particular effects of existing policies on men and women. This awareness of gender difference should guide policy responses at all levels of government and actors operating at the global scale. For development projects aimed at improving urban food systems, maintaining a political will and commitment to gender equality will overlap with the integration of practical and strategic needs. Addressing structural causes of urban poverty and hunger will be key to the sustainability of these projects over the long term.

BOX 13.2 THE ROLE OF THE NATIONAL GOVERNMENT IN CREATING THE CONDITIONS FOR WOMEN AND MEN TO BENEFIT FROM URBAN LIVESTOCK KEEPING IN KISUMU, KENYA

Development practitioners in the Global South have observed that gender inequality is a consistent challenge to implementing urban food security programmes that promote livestock keeping by urban households (Hovorka et al. 2009). Urban livestock, which in the case of Kisumu, Kenya, included chickens, goats, pigs, ducks, and cattle in significant numbers, is a source of food and livelihood security in many households (Ishani 2009). Ishani (2009) reported on a survey conducted as part of a project aimed at improving urban household food security by supporting urban livestock keeping. The project included men and women, including many women who were also the heads of their households. Gender mainstreaming throughout the project cycle led to an increase in the sharing of household responsibilities between men and women and 'a measure of self-esteem and confidence which did not exist before' among participants (Ishani 2009: 118). Women, previously excluded from decision-making at all scales, often experienced a dramatic change in outlook: 'Women in particular have become the "push" factors for change, and they now take the lead in the household to ensure that these changes do take place' (Ishani 2009: 119).

The project adopted a multi-stakeholder approach and the report on experiences highlighted the importance of support from the central government. In the first instance, there is a need for financial, technical, and institutional resources to extend the benefits of this programme. The state plays a unique role in potentially providing a funding source available in the longer term and not vulnerable to project funding cycles. In her conclusions, Ishani (2009: 119) also argues for a scaling-up of the gender mainstreaming focus demonstrated in the project and the importance of policy reforms at local and national levels aimed at improving gender equality:

> Gender equity, however, cannot be achieved at the project level if there is a disparity in policies benefitting one sex and not the other.

> All policies, at the local level and at the central government level, have to be formulated in a gender-sensitive manner. Issues such as inheritance and succession, especially for women, should be of paramount importance in order for the whole of the household to benefit.

Implementing a gender-mainstreamed urban food security programme around urban livestock revealed the importance of policies and resources at multiple scales, particularly the national scale where sustainable financial resources can be mobilised and key policy reforms can be made.

Source: Ishani 2009.

The fourth element is capacity building and resource allocation. It is related to the first element in that resources need to be devoted to achieving conceptual clarity, and these actions constitute capacity building. Hovorka and Lee-Smith (2006: 132) identify a danger of losing the focus on gender *because* of its ubiquitous relevance at multiple scales and to multiple dimensions of any project or policy, summed up in the statement: 'By making gender everybody's job, it can easily become nobody's job'. The investment of substantive resources into the gender elements of a project will demonstrate the leadership and commitment noted in the third element of political will and commitment. Investing resources into mainstreaming gender will help stakeholders at multiple scales to 'look beyond' the conceptual conflation of gender with women and to engage in the kind of self-reflexive and critical thinking needed to overcome ingrained stereotypes and biases (Cornwall and Molyneux 2007).

The fifth element is 'scientific research on gender dynamics' (Hovorka and Lee-Smith 2006: 133). Within a project or policy formulation cycle, this research element can provide a virtuous cycle of monitoring and adjusting action plans when gender-related objectives are not being met. The ubiquity and complexity of gender difference means that even the most rigorous gender planning can have unforeseen consequences. With regular monitoring and mechanisms for on-going communication among stakeholders, developments that reinforce gender inequality (for example, by adding onerously to women's labour or disproportionally enriching men) can be re-conceived. The focus on scientific research also speaks to the important role of the wider research community to contribute to policy formulation and programme/project development to address urban food insecurity. As the examples in this chapter demonstrate, academic researchers play central roles in identifying problems, linking issues at multiple scales, and identifying connections between practical and structural causes of gender inequality and food insecurity. In an increasingly urban world, with an increasingly integrated global food system and a persistent correlation of being female and being poor, the integration of perspectives rooted in multiple scales will play an increasingly instrumental role in understanding and overcoming global poverty.

Concluding thoughts

A gendered lens of analysis is fundamental to understanding food security: gender identities and social categories shape the meaning of food, how and by whom it is consumed, and the systems of production and distribution. This chapter's gender analysis of urban food systems draws from feminist understandings of how to bring about gender equality by addressing practical and strategic needs to understand simultaneously the immediate needs of urban residents to have access to safe, nutritious, and culturally appropriate food while also recognising the bigger picture of long-term sustainability of urban food systems to realise the human right to food. The chapter demonstrates that challenges and opportunities for urban food systems exist at multiple scales, and that they consistently intersect with problems related to gender inequality. Future action to improve urban food systems can refer to the five elements of gender mainstreaming for guidance. Policymakers, development workers, and researchers should also integrate into their projects an understanding of the multiple layers of policies, discourses, and social relations that contribute to shaping urban food systems. This will help to bring a balance of practical and strategic objectives of gender equality and food security in cities.

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14

FINANCING URBAN AGRICULTURE

What do we know and what should we know

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Introduction

In cities around the world, urban agriculture, considered here as both intra-urban and peri-urban agriculture, plays an increasingly important role in making cities more sustainable and better fed. By growing food, the urban poor can reduce household food expenses and generate additional income, thereby enhancing food security and reducing poverty. However, urban agriculture requires increased financial and political legitimacy if it is to continue developing as a productive force. While political support for urban agriculture has been steadily increasing, financial support for urban growers has been more limited. Most urban agricultural producers lack access to credit and, at the same time, the few financial systems in place do not fit well into urban farmers' needs, expectations and capabilities. Information about such schemes is also scarce. Little is known about how urban producers fund their activities and about how credit and investment interventions around the world could benefit large numbers of producers. Existing literature on financing urban agriculture is scarce, and refers essentially to credit systems for market-orientated urban agriculture in North America and, to a lesser extent, Europe.

This chapter thus examines how different types of urban agriculture are financed, a concept that encompasses credit but is not limited to it, as will be discussed further down.[1] It draws from direct exposure to a large number of local processes in Latin America and the Caribbean region from 1994 to 2004 and to others from 2004 to 2014. It draws as well primarily from findings from three programmes spanning from 1988 to 2014:

- Research on, and development of, urban agriculture in the Fortaleza metropolitan region of Brazil from 1988 to 1997 (Maranguape, Maracanaú, Eusebio, Fortaleza) with special attention to their economic and financial dimensions (Cabannes 1997a).

- Survey on credit and investments for urban agriculture was carried out with 13 cities – from Asia, Latin America and Europe. It was commissioned in 2002 and 2003 by UN-HABITAT, UMP-LAC, IPES, IDRC and RUAF Foundation (Cabannes 2006).[2]
- Applied research programme coordinated by RUAF Foundation (2008–2011) carried out with 17 cities from the "Global South" on financing of small-scale urban and peri-urban agriculture (Cabannes 2012; Cabannes 2013).

As a result, this chapter reflects the collective work and contributions of a wide array of actors, both academics and practitioners. It addresses the following central question "What kind of financial system is best suited to each different type of urban agriculture?"

First, some key concepts used are clarified and in particular what we mean by "financing urban agriculture", a notion far from access to credit, as it is commonly understood. The following two sections summarize key lessons from the first survey in 13 cities and for the most recent one in 17 cities. Then we will explore if there is a right mix between savings, resource mobilization, credits and subsidy. The next section makes a balance of what we know better than 20 years ago, and what we should know better. The final section concludes with recommendations for an action-research agenda on urban agricultural finance.

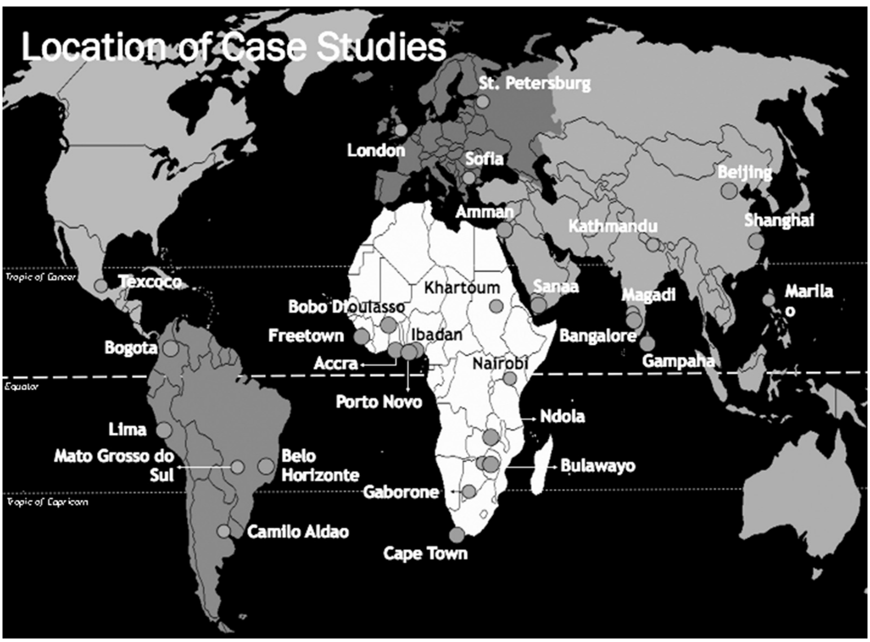

FIGURE 14.1 Location of case studies
Source: Cabannes 2012.

Key concepts

Different financing practices for different types of urban agriculture

Currently, urban agriculture is being practised for meeting subsistence needs, as a market-oriented activity, for recreation, or as a combination of these, each of which requires a different financing instrument or mechanism. For instance, micro-credit may not be the best form of financing for a poor family that undertakes urban agriculture at subsistence level and is not capable of repaying a formal loan. And a small cooperative composed of farmers aiming for expansion of their urban agricultural activities would need forms of financial support that go beyond the provision of free access to seeds or other equipment. Thus it is necessary to get an in-depth conceptual understanding of these types of urban agriculture in order to select the appropriate financing mechanisms of these interventions (see also Figure 14.2).

The first type of urban agriculture, and probably the most common, refers to urban agriculture as a way by which the urban poor and, to a lesser extent, the middle class, support their livelihoods. In this case, urban agriculture plays a part in a subsistence economy, generally family-based, and is seldom monetary. This activity does not generate a cash surplus but provides food or medicinal plants that reduce the expenses of the family, improves their diet and provides them with medicine (Cabannes 1997a).

The second type is related to market-oriented activities. They can be individual or family-based enterprises stretching from small to large or activities undertaken through larger cooperatives or producer associations. They refer to the whole food chain, from the production of vegetables, milk, fruit and other products, to agro-processing and marketing. As part of these market-oriented activities, the products

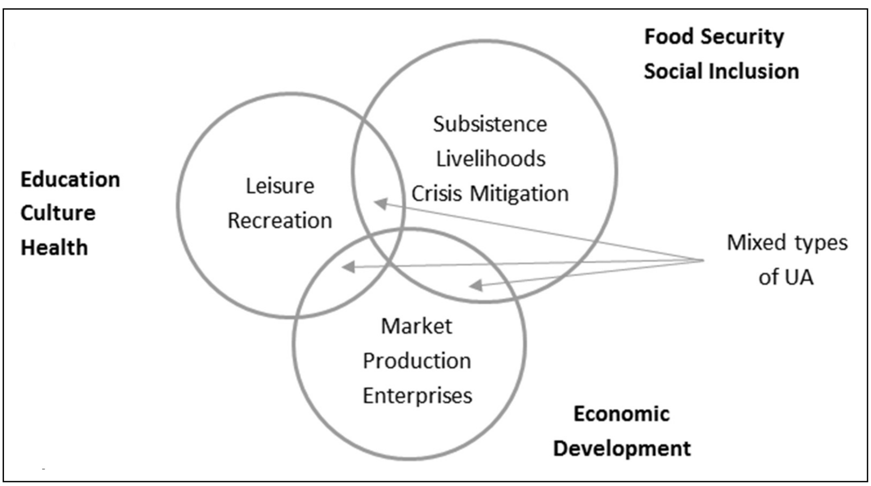

FIGURE 14.2 Various types of urban agriculture
Source: author.

are sold directly by the producers at markets or through intermediaries. To a lesser extent, these products are distributed through formal distribution channels such as supermarkets and greengrocers.

The third type refers to urban agriculture that is undertaken as a part of leisure and recreational activities, occasionally or regularly. This type is more common in the developed rather than the developing countries. In some cities, this type of urban agriculture is seen as a way to maintain or restore the relationship between urban citizens and nature, raise awareness on environmental issues and allow children to experience food production cycles.

Mixed forms are a combination of two or three of the previously described types. For instance, a family involved in urban agriculture for its own food consumption can also sell the surplus locally, providing extra, occasional cash. Similarly, European farmers practising urban agriculture primarily as a recreational or health-related activity use some of the produce for food, thus reducing their home expenses occasionally. The choice of the most appropriate financing mechanisms for urban agriculture should be guided by the type of urban agriculture type that is looked for: (a) subsistence-oriented, (b) market-oriented, (c) leisure and recreation or a combination of them.

Financing as a highly complex and changing combination of four ingredients

The concept of financing is not limited to micro-credit or credits delivered by banks and Micro Finance Institutions (MFIs), as in most of the scarce existing literature. Financing is considered here as a highly complex and changing combination of: Resource Mobilization (both monetary and non-monetary) + Savings + Subsidies + Credits. One central argument is that this equation needs to be taken into account and serve as a base for any consolidation of the financing system for urban agriculture. Approaches only focusing on credit usually show their limits and might be useful for a thin slice of the variety of producers.

Most studies from the 2002–2003 survey have indicated that financial support for urban agriculture is best based on a combination of those mechanisms: savings, subsidies and (micro-) credit. Savings could, for example, work as collateral for receiving credit. Tax incentives or other subsidies could motivate people to become involved, and complement credit systems with training and assistance, and in this way better guarantee success and sustainability of urban farming.

Learning from field experience: credits and investments in urban agriculture

The first global survey on diverse modalities of credit and investment provision to urban agriculture that took place in 2002 and 2003 highlighted how local financial systems for urban agriculture work, identified the myriad of actors involved, the origin of resources, the financial intermediaries and the "financial products" proposed to develop urban agriculture. Some studies went one step further and identified major bottlenecks of local financial systems for urban agriculture.

Understanding the credit cycle: from financial sources to financial products

In general terms, a credit cycle can be summarized in three successive steps. The first refers to the financial sources, which can be international, national or local, from public, private or institutional sectors or from private savings. The second refers to the transformation of these resources into financial products by specific financial intermediaries, and the third to the wide array of financial products offered to potential loan takers. The case of St. Petersburg, based on information from 2002 with some level of complexity, illustrates how a system works at local level – see Figure 14.3.

Financial flows and products for urban farmers from the study case of St. Petersburg, Russia (Moldakov 2002), illustrate the complexity and the richness of financing urban agriculture. The sources of finance are of different origins:

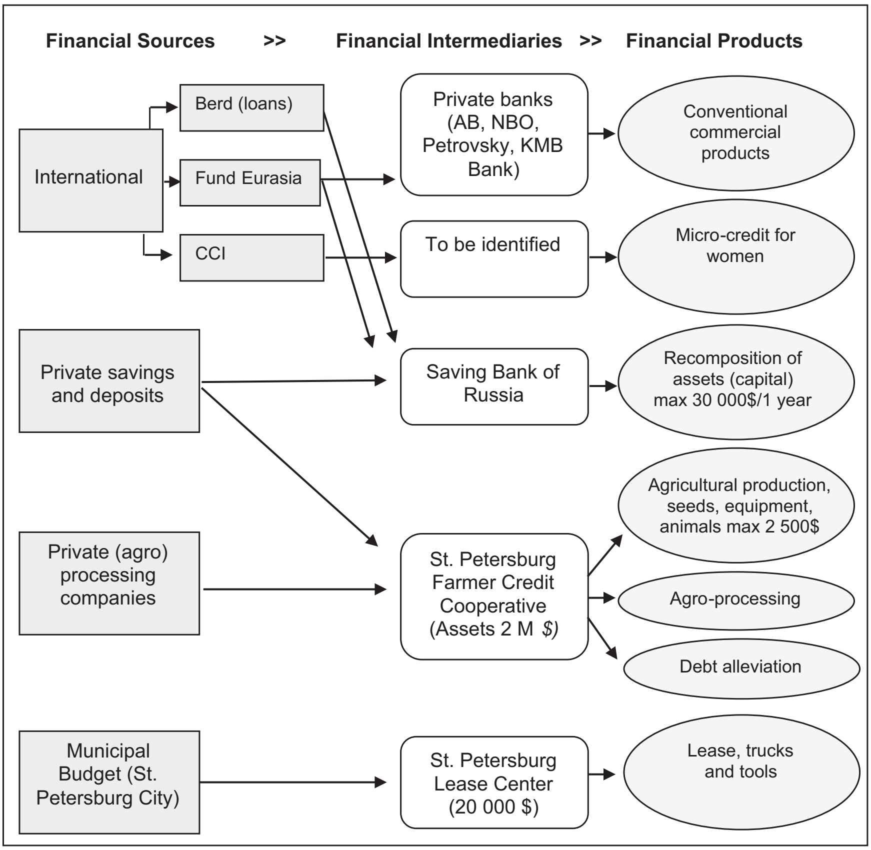

FIGURE 14.3 The St. Petersburg urban agricultural credit cycle: an example of complexity

Source: Cabannes 2004a based on Moldakov 2002.

(a) international, being loans and grants through the European Bank for Reconstruction and Development or the Eurasia Fund; (b) private (agro-) processing companies; (c) private savings and deposits from individuals; and (d) public resources coming from the municipal budget. These sources have different time horizons: the savings and deposits are on a monthly or occasional basis, whereas the municipal budget is annual; the international resources are usually made on a project-by-project basis, stipulating a number of years for disbursement. Transforming financial resources from diverse origins into strong, reliable and steady credit flows is a key issue in any financial system. A good answer lies essentially in the quality and the nature of the financial intermediaries that will transform these resources into financial products.

The case of St. Petersburg is typical of the multiplicity and different characteristics of the financial intermediaries, some of them being local and others being a branch of a national bank. Some of these institutions have a unique source of financing, whereas others have the capacity to draw on from multiple sources. The main institutions identified in this particular case are: (a) St. Petersburg Lease Centre, having a limited volume of resources, drawn mainly from the municipal budget; (b) St. Petersburg Farmer Credit Cooperation, fed by both private agro-processing companies and private savings; (c) Saving Bank of Russia that is channelling international credit and grants to various Russian cities, including St. Petersburg; and (d) some private banks, such as the Petrovsky Bank, AB Bank or NBO Bank who, in their turn, receive funds from national and international sources.

These multiple sources and the variety of financial intermediaries explain the wide variety of products that an urban farmer can access, in theory. They cover the following kind of credits and grants: leases for trucks and tools, debt alleviation; micro-credits for agro-processing or for agricultural production, seeds and animals; short-term loans (less than one year) for composition of assets; and micro-credits, especially for women or conventional commercial loans, open to clients able to provide a high level of guarantee.

Central role and diversity of financial intermediaries

One crucial finding is that financial intermediaries play a central role in transforming a great diversity of financial sources into multiple "financial products" with specific interest rates, maturity period, level of collaterals, grace period, eligible destination and beneficiaries, minimum and maximum levels of loans, etc. Understanding these intermediaries, who they are, how they operate and their comparative advantages and limits was crucial simply because, by and large, they have a vast power to decide on the financial products that will be offered to urban farmers and which types of urban farmers can be eligible for both subsidies, soft loans or conventional loans. Figure 14.4 introduces the tool that allows unpacking a financial system at local level by organizing existing

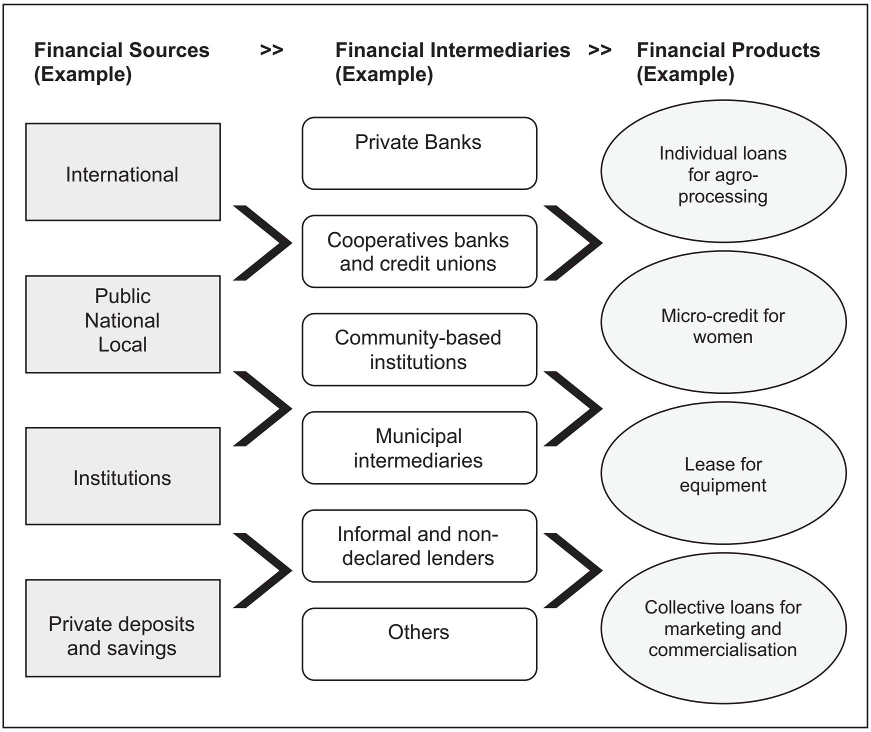

FIGURE 14.4 Financial intermediaries in the urban agricultural financial cycle
Source: Cabannes 2004a.

information and measuring the importance of the flows and the role of intermediaries.

The city surveys clearly pointed out the large number of actors providing financial sources and managing funds (intermediaries) for urban agriculture. A more detailed analysis is needed to define which system(s) is(are) best adapted to the specific local circumstances. Funding sources are found in the context of programmes for poverty alleviation, food security (Argentina), employment and income generation (Brazil, Botswana), or integrated environmental management. Funds stem from, for example, the "Fund for Social Municipal Infrastructure" in Mexico (Ramirez Garcia 2002), "Fund for Social Investment" in Brazil (Araújo 2002), within general "Financial Assistance or Entrepreneurial Programmes" in Botswana (Mosha 2002) or through specific "Agricultural or Horticultural Programmes" as, for instance, in Bangalore, India (Premchander 2002).

However, in most of the surveys, there is confusion and overlap between the source of funds – private, public, institutional, international – and their transformation into credit or subsidies. These two aspects and the role different actors play in each of them should be distinguished and clarified.

Various financial intermediaries that transform resources into loans directed to urban farmers will be presented in the next sections and illustrate the three most common types found in the cities surveyed:

a. Local government intermediaries will be illustrated with the cases of Texcoco in Mexico and Rosario in Argentina.
b. Private and community-based intermediaries illustrated by the experience of a savings and credit cooperative from Nepal.
c. Private banking system with the case of PROVE Pantanal Programme in Brazil.

a. Local governments and public sector intermediaries

The case of Texcoco, Mexico

The local government of Texcoco, in the Mexico metropolitan region, set up an innovative urban agricultural loans programme in the early 2000s that obtained significant results both in financial and social terms (Ramirez-Garcia 2002).

Resources from the central governments were transferred to local governments as part of a vast national social programme. The Texcoco municipality decided to transform these resources into a limited and innovative set of loans to agricultural cooperatives (in particular for flower production) and to small solidarity groups of producers that had not yet formed cooperatives, as was the case with a group of rabbit keepers. A third line of loans was specifically tailored to women urban farmers. No specific institution was set up and the resources were simply earmarked and deposited in a bank that was managing the municipal resources.

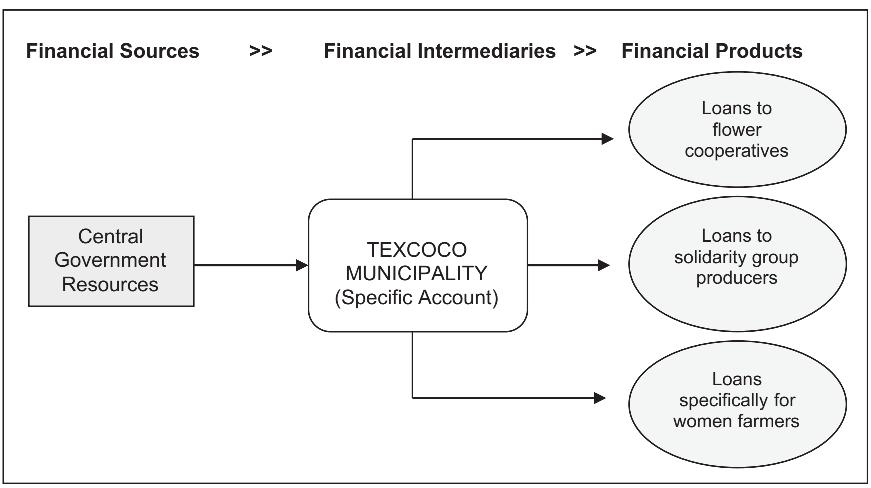

FIGURE 14.5 Financial flow for urban agriculture, Texcoco, Mexico

Source: Cabannes 2004a based on Ramirez-Garcia 2002.

After a couple of years, this successful programme received less attention from the newly elected local senior officials and the mayor. Despite requests from the producers, the technicians in charge and the university that was technically supporting the activities, the programme was left to die out slowly.

Participatory budgeting (PB) in Rosario

The experience of the city of Rosario, a city of one million inhabitants in Argentina, shows under which conditions municipal earmarked resources can meet the needs and the expectations of urban producers. As shown in Figure 14.6 the financial resources for urban agriculture are managed in two different ways: on the one hand, the Municipal Secretariat for Social Promotion develops a set of support activities to assist local urban farmers (input supply, technical assistance and training). In addition, since 2002, Rosario Municipality leads every year a Participatory Budgeting process through which citizens – whether organized or not – define the destination of part of the public resources of their city (Mazzuca et al. 2009).

Interestingly enough, in two out of the six districts of Rosario where the approach was introduced, organized urban farmers proposed projects related to

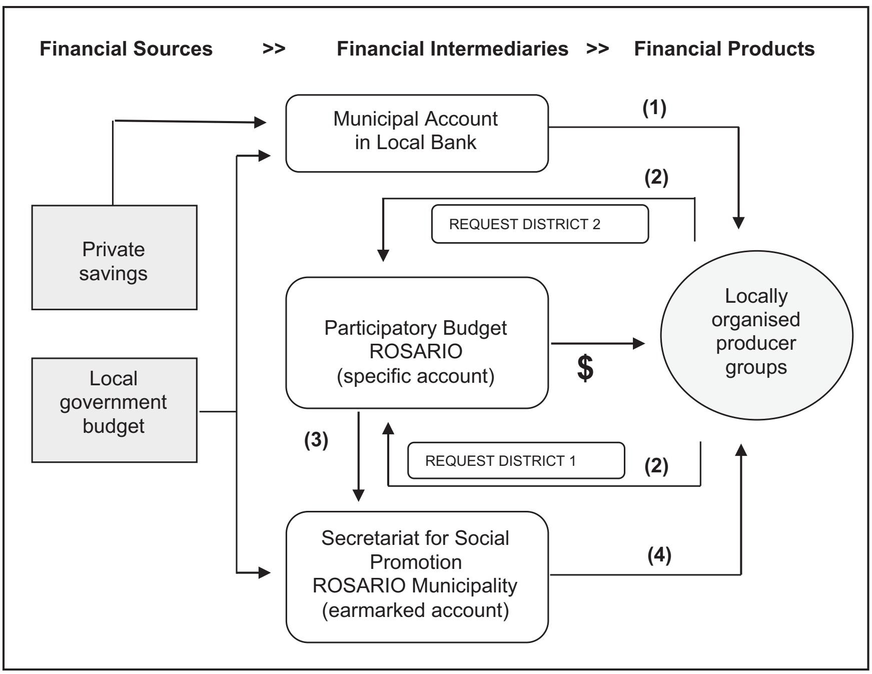

FIGURE 14.6 Financing of urban agriculture with participatory budgeting in Rosario, Argentina

Source: Cabannes 2004a based on Municipality of Rosario (oral communication).

the production and processing of vegetables and transformation of medicinal plants. These two projects were eventually prioritized and were integrated into the municipal budget allocations. The corresponding resources were then earmarked within the Municipal Secretariat for Social Promotion. Financially speaking, they were included in the budgetary allocation and specific funds were deposited in the bank managing the budget of the city.

Comparison of Texcoco and Rosario financial intermediaries

The key element that differentiates the experience in Texcoco from that of Rosario lies in the control of resources. In Rosario, the producers have direct control of public resources (bottom-up approach), whereas in Texcoco, decision-making over the resources always remained in the hands of the local government. However, even though participatory budgeting allows for better adaptation of public resources to the needs of the population, it is not a full guarantee of continuity as the process could be interrupted by circumstances such as a change of government.

Public resources and subsidies have been a crucial source of funds for facilitating the access to credit of small urban farmers, and for leveraging and channelling additional resources. However, the dependence on public money has the risk of a sudden interruption to, or closing of, excellent and economically successful urban agricultural activities. The case of Texcoco shows the risk of depending on public resources as the urban agriculture programme was halted after a change of local government. The extent of independence of a financial intermediary and its ability to survive political or policy changes should be given close consideration. In order to reduce the dependency of a credit system on political will, it is necessary to build strong intermediary financial institutions that can lend and work with public money, but that will not depend on political orientation for their continuity. This is probably one of the key issues to be dealt with as far as financing of urban agriculture is concerned.

b. Private and community-based intermediaries

The experience of a savings and credit cooperative in Nepal

The Mahila Prayas Savings and Credit Co-operative Ltd. (MPSACCO) was established in Nepal in 1998 (CMF 2002). This relatively young institution offers both individual and peer lending for agricultural activities, for setting up shops and for dairy farming.

The financial resources of the cooperative's members are generated through various types of savings such as regular compulsory (monthly), voluntary, marriage and festival savings. This variety indicates how a community-based banking facility is tailored to cultural and local practices and substantially different from conventional banking systems for the poor in which savings is simply a compulsory activity that is a precondition for getting a loan.

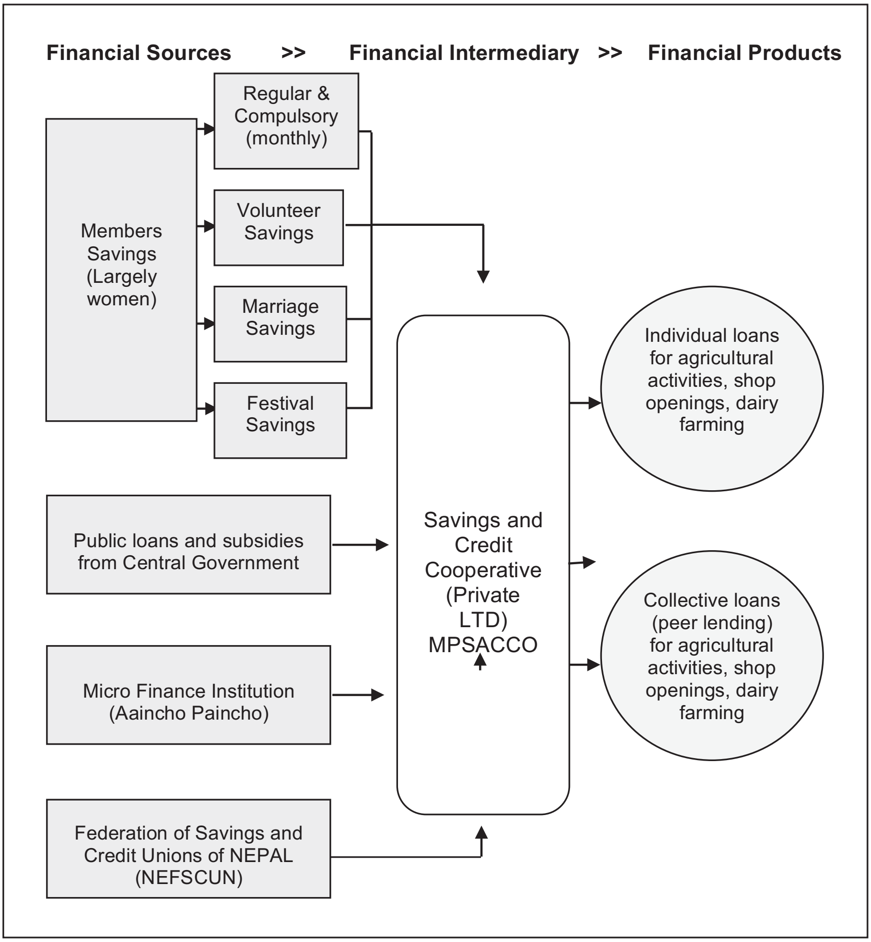

FIGURE 14.7 Financing of urban agriculture in Nepal

Source: Cabannes 2004a based on CMF 2002.

In addition, the central government provides loans and (limited) grants. Various "Social Economy" institutions have provided loans, occasional subsidies and technical assistance to MPSACCO and its members (i.e., Cooperative Development Board, Federation of Savings and Credit Unions of Nepal and Aaincho Paaincho, a Micro-Finance Institution).

c. Private and banking sector as financial intermediaries

The PROVE experience in the state of Mato Grosso do Sul, Brazil

The PROVE programme is based on a similar successful experience carried out in Brasilia, in the mid-90s (Homen de Carvalho 2001; Araújo 2002). Its basic

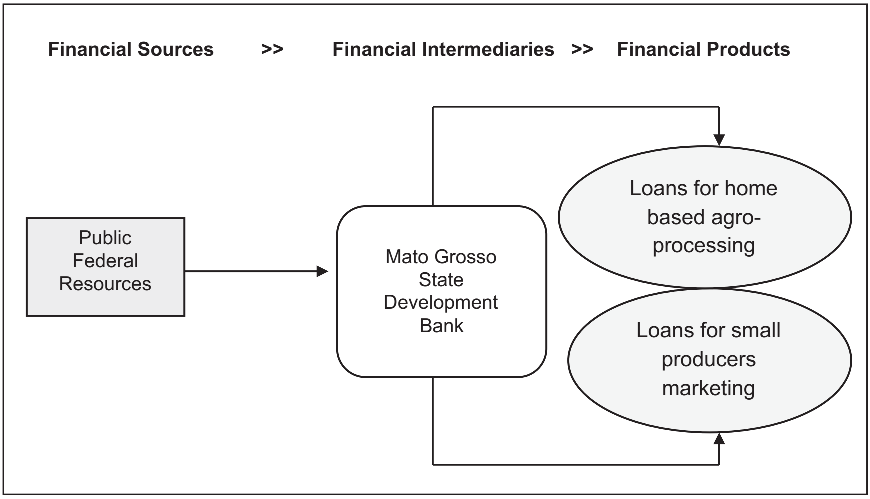

FIGURE 14.8 The case of PROVE Pantanal, Mato Grosso do Sul State, Brazil
Source: Cabannes 2004a based on Araújo 2002.

principle is to provide credits and technical assistance to home-based producers, so that they can add value to their agricultural family-based production by processing primary produce and selling it to supermarkets.

The credit that PROVE provides at state level was funded through central government resources, while the technical assistance comes from the state government budget. Interestingly, the state government separated the technical assistance component from the management of the credits, and delegated the financial management to a development bank operating through its branches at state level. The bank authorizes the various loans and the borrowers repay at this same bank, in a fairly conventional way.

Such a model raises again the issue of what might happen in the case that the federal government stops feeding the current credit line. Two answers might be given. For one, the loans are paid back to the State Development Bank that does not have to pay back to the federal government. The budget allocation from the federal government to the State Bank is used as a starter for generating a revolving fund. The money paid back by the clients can be given out again as loans. However, currency devaluation and possible reimbursement defaults will cause the lending capacity to shrink.

Secondly, this financial setup has had the opportunity to open the doors of the bank, in most cases for the first time ever, to family-based urban farmers. If they pay their first loans back and thus gain credibility, they will be in a better position to apply for future loans from the bank, beyond the specific, subsidized PROVE credit line. In this sense, the PROVE programme acts as a bridge between informal producers and the formal banking system, and this makes it especially attractive.

Lesson learned: urban farmers should be involved in financial intermediation

A thorough understanding of the best adapted financial intermediaries – either a private cooperative such as in Nepal; a public/private one in Bangalore; a public bank such as in Mato Grosso do Sul; or a private bank – is crucial in order to optimize usually scarce or at least limited financial sources. In this context, involvement of producers/user groups in fund management such as is often the case in credit cooperatives, credit unions and community-based financial organizations appear as viable and important mechanisms that necessitate attention. The cases of London (Mbiba and Wiltshire 2002) and St. Petersburg are also particularly relevant.

Financial practices of small-scale urban farmers, banks and public actors: lessons learned from 17 cities

From 2008 to 2011, 17 cities from the Global South carried out an applied research which focused primarily on practices and innovative ways that small-scale urban farmers, producers' organizations, local governments, MFIs, banks or NGOS were putting into place to finance activities related to urban agriculture. In connection with this the following three key issues were examined:

- What are the practices of public and private institutions that finance, or could possibly finance, urban agriculture?
- Needs and demands for finance from urban poor engaged in urban agriculture, agro-processing or marketing. A central objective was to understand how and through which mechanisms these urban farmers all along the value chains are financing their activities and expanding them.
- The third broad issue explored was to identify a way to bridge the gap between existing and potential financial resources (the offer side) and the needs and demands from small-scale urban farmers (the demand side).

The cities studied are a selective sample of primarily large cities where some form of urban- and peri-urban agriculture is being practised. Most of the cities (see Figure 14.1) have a population above one million (Bulawayo, Accra, Ibadan, Amman, Sanaa, Cape Town, Belo Horizonte and Freetown); four of them (Bogota, Lima, Shanghai, Beijing) are megacities. Apart from the small municipality of Magadi, at the periphery of Bangalore, the remaining ones have between 500,000 and one million inhabitants (Ndola, Bobo Dioulasso, Porto Novo, Gampaha). Most of them are either national capitals (Accra, Amman, Sana'a, Porto Novo, Bogota, Lima, Freetown, Beijing) or regional ones (Ibadan, Bulawayo, Ndola, Cape Town, Bobo Dioulasso, Belo Horizonte and Gampaha). Districts from Shanghai (Minhang), Beijing (Huairou, Tangzhou) and Magadi were chosen for being positioned at the periphery of large metropolises, offering a more peri-urban perspective.

Credits and subsidies practices from public and private financing institutions

One of the assumptions that resulted from the 2001–2003 city survey on credit and investment was that credits for urban agriculture were the exception and not the rule. The second batch of observations suggested a different conclusion as credits for small-scale urban farmers do exist in various cities even if they are generally limited in scope and number. Moreover, they are more frequently for commercially oriented activities such as raising animals, agro-processing or marketing. These loans are relatively common, for instance, in cities such as Lima, Ibadan or Amman. The number of credits and their volume has reached such a critical mass that these practices deserve further research and understanding.

A second finding is that despite the volume and reasonable number of loans in some cities, most credit institutions interviewed expressed reluctance to give loans to urban farmers for a long list of (good and bad) reasons. The most frequently mentioned in most studies that underlie their position are relatively few: (i) a high rate of default; (ii) too high risk because of possible crop failure, essentially for climatic reasons as, for instance, in Gampaha, Sri Lanka (Jayasinghe-Mugalide 2009); (iii) limited financial management capacities of farmers (e.g., Ndola, Zambia); and (iv) lack of proper title deeds or collaterals from urban farmers.

A third conclusion common to various cases is that high interests loans practised by MFIs and conventional banks have had limited positive impacts for improving the situation of poor farmers to shift from a subsistence practice and venture into more market-oriented activities.

Another lesson learned is that central and local governments play a major role in the success and failure of city-level financing systems for urban agriculture. Their role is primarily to deliver subsidies and in some cases, such as in Cape Town, with significant value (Mangaliso 2010). One key finding relates to the creative range of ways through which local governments are using their scarce resources. In addition, they tend to play a role in setting up public finance strategies covering a wide range of financial interventions that complement the banking and micro-finance system. Some of these interventions are presented later.

The first survey on 13 cities had already given some preliminary clues on different forms of subsidies designed locally:

- Financial subsidies to the banking system, such as those related to "soft conditions" for credit.
- Direct subsidies to the farmer, for main agricultural inputs (land, water, seeds etc.), or subsidies in the form of free technical assistance and training or support to obtain inputs (Botswana, Nairobi-Kenya).
- Subsidies to generate a facilitating environment, such as in St. Petersburg, where transport to agricultural plots outside the city was subsidized. Private-sector subsidies such as grants and charities from NGOs and other civil society

groups (as in the London case), and from public subsidies coming from local and national governments, such as the case of the HOPCOMS cooperative in Bangalore, are other forms of subsidies.

Urban farmers' financing practices; priority to self-financing and non-monetary resource mobilization

Poor urban farmers usually self-finance their activities

One of the key conclusions of the 2002–2003 research was that urban farmers rely heavily and primarily on the mobilization of their own resources, either monetary or non-monetary. Generally speaking, resource mobilization and savings occur in very different ways: (a) individual, (b) family-based, (c) collective savings of small groups of producers, or (d) community-based. In some cases, voluntary and organized savings are more formalized as in the case of the Nepalese savings and credit union cooperatives. These results were enriched through the second applied research that concluded most poor urban farmers stand outside the formal institutional landscape. They usually self-finance their activities through a rich array of solutions that exist across the board and in various continents, such as the following:

- Loans from families and friends, or (less commonly) from remittances sent by some members of the family working abroad.
- Rotating savings systems are present under different names in different cities: called *tontines* in Porto Novo, Osusu in Ibadan, groups savings in Bulawayo, or *banquitos* ("tiny banks") in Lima; they share the same basic principles with some local variations: small groups of persons saving; voluntary adhesion; and each member receives the sums saved on a weekly, fortnightly or monthly basis.
- Cross subsidies from one item that at a specific period is highly valued, for instance, raising and selling goats in the Sana'a case, that allows taking risks on less profitable or risky products (Al Jundi 2010). These forms of multiple commodities produced at the same time on a family-based perspective recall the quite resilient and traditional poly-cultivation and animal breeding of family-based rural farming systems.
- Informal credits from input suppliers of seeds, pesticides or fertilizers, or market traders as seen across urban Ghana, who accept being paid back once the products are sold (Drechsel et al. 2013).

High level of needs and reluctance to ask for loans or even subsidies

A second key finding is that urban farmers, in most cities, express a high level of needs but at the same time are quite reluctant to ask for loans or even subsidies. There are many reasons for this expressed by the urban farmers; the key reasons are briefly mentioned below:

- The loans offered are generally not adapted to agricultural and animal-raising cycles: the loans to be paid back in one year are not sufficient for livestock (Beijing); timing is too short for reimbursement, too long to be made available (Bobo Dioulasso) while referring to the need of resources at a specific sowing time in the year, usually at the beginning of the rainy season (Ouattara 2009).
- "Too much bureaucracy"... "the process is onerous"... "lots of paperwork"... "no clear procedures" are opinions expressed in cities as different as Porto Novo, Ndola, Sana'a or Bobo Dioulasso, highlighting the difficulties encountered with financial institutions.
- The impossibility to get loans for not having formal land titles required by banks as collateral or guarantee is expressed by urban farmers in a large number of cities such as Magadi, India. As a result, they do not want to apply for "impossible loans" or even subsidies that might require a proof of ownership of the land cultivated that poor farmers usually do not possess (Ramalingegowda et al. 2010).
- Much too high interest rates, primarily those imposed by MFIs is a recurrent argument, even if some of the loan takers accept them for a lack of other options. Interest rates as high as 60% per year are offered in Accra, making it quite difficult for a poor urban farmer to reimburse (Egyir 2010), which forces them to continue seeking informal credits, e.g., in West Africa from market women with all related disadvantages.
- Loans are not small enough: for instance in Bulawayo, urban farmers are reporting that the loans offered are 1,000 dollars as a minimum, and therefore beyond the repayment capacities (Chaibva 2010). This opinion echoes another one, stating that the financial products offered are not related to the (limited) income of urban farmers.
- A low capacity to prepare funding applications, either to obtain subsidies or to get a loan, is expressed under different forms by the interviewed farmers who explain their reluctance to engage: for instance, the Freetown reports summarize, "there is a lack of knowledge on how to obtain credits" (Konneh 2010).

Innovative ways of bridging the gap between a limited demand and a restricted offer

In several of the 17 studied cities and in various cities much beyond the study, quite innovative solutions significantly improve the access of poor urban farmers to finance understood in its broader sense summarized in the following equation:

> *Urban agriculture finance = monetary and non-monetary resources mobilization + individual and collective savings + subsidies under different forms + micro credits and conventional loans.*

These innovative experiments relate fundamentally either to the improvement of the financial sector itself or to generating a more enabling environment.

Improving the financial sector and its volume of resources

Four innovative mechanisms were identified through the research for improving the financial sector itself:

- Diverting or channelling financial resources to urban agriculture primarily from (a) rural agriculture loans; (b) housing loans and subsidies, to be used for the development of "productive" housing, encompassing the house itself and at the same time its immediate productive surroundings, such as a garden to cultivate vegetables, sheds to raise animals or develop home-base agro-processing activities; (c) income-generating and job-creation loans and subsidies that are marginally benefiting the urban farmers; and (d) slum improvement resources and programmes that again rarely consider urban agriculture.
- Evolutionary loans with decreasing levels of subsidies that allow the loan taker to pass through a couple of lending cycles from a high level of subsidy to a conventional banking loan. This system was massively put into place in Fortaleza, Brazil, for the Better Home (Casa Melhor) programme that considered housing as a productive asset (Cabannes 1997b).
- Creation of community banks and creation of local and regional currencies, such as the Banco Palmas, in Fortaleza, Brazil (www.bancopalmas.org.br/).
- Credits for consumption (in local currencies) of locally produced or transformed food, such as in the case of the Banco Palmas. They were crucial to generate a locally sustainable financial system and are unfortunately very rare.

Generating an enabling financial environment

The following innovations emerging from the research differ from the previous ones, as they are not properly speaking of financial nature but contribute to generating a positive environment that in turn impacts the performance of the sector. Five of them seem particularly important:

Creating or strengthening of formal organizations and confederations of producers

One of the challenges faced by urban farmers and producers is that they are often not legalized and are considered informal. As a result they are not eligible for most of the formal banking systems and public institutions.

Agrosilves, an organization that gathers a couple of hundreds of pig raisers in Metropolitan Lima, has been successful in attracting the attention of two banking institutions and negotiating individual loans as a result of a collective approach. The credit institutions see their benefit in getting a critical mass of clients already "pre-selected" by Agrosilves. One of the most difficult obstacles to obtaining a mortgage is to get a proper land title that will guarantee the loan. It could be by-passed in this case as Agrosilves emits a certificate of residence that is accepted as a proxy by the banks (Saénz 2010).

In the city of Ibadan, Nigeria, the urban farmers are locally organized in 21 "commodity associations" out of the 28 sectors that compose the All Farmers Association of Nigeria, resulting in increased legitimacy of the farmers (Adeoti 2010), while at the same time singling out specific risks and financial specific needs of the different producers in terms of amount of loans, possible guarantees offered, and grace period or duration of the repayment in relation to the cycle of the production. Getting organized is not only proposed by urban farmers but also by public and finance institutions.

Increase security of tenure and access to urban land for farming

The lack of formal land titles appears as one of the key obstacles to increasing the accessibility of urban farmers to finance. An ongoing experience developed in Freetown, Sierra Leone, is a good example of how to promisingly address this bottleneck:

> The Freetown Urban and Peri Urban Agriculture Forum, involving key political institutions, credit institutions and farmers, have designed an innovative financing mechanism in 2010. The new programme relies on authorities for the permanent allocation of valleys, slopes and low lands for use in intra- and peri-urban agriculture. Land is allocated to registered and functioning farmers groups for a period of 5 years for a token rent provided that they abide by the Agreement regulations. The group receives technical training and monitoring and, for farmer groups participating in the scheme, four credit institutions (First International Bank, Access Bank, Luma Micro Finance Trust Limited, Salone Micro Finance Trust) have agreed to accept such land agreement together with the group's existing savings or current account as a collateral for two purposively designed credit products. The first is a micro credit of between 100 and 400 EUR (repayment period 1 year); the second is a loan between 1,000 and 2,000 EUR (repayment by 2 years) with a yearly interest rate of 24%. The number of households that could potentially benefit from the scheme once it is fully established is estimated at 2,500.
>
> *(Personal comment Marco Serena 2011)*

Positive impact of technical support to urban farmers for formulation of business plans

One of the main reasons why urban farmers are reluctant to try to get loans is their limited capacity to put together an application and more importantly a business plan that does not go against their own interest. At the same time, the financing institutions repeatedly express the limited capacities of urban farmers at that level. The RUAF FStT programme, such as in Porto Novo, Benin, gives support to farmers to get a proper business plan. As a result, a first batch of 19 loans was approved by a locally established MFI to around 130 tomato growers (Glele 2009).

Participatory budgeting

As referred to already through the experience of Rosario, Participatory Budgeting is a mechanism (or a process) by which the population defines the destination of part, or the totality of, public resources (Cabannes 2004b). Participatory Budgeting emerged in 1989 in Brazilian municipalities, and Porto Alegre became the most emblematic of them all. Twenty-five years later, in 2014, at least 1,700 municipalities in more than 40 countries in all regions in the world have adopted Participatory Budgeting as a means to decide upon their financial priorities, with a great deal of difference between them. Some cities, such as Seville in Spain, Rosario in Argentina or Porto Alegre in Brazil, have included urban agriculture projects as part of eligible priorities by the population. Results have deserved, and would deserve, much greater attention. The most interesting aspect is that Participatory Budgeting offers a permanent and endogenous source of funding to organized urban farmers to finance what they exactly want and need.

Urban agriculture insurance system

Both Beijing and Shanghai have been setting up insurance and security systems for urban farmers (Cai and Guo 2010; Cai et al. 2010). Limited information gathered so far through the research, and that would deserve a more in-depth examination, already suggest that opening up insurance mechanisms to urban farmers could be one of the most interesting mechanisms for consolidating urban farming activities. In Minhang district (Shanghai), Anxin Insurance Cooperation Ltd., a public finance institution, provides insurance to urban farmers, subsidized in 2009 to the value of 4.5 million Yuan (about USD470,000). Fifteen types of insurance are tailored to different equipment and crops: greenhouses, vegetable plants, fruit and wheat, pig, cow and fowl breeding, seed production, agricultural implements and property insurance.

The insurance system is one of the ten pillars of a comprehensive subsidy policy. Information to date is insufficient to calculate what proportion of the insurance is devoted to small-scale urban agriculture, as it seems earmarked essentially for what in China is called "upper end" urban agriculture. In Huairou and Tongzhou districts in Beijing, a similar system started in 2007, and so far 18 kinds of plants and breeds are insured for around 1,600 households; 30% of the total cost is subsidized.

Is there a right mix between savings, subsidies, credits and resource mobilization?[3]

Two subsequent and challenging questions remained unanswered thus far: Is there a right or best mix among these various components that would increase the chances of long-term sustainability of urban and peri-urban agriculture? And if there is, how can it be made operational? Instead of giving a general answer, four specific and quite innovative cases summarized below were analyzed in order to bring to light their local mix and combination of savings, subsidies, credits and resource mobilization for business-oriented and self-consumption practices:

- Village Savings and Loans Associations (VSLA) have been expanding since 2009 in Liberia. In 2013, around 3,000 VSLA members belonged to these associations. VSLA improved access to credit for urban and peri-urban farmers, and even bridged community-based finance with micro-credit and central government banking (RUAF Foundation 2013).
- Community Land Trusts (CLTs), as non-profit, community-based institutions, retain permanent ownership of land on behalf of their members and have been expanding swiftly, primarily in the United States, since the early 1980s, in order to provide affordable housing for lower- and lower-middle-class citizens. Interestingly enough, an increasing number of CLTs have non-residential components and support urban agriculture in diverse forms (Davis 2010).
- SANASA Development Bank, a cooperative Bank in the city of Gampaha, Sri Lanka, recently set up an innovative revolving fund, operating partially as a fixed deposit account bringing financial resources to urban farmers, and partially as a savings and short-term loan device opened up to small groups (RUAF Foundation 2013).
- As briefly introduced before, both Beijing and Shanghai have been setting up insurance and security systems for urban farmers, introducing what could become one of the most interesting mechanisms for consolidating urban farming activities.

Based on this limited number of cases, and referring back to the 30 cities that were part of the research programmes mentioned previously, it seems that there is not one right mix: successful combinations are country- and city-specific. Accordingly, no standard recipe is proposed here. However – and this is important – successful local cocktails tend to use the same four basic ingredients: monetary and non-monetary resource mobilization by farmers + savings + credits + subsidies. Even if some local financial systems might be initially based essentially on one or two components (for example, credit or subsidies only), the systems that last and grow through time are precisely the ones that gradually integrate the missing elements. For instance, even if Community Land Trusts, as their name denotes, are community-based organizations drawing on the community's own resources, their resilience through time goes hand-in-hand with their capacity to obtain financial subsidies from a wide array of sources in order to acquire "free" land and, at the same time, access low-cost credits from cooperative or commercial banks.

Another remarkable common thread between the cases that were not highlighted during the study is the subtle combination of individual and collective dimensions for both savings and loans. Each one of the four cases sheds some light on this issue. For instance, VSLA in Liberia are certainly collective saving groups, composed usually of 15 to 30 members who voluntarily get together to save in order to allow one or more member of the group to take a loan from the fund. These associations share common features with *sou-sou, tandas, banquitos* or *tontines,* sometimes called rotatory saving systems that exist often among urban farmers. They share features in the sense that saving amounts, number of members and frequency of deposits are fixed by the members, and collected resources are highly controlled and managed by the community. The essential difference in the case of VLSA is that the collective saving group authorizes individual loans to its members, with interest rates decided collectively. Discussions between SANASA Development Bank, urban farmers and their advisors at Gampaha, Sri Lanka, led to the setting up of a collective saving scheme with a unique account. However, each individual who deposits his or her saving has a passbook clearly indicating the amount of savings.

A third common thread is that each one of the cases presented includes an amount of subsidies of various origins; these subsidies were largely underestimated, or at least kept quiet in the first drafts on the four cases, as if a key for success for financing urban agriculture was that they could function without a certain level of subsidy. Making these subsidies explicit is key in order to make the best use of them, as is having their destination defined by the urban farmers. Why should NGOs, international aid, researchers, local or the central government decide on the destination of subsidies? One lesson learned from Participatory Budgeting experiences open to urban farmers, in cities such as Seville in Spain or Porto Alegre in Brazil, is precisely that the farmers themselves decided the best way to optimize scarce public resources that were made available, and in both cases they were quite successful.

Quite interestingly, subsidy for training, and for technical assistance to urban and peri-urban producers, appear as a common feature in the cases presented: CARE Liberia is supporting the training modules and one year of a technical officer for VSLA in Liberia; CLT provides information and training courses to any candidate, for instance, on banking conditions and affordability; and at Gampaha, training workshops and services are offered free of charge to participants (first by RUAF, now by Gampaha Agricultural Department). Specific subsidies to each case and situation, such as subsidized insurance premiums in China or limited ground lease permitting affordability in CLTs, are referred to in the dossier cases.

Our last observation refers to the credit component. A surprising aspect is the limited role of MFIs and micro-credit institutions in spearheading innovations in finance related to urban agriculture. They are largely absent, as noticed in the conclusions of the research on 17 cities. Quite remarkable and counter-intuitive is the fact that public banks such as those in Beijing or Shanghai, or cooperative commercial banks such as those in Sri Lanka, or the Central Bank of Liberia, through its micro-finance unit are introducing innovative solutions and also taking some risks. One could have expected private MFIs to play that role as well.

Examining the financial products offered and the loan conditions is quite revealing and inspiring. First, they tend to be customized and tailored to specific needs, as the financial needs of an individual starting with small-scale agro-processing are quite different from those of a farmer needing to buy seeds and equipment before a rainy season, or those of a family who would like to expand its production of chickens. Each one of them needs different amounts, for different reimbursement periods – depending on when they will sell their vegetables, chickens or transformed products – and at quite a different period in the year. Second, the intricate individual/collective dimension is maintained, even if different from what was observed in savings: peer pressure for reimbursement, mixed with solidarity in case of proven hardship, seems to be a recurrent feature, associated with collective guarantee and individual responsibility.

These findings have a direct consequence on the way business plans are formulated. Once they are formulated and the cost of the operation is defined, the next exercise is to establish a financial plan that would indicate the specific contribution of the four ingredients: credit, subsidy, savings and resources mobilized. As the combination might vary over time, a systematic exercise that any business plan should consider is to anticipate how the mix of components could and should vary. For instance, the proportion of subsidies (e.g., for training) might go down when, in parallel, credit might increase, and the proportion of own resources mobilized by farmers might increase as well.

Conclusions and balance: what do we know better and what should we know better?

Good progress has been made since the first research in the 1990s on financing urban agriculture. The analytical tools designed to unpack local monetary flows going to urban agriculture allowed to identify bottlenecks and design proper financial products. In parallel, better understanding of the informal and non-monetary side of urban agriculture was probably one of the major items of progress achieved over the last ten years, notwithstanding the need to process available primary data collected during both applied research programmes.

Optimization of public subsidies

Research in the early 2000s pointed out the empowering and leveraging impact of subsidies for urban agriculture. Some progress has been achieved over the last ten years in widening our knowledge on subsidy mechanisms for urban agriculture along the value chain and their quick positive impact. However, much research still needs to be done to identify the comparative advantages of these mechanisms, primarily processing the information available in the 17 cities from the second research. This should help in setting up strong and clear subsidy components within national and municipal urban agricultural policies that should unlock the key bottlenecks of the finance system.

Fiscal and financial municipal policies

Progress has been made on increasing knowledge on issues such as Participatory Budgeting and its impact on urban agriculture. However a lot remains to be done still on partnerships with banks and micro-finance institutions, mixed municipal funds, innovative institutional financial setups, and fiscal policies, which are keys to increase the access of urban producers to financial products.

Comparative advantage of financial intermediaries

Several types of institutions of financial intermediation have been identified and described such as public bodies, private agencies and banks or community-based institutes. A comparative study of their advantages and their limits remains to be done to further strengthen the ongoing experiments.

Combined local mix of resource mobilization, savings, subsidies and credits

Urban agricultural finance offers unconventional and quite innovative solutions that are not standardized, and this is probably one key of their – as yet – limited, but expanding, success. However, they tend, as described above, to gain strength gradually through relying on the same combined local mix of resource mobilization, savings, subsidies and credits.

Financing urban agriculture as part of urban metabolisms

Progress has been made over the last ten years on conceptualizing (intra- and peri-) urban agriculture as part of an urban metabolism and on showing how urban agriculture is a unique possibility to make cities work better and at the same time produce nutritious food: for instance in making good use of grey waters for irrigation, or in being a solution to treat used waters. What we know very little still is what should be financed and how should be financed a better integration of urban agriculture within urban metabolism, primarily to improve the links between urban agriculture and the transformation of organic waste into compost in order to reclaim existing soils, or between used water networks and cultivated urban lands.

Financing which type of urban agriculture?

One lesson learned is that different financial mechanisms and a specific balance of credit/subsidy/savings/monetary and non-monetary resource mobilization are needed for each specific type of urban agriculture, e.g., market-oriented activities, subsistence ones for domestic consumption, or leisure and education in urban agriculture. Lessons from the field suggest that a right balance between all three types is probably the best way to turn urban agriculture more resilient at city level. Specific financial mechanisms and a facilitating financial environment probably play a crucial role in urban agriculture.

Financing access to secure land through collective, cooperative and communal forms of tenure

Financing access to intra- and peri-urban land remains probably one of the least studied and most needed topics in relation to urban agricultural finance. How do small-scale urban farmers resist against evictions and land grabbing? What are the financial mechanisms they use to stay in place, or expand farming or breeding land? Putting into light financial mechanisms that increase secure tenure is particularly important in front of massive land grabbing in rural and peri-urban areas and speculative land markets in cities. In this context, financial mechanisms and practices that facilitate or strengthen collective, communal or cooperative forms of farming and land tenure are crucial for years to come. These non-individual forms of tenure tend to indicate, as in the case of Community Land Trusts, that they increase security on land for the poor and for small-scale producers.

Recommendations for an action-research agenda on urban agricultural finance

Financing remains a major bottleneck for expansion of urban agriculture

Findings from research on the 17 cities, which confirm and expand the early research in the 2000s, strongly suggest that, despite some progress in a limited number of cities, the financing of urban and peri-urban agriculture is a major bottleneck in maintaining, expanding and scaling up the production of affordable, nutritious and accessible food in cities.

Therefore, strategic decisions with a strong financial significance should be taken.

Support from a broad scope of public and private institutions is needed

Governments, banks and international aid agencies need to support urban farmers all along the value chain. National and municipal urban agricultural policies should have a strong, clear subsidy component aimed at removing the key bottlenecks in the financial system. Governments and finance organizations could concentrate on supporting, consolidating and transferring innovations currently taking place in various cities and that are quite promising for the future. This is the price to pay if we want to be serious about expanding intra- and peri-urban agriculture and increase the capacity of cities to produce affordable nutritious food, not only for the better-off but for the poor and the most vulnerable.

Innovative ideas that need to be further developed

In several participating cities, innovative proposals were formulated and some were partially implemented. Their aim is to improve the access of poor urban farmers to finance, understood in its broader sense. The first recommendation is that these proposals that result from deeply grounded practices and research should be given a strong support locally, nationally and internationally. Proposals include the following:

- Local revolving funds for urban farmers with an insurance component in Amman (Samir El-Habbab 2010). Experiments in Beijing and Shanghai mentioned in this chapter could be useful.

- Involvement of leasing companies in Ndola, for instance for acquiring tractors or watering cans (Phiri 2009). The experience in the capital city Lusaka with leasing of bicycles proved positive and could serve as a source of inspiration.
- Mutual saving funds for urban farmers in Bogotá and support from the Banca Capital municipal programme that would match each peso saved by farmers (Figueroa et al. 2010).
- Introduction of the Islamic law principle of *reba* by some banks, such as Al Amal Bank (Sana'a), to address the prohibitive interest rates practised by MFIs. Two modalities co-exist: first, *murabaha,* whereby the institution buys the product that is needed by the borrower who, in turn, repays the price of the product plus the transaction expenses; and second, *mudarabah,* whereby the institution gives a loan to start a specific business and claims a percentage of the profit for itself (Al Jundi 2010).

Creation of a powerful international funding facility and of municipal local funds for urban agriculture

Support at all levels to generate a funding facility for urban agriculture is urgently required. It could channel a mix of funding and subsidies to the sector through, for instance, small grants to subsistence agriculture; revolving local funds; grants for technical advice and support to business plans; and guarantee funds and insurance facilities. RUAF Foundation, along with the vast numbers of actors it works with, could spearhead such an initiative.

Mixed municipal funds are not yet very common in the field of urban agriculture, but they exist in other sectors such as home improvement and/or

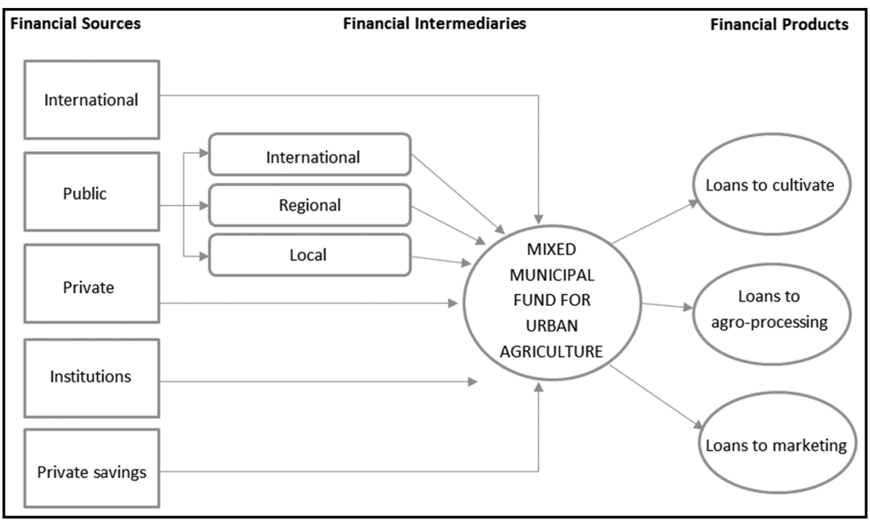

FIGURE 14.9 Mixed municipal fund for urban agriculture

Source: Cabannes 2004a.

generation of income. They were largely discussed and introduced as a result of the 2002–2004 survey on financial intermediaries (Cabannes 2004a). A central element of these funds would be the diversity of their financial sources to include international donations or loans, public resources and private savings, particularly of urban farmers.

"Resource cities" on financing mechanisms for urban agriculture

In addition to consolidating experiences at city level, it is suggested to build the capacities of the actors of these cities, in order for them to become the international and national advocates of their experience. Such consolidated cities could become "resource cities", capable of exporting their knowledge and advising interested cities that would become their associates and become "on-the-job training centres". The situation is ripe to select a limited number of cities and contribute to build their capacities.

Urban agriculture needs a broader urban scope: 21st century Garden Cities of To-Morrow

Over one hundred years ago, Ebenezer Howard launched Garden Cities of To-Morrow, and soon after Letchworth Garden City started to be built. It introduced two major innovations: land was commonly held in trust and half of it was cultivated. In 2014, this land is still cultivated and the Heritage Foundation still manages most of the city land. The financial mechanism was resilient enough to resist speculation and allows for substantial resources for the benefit of the community.

There is a need to posit urban agriculture within a broader framework of principles adapted to the constraints and opportunities of the 21st century cities. This is the challenge that the manifesto on Garden Cities for the 21st century addresses, embedding urban agriculture within a renovated urban vision (Cabannes and Ross 2014). Financing urban agriculture has to be part of the broader city-region financial mechanism that must, and can, be beneficial for family-based, community-based, and small- and medium-scale agriculture.

Notes

1 This paper draws on the major RUAF research programme and on analysis carried out in cooperation with Marielle Dubbeling, RUAF Foundation. Her invaluable contribution is duly acknowledged. We would like to thank as well each of the authors of the 30 case studies for their unique contribution and goodwill. For a more comprehensive research synthesis, see Cabannes, Y. 2012. Financing urban agriculture. *Environment & Urbanization* 24(2): 665–683.

2 A summarized description of these 13 cases is available in the ninth issue of the *Urban Agriculture Magazine* (RUAF, April 2003).

3 This section is adapted from a text from the author: Financing urban agriculture: Seeking the right mix of subsidies, credit, savings, and resource mobilization, published in *Urban Agriculture Magazine* 26, 2013.

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15

ROLE OF URBAN AGRICULTURE IN DISASTERS AND EMERGENCIES

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Introduction

> More than 1 billion people live in unsafe and unhealthy conditions in slums, refugee camps and informal settlements. And these numbers are growing. Over 50 million of them are refugees living in camps or temporary illegal settlements. If these forcibly displaced people had their own nation, it would be the world's 26th largest country.
>
> *(Buscher 2011)*

Natural hazards, civil conflicts, wars and economic crises can all have a profound impact on generating unstable and unsafe conditions, and placing immense pressures on communities and local support mechanisms. These emergency scenarios often result in people fleeing their homes to safe areas or crossing borders to other countries, thereby creating mass refugee situations. Many of these refugees or internally displaced persons (IDPs) not only remain in refugee camps for extended periods but also increasingly in and around urban areas (often illegally). Consequently, many people living under the harsh conditions of refugee life will try to improve their livelihoods, including improving their access to food by establishing some form of agriculture, such as small-scale gardening or livestock husbandry.

In this chapter the linkages between urban agriculture and disasters and emergencies are explored, by providing a broad illustration of the potential role that urban agriculture can play in "disaster risk management". Disaster risk management is an overarching term that covers all aspects of disaster management, including *pre-disaster* activities such as "disaster risk reduction" (DRR) programmes that aim to build resilience, as well as *post-disaster* activities such as working with refugees in camps or urban areas, linking relief, rehabilitation and development (LRRD). The pre-disaster and post-disaster phases are commonly referred to as the "disaster management cycle". The core message is that enhancing the role of urban agriculture, both in pre- and post-disaster situations, may assist in increasing the resilience of communities, prevent (some) disasters from happening in the first place, and improve effective responses at local, national, regional and international levels when disasters do strike.

Increasingly, refugees seek their refuge in cities, and many camps gradually develop into settlements. Urban agriculture has been identified by many organizations as a component of that response, illustrated by a number of guidelines seeking to mainstream local food production into disaster and emergency programmes. The Humanitarian Charter and Minimum Standards in Humanitarian Response, for example, recommends the protection of local food production systems while also promoting kitchen gardens and agroforestry in refugee camp settings (The Sphere Project 2011).

The chapter starts with looking at different disaster and refugee situations, finding that there is an increasing need to look (differently) at urban areas to find solutions. It then continues by describing the role of urban agriculture in different settings, and the existence of guidelines on the issue. It ends by looking at disaster risk reduction, and concluding that urban agriculture can play a role in all aspects of disaster management, which increasingly is urban and hence should take an urban focus.

Disasters and emergencies and the immediate demand for food

There is no shortage of examples that illustrate the graphic and often horrifying impacts that disasters and emergencies can have. Despite the different hazards and geographical settings, many of the impacts at the location where the disaster strikes, and where people seek refuge, are similar, such as food and water shortages, insecurity and a collapse of the normal (urban) functions. The level of vulnerability determines the actual impact of a hazard, and the disaster risk is a function of the intensity of the hazard and the level of vulnerability, often expressed as: *risk* = *hazard* x *vulnerability* (Wisner et al. 2004).

Environmental and natural disasters impact upon millions of people globally in the form of drought, flooding, hurricanes and earthquakes. Unlike natural disasters, many *man-made emergencies* are deliberate and intentional acts that cause significant population movements (internal and cross border). These situations involve an intricate web of volatile and often hostile military and political forces. Disasters can be rapid-onset, such as the 2004 tsunami in South Asia, or slow-onset, the latter building up over a period of months, such as the Ebola outbreak in West Africa, or even years as was the case with the global spread of HIV (human immunodeficiency virus). If the crisis is characterized by conflict, political instability or high levels of violence, it is often referred to as a complex emergency, as is occurring in Iraq and Syria.

In the first decade of this second millennium, *economic crises* have resulted in rising food prices, declining real wages, redundancies in the formal labour market, and cuts in food subsidies, affecting vulnerable people. Reduced public expenditure also has its impact on basic services and infrastructure. As a result, a mix of IDPs, refugees and migrants adds up to the urban poor and resort to non-market (informal sector) livelihood activities, including urban agriculture. Economic crises often have a social or political origin. Probably the best known example of a country adopting a national urban agricultural policy in response to such economic and political constraints is Cuba. Other examples of cities that have promoted backyard gardening, rooftop gardens, institutional and school gardens as a standard component of emergency agricultural response include Harare, Zimbabwe; Jakarta, Indonesia; Lagos, Nigeria; Rosario, Argentina; and Gaza in Palestine.

BOX 15.1: CIENFUEGOS, CUBA

Cuba is often presented as an example of effectively supportive government policies that encouraged urban agriculture. Major national measures were taken in response to the economic crisis in the 1990s affecting the agriculture and food sector, like the conversion of large state-owned farms into new cooperatives, or Basic Cooperative Production Units, and the granting of land to people and organizations to produce food. The National Urban Agriculture Programme started in 1993, and proposed to stimulate food production in available urban and peri-urban spaces, taking advantage of the opportunities offered by the availability of labour and the close proximity between producer and consumer. Within 15 years of implementation, the National Urban Agriculture Programme led the municipality of Cienfuegos to unprecedented levels of production, along with other favourable results.

Source: Socorro Castro 2009.

Global food prices increased over 80% in the period 2006–2008 (RUAF Foundation 2008). Net food-importing countries – such as most countries in Africa – were hit hardest by these rising prices. Although the prices of main commodities have come down, the prices of most food items are still high and often double what they were before the increase. Tackling the complex causes of the food and agriculture crisis requires a comprehensive approach (Hovland 2009), at international, national and local levels. Urban agriculture has a clear role to play in contributing to urban food security. Agricultural production in and around cities reduces food transportation costs, and can improve access to (cheaper) fresh food, thus reducing vulnerability in the poorer sections of the city, while also improving the general urban ecology and environment.

Complex emergencies are frequently found in fragile states. Many of the fragile states, a group of 30 to 50 countries depending on the definition used, are low-income countries characterized by weak state institutions that are largely ineffective, leading to bad governance and corruption. Their economic, social and political institutions have a diminished capacity to absorb shocks and they are therefore more susceptible to conflict and crisis. As the level of vulnerability determines the actual impact of a hazard, the impact will be more extensive in these countries than in countries characterized by security and stability, thus highlighting the increased attention needed for these fragile states.

Refugee camps and settlements

Insecurity in specific regions can continue for many years resulting in refugee camps gradually converting into "shanty towns" or becoming permanent settlements (Adam-Bradford et al. 2009). Many of these "camps" are difficult to distinguish from surrounding towns. Many displaced people will never return to their original "home" areas for a variety of reasons, and would rather seek new livelihood opportunities in and around nearby cities. While displaced people are entitled to support themselves in obtaining food and other basic needs (for instance, in Kenya and Jordan), they are often not allowed to work or fully integrate with the host society, a constraint that is often compounded by a lack of access to land for productive uses. Although displaced people have a certain protective status, the reality on the ground often shows that they do not have the right to use land or undertake productive activities. Refugees are initially completely dependent on aid from the international community. In addition, land is scarce and not always of good quality, hampering the development of gardens.

Dispersed refugees in urban areas

Although camps are clearly different, similarities exist between agriculture in camp settings and in urban (slum) areas. Many refugees become "urbanized" by the experience in these refugee camps, or because they seek refuge in urban areas (Buscher 2011; UNHCR 2012 and 2014) and when they return they do not want to go back to the rural areas. Consequently, an increasing number of refugees live in urban areas, usually in slum areas, or otherwise face similar challenges as the urban poor. More than 50% of the refugees live in urban areas, and at greater distances than before. The majority of these people stay unemployed, live in poor and overcrowded areas, and depend on international and/or non-governmental organizations. The growth of these urban refugees is much larger than the growth in humanitarian financial assistance, and as the average length of displacement is 17 years (Buscher 2011), continued feeding and providing direct services to these populations is not possible. This is increasingly recognized, although still many refugee organizations are not equipped to work in the highly complex urban areas.

Refugees, who migrate to urban areas, are looking for access to better housing, health care, education and economic opportunities, sometimes after having been in camps. They are, on the whole, higher educated and more resourceful, and under the right conditions would be able to become self-sufficient. In Kampala, for example, a study found that most of the urban refugees are educated and self-selection often brings the most entrepreneurial and educated to the cities (Buscher 2011). Most countries and cities, though, are ill equipped to host this large number of refugees. And when the large number of refugees that arrive in urban areas exceeds the ability of local urban authorities to effectively manage their integration, then pressures on services and local resources soon emerge, bringing tensions between the refugees and the host communities.

Furthermore, most host governments are reluctant to allow refugees to work. They fear competition and worry that with jobs and income, refugees will de facto locally integrate, never to return to their countries of origin. It appeared that refugees with cash in pocket and marketable skills are more likely to return home, as was the case with the Liberian Buduburam camp in Ghana (Crowell and Nutsugah 2013). Hence, refugees residing in cities are often very vulnerable as most of them are single women heads of households. This is due to the consequences of the international food crisis, which results in increased unemployment, rising food prices, increasing difficulties in paying rent and lack of access to education and healthcare. But also due to the fact that in some areas, like East Africa, and in countries like Jordan and Lebanon, there are simply too many refugees and the cities cannot cope. An increasing number of them are requesting to be moved to the camp as they are unable to pay rent, or send their children to school.

BOX 15.2: SOMALI REFUGEES IN NAIROBI

Mark Yarnell of Refugees International illustrates the precarious situation of urban refugees as he describes the situation of Somali refugees in Nairobi *(adapted text by the authors):*

> Tens of thousands of refugees from Somalia and elsewhere live in urban centres throughout Kenya, where they are able to provide for themselves, send their children to local schools, and access health facilities. Over the years, Nairobi's Eastleigh developed into one of the most dynamic parts of Nairobi's economy, with shoppers going there from all over the city to take advantage of the competitive prices and range of goods available there. It is a far cry from life in the sprawling Dadaab refugee camp in arid north-eastern Kenya, where over 350,000 Somalis live in tents provided by the United Nations High Commission for Refugees (UNHCR) and remain dependent on monthly food rations. However these days,

> the streets of Eastleigh are unusually quiet. In March, Kenya's Cabinet Secretary for Interior ordered, on the grounds of 'emerging security challenges in our urban centres,' all refugees to report to the Dadaab and Kakuma refugee camps.
>
> *Source:* Mark Yarnell at http://urban-refugees.org/debate/category/non-classe/.

Crisis situations therefore have a higher impact in vulnerable areas and a disproportionate impact on the urban poor, especially women, children and the elderly. Building resilience, or reducing this vulnerability, is paramount. Urban agriculture can play an important role and hence needs to be integrated in disaster mitigation strategies. Mitigation is a collective term for all actions taken prior to the occurrence of a disaster (pre-disaster measures), including preparedness and long-term risk reduction measures. New insights in the field of disaster risk reduction have demonstrated the strong connection between resilience and the sustainability of socio-ecological systems. The costs of restoring communities back to something resembling their original states are much greater than the costs of investing in a community or urban disaster risk reduction programme and increasing its resilience before a disaster strikes.

The role of urban agriculture

Urban agriculture has always been used as a food security strategy during economic and emergency situations. Examples include the extensive "Dig for Victory" campaign in Britain during the Second World War, and more recently "Operation Feed Yourself" in Ghana during the 1970s. Similarly, in many other countries, backyard farming, and institutional and school gardening have all been encouraged during times of food instability.

Urban agriculture, with its emphasis on space-confined technologies, use of composted organic waste and recycling of grey wastewater, offers good options for the provision of fresh vegetables, eggs, dairy products and other perishables to the population of these "new settlements" in addition to generating some income, and other benefits. Growing nutritious crops requires a limited growing period and low investments, and the use (often available) of traditional knowledge and skills and local resources (minimal land of low quality, recycled organic waste and wastewater, local seed, etc.).

Increasingly these potentials of vegetable gardening and other agricultural production activities (e.g., eggs, mushrooms, medicinal herbs, etc.) in protracted refugee situations are being recognized, in addition to the need for higher calorie intake (The Sphere Project 2011). In addition to food, becoming involved in constructive activities may help people regain dignity, hope and self-respect and enhance overall well-being. Home or community gardening activities help increase self-reliance, allowing people to grow their preferred crops and varieties, and can improve their skills and knowledge, while additionally reducing operational costs for humanitarian agencies and potentially contributing to restoring the social fabric of disaster-affected communities. Urban agriculture can play multiple roles in different phases of the disaster management cycle. Instructions for developing and protecting primary food production are given in a number of guidelines, which also contain planning and design recommendations for allocating small plots of land for use as kitchen gardens.

FIGURE 15.1 Cultivation tower (India)

However, in reality NGOs seldom provide such technical assistance but rather resort to the provision of food aid which is often implemented with no exit strategy and thus in the long-term building dependency on food aid.

When developing agriculture-based interventions and projects in urban refugee settings, the following issues should be taken into consideration:

- Physical characteristics of the local setting, such as infrastructural capacities, basic social services (water, sanitation, waste use, health), land availability and energy supply (wood, kerosene).
- Social characteristics, such as IDP/refugee rights, security, social fabric and cohesion (race, tribe, gender), uncertainty, traumas, labour supply (abundant but weakened), and possibility of conflict among refugees and IDPs.
- Food availability, food quality, balanced food basket, culture, income, etc.
- Political issues that can inhibit interventions.

The development of livelihood strategies, including agriculture and animal husbandry, will depend not only on the availability of, and access to, land, irrigation water, seeds and natural resources, but also on freedom of movement. Humanitarian agencies may provide refugees with seeds, tools and, when necessary, technical support, but access to land and common resources is often constrained by the policies implemented by the host country, which may restrict their freedom and mobility. In particular, access to land is limited by the traditional land tenure system and laws concerning landownership and rights of usufruct. Hence the host governments need to take a more positive attitude to the planning and management of refugee camps and settlements as in the case of Uganda (van Rooij and Liem 2009; Betts et al. 2014). Likewise in the process of slum development, attention to increased self-reliance is important. Protecting and supporting livelihoods can be instrumental in safeguarding food security and minimizing relief aid dependency among beneficiaries.

Beneficiaries' interest in agricultural activities may evolve over time, as their immediate needs start to be met. But some may not wish to start growing vegetables as this might trigger the impression that they have to settle at that location for an extended period of time. For many, agriculture still has a permanent character. During the first period of emergency relief, agricultural production is unlikely, but the planning of future production sites must be taken into account in the camp layout or the housing reconstruction plans. We will discuss here the importance of food production versus solely distribution, the role of urban gardening in refugee camps, and the role of urban agriculture for urban refugees.

Food distribution versus food production

Despite some successful examples of small-scale food production in refugee camps, many relief aid strategies still focus on food distribution as the main response mechanism (Adam-Bradford et al. 2009). In a disaster aftermath the emphasis is on fast and effective food distribution. But when food distribution programmes are viewed over the long-term, secondary issues such as food dependency, corruption, and programme costs come into play. Despite being effective for its purpose, i.e., saving life, food distribution remains a highly inefficient food security tool due to high food and fuel prices and often extensive logistical costs. Of course, there are situations when food production is not a viable option, for example when agricultural land is contaminated or mined. Food distribution with no or minor attention for gardening initiatives (not as part of the longer-term strategy) would result in major lost opportunities, as the implementation of food production can play an important role in mobilizing and rehabilitating communities following the impacts of a disaster or emergency.

Therefore, food distribution, as part of immediate relief, should be planned in conjunction with food-producing options, as part of the rehabilitation and development strategies, so that transitions from food dependency to food security can be made at the earliest opportunity and with minimum risk to the beneficiaries. The reasons to support agriculture-related activities in the early stages of the post-disaster phase are numerous, such as the need for fresh and diverse food (in addition to the supply of staple foods).

Refugee camps and settlements

Despite many ongoing conflicts, in some countries there are opportunities to rebuild communities and to facilitate the return of refugees and other displaced populations. This is also still the basic assumption in the political standpoints and hence of refugee strategies (Adam-Bradford et al. 2009). Due to prolonged stay in camps, humanitarian aid is often not enough to sustain basic needs, and refugees are forced to find other ways to support themselves. Refugees make a living through (illegal) trade, small businesses and agricultural production. A typical refugee camp will, after some years, have several visible activities of this nature (Jansen 2009). However, refugees face restrictions that ordinary citizens do not face in conducting business, which makes earning a livelihood difficult. Examples are the restriction of free movement, work permits, and high costs of all kinds of services, especially market information (although many black markets develop). Land is not always of good quality, hampering the development of gardens, while access to this land and water of good quality, as well as seeds, construction material, etc., is also restricted. The United Nations High Commissioner for Refugees (UNHCR) estimates that more than half of the refugee camps in the world are unable to provide the recommended daily water minimum of 20 litres of water per person per day (UNHCR 2012 and 2014). The application of micro-finance in refugee camps is difficult, since many refugees are reluctant to start a business, and repayment is low.

Most refugee camps do not have sufficient food to provide for their populations, and refugees are frequently dependent entirely on humanitarian aid. Besides, the quantity of food is often insufficient and the lack of calorie-rich and nutritious food causes many refugees to suffer from deficiencies in essential vitamins and minerals, which can lead to a variety of diseases. Guidelines do exist and refugees are encouraged to grow their own food in small gardens or sacks (Corbett 2009), ensuring the consumption of some vegetables. These gardens serve as a supplement to food rations, though in most cases refugees are not allowed to sell surplus. For over two decades the official government policy in Uganda is that refugee settlements are designed and planned around agricultural livelihoods. Once a refugee is registered in a settlement, they are allocated a plot of land and issued seeds and tools to farm their plots. In addition, they also receive extension and support in the rearing of chickens and pigs, and the planting of home gardens. Many of the settlements, such as Nakivale, have become so productive they now export crops to local and regional markets (Betts et al. 2014).

BOX 15.3 GUIDANCE ON AGRICULTURAL INTERVENTIONS IN THE SPHERE GUIDELINES

The minimum requirement of surface area per person in a planned settlement is 45 m^2, so a camp for 1,000 refuges would have to be 4.5 hectares (ha). This includes space for household plots, roads, footpaths, sanitation, and other infrastructural inputs, but moreover it also allows for "limited kitchen gardens for individual households" (page 257). On a 4.5 ha site and using an average household plot size of six persons, this would result in the implementation of 166 small kitchen gardens. The Minimum Standards in Food Security and Nutrition provide the bulk of practical guidance for practical agricultural interventions with key aspects being addressed in Chapter 4 Food Security (page 175), which includes three components: 4.1 Food security – food transfers; 4.2 Food security – cash and voucher transfers; and 4.3 Food security – livelihoods. For example, primary production mechanisms should be protected and supported through local capacity building measures and, where appropriate, with the distribution of seeds, tools, fertilizers, livestock, fishing equipment, hunting implements, credit and loan facilities, market information, transport facilities, etc.

Source: The Sphere Project 2011.

During the prolonged period, these micro-gardens, provide livelihood and even income-generating opportunities, but may also contribute to wider social and economic rehabilitation, in protracted camps, and in and around cities, where levels of unemployment and urban poverty may be particularly high.

Refugees may also arrive at a camp or settlement with their own livestock and seeds and, once settled, start their own agricultural activities. Examples include IDP camps in Iraq where Kurdish refugees were keeping goats and sheep in livestock pens built from scrap materials, and growing vegetables and even small plots of wheat which were processed on site and then used for traditional bread-making (Adam-Bradford et al. 2009). In Banda Aceh, many of the survivors from the 2004 tsunami have planted home gardens around their temporary shelters; two years later, these gardens had matured into highly bio-diverse home gardens with multiple layers and, in some cases, with over 30 different crops being grown on small plots of land measuring just 3x5 metres (Adam-Bradford and Osman 2009).

Stimulating small-scale gardens for groups, or community gardening, can also help build different forms of capital (social, human, financial, economic, physical, natural, etc.), and contribute to longer-term resilience. To be able to build sustainable, shock-resistant communities, the active engagement of people themselves throughout the process is crucial. In cases where food growing systems are introduced as project activities, it is important to use participatory processes to ensure the technologies are appropriate to the local context and to the culture of the beneficiaries themselves. Rather than implementing what may become complicated technical solutions, such as hydroponics or even rearing livestock, efforts should be directed at building the foundations first, such as developing compost-production plants utilizing camp organic waste that will then feed into horticultural projects or planting fodder trees as camp windbreaks, which will then increase availability of fodder before livestock are introduced (SAFIRE and UNHCR 2001).

Also the use of grey water is propagated, although this needs to be done with care, needs risk minimization strategies and proper management (Dalahmeh and Almoayed 2009). These initial activities can also be used to galvanize community-based groups, share knowledge and identify early innovators or experienced farmers who can then serve as community role models using demonstration garden and livestock sites.

Insecurity in specific regions can continue for many years. Refugee camps tend to gradually convert into "shanty towns" or become permanent settlements. Many of these "camps" are difficult to distinguish from surrounding towns. Many displaced people will never return to their original "home" areas for a variety of reasons, and would rather seek new livelihood opportunities in and around nearby cities. More than 50 million people live in camps or temporary settlements. The average lifespan of a refugee camp is close to 20 years, and the average stay of a refugee in such a camp is up to 12 years (UNHCR 2012 and 2014). It is clear that a new and integrated approach to designing and managing these camps is required. Consequently, the status of refugees and IDPs needs to be improved and implementing agencies need to give adequate attention to human rights and entitlements, such as access to land for gardening and farming.

BOX 15.4 REFUGEE CAMPS IN JORDAN

More than 50 million people in the world live in camps or temporary settlements. The average lifespan of a refugee camp is close to 20 years, and the average stay of a refugee in such a camp is up to 12 years. Various organizations are discussing and working on a change in humanitarian aid, and are stimulating innovation, and developing an integrated approach in designing, managing and financing refugee camps.

The Al Za'atari camp in northern Jordan opened in mid-2012, and it is unknown how long the community will have to live here. Currently there are around 100,000 refugees, more than 50% children, who live in close to 30,000 tents and caravans. Its envisaged lifespan is five years, costing overall 14 million Euros a month (already half a million on electricity). Infrastructure is already deteriorating, for instance the WASH (water, sanitation and hygiene) centres that did not meet cultural contexts were destroyed and need rehabilitation.

The refugee community is making the best of available opportunities, innovating while trying to find solutions to their day-to-day struggle. Governance structures are emerging, childcare and theatre are organized, and informal commerce has started: the market of Al Za'Atari is the fastest growing in the region.

More efficient, effective and sustainable planning is required, based on the local situation and a vision on (urban) development of the entire Mafraq Region. Linkages need to be made between the ever-increasing urban refugees of the region of Mafraq and the huge impact this has on the host communities. The efforts of the many relief organizations and private initiatives need to be coordinated and formed into multi-stakeholder planning processes with longer-term perspectives, with the objectives of building resilient settlements.

The former UNHCR camp commander of Za'Atari invited many key experts in the world to bring innovative solutions for the transition from emergency aid into development. The Dutch Government asked VNG-International and the City of Amsterdam to step in. The Dutch mission operates via the Jordan Government and UNHCR. With integrated planning as an overarching theme, the project focuses on solutions in key aspects as transport, WASH, waste, ambulance, food and governance. Planning is addressing and connecting three levels of scale: *Region, Camp and Shelter*. This is based on the philosophy that any confrontation between refugees and host communities causes problems but this can also lead to local solutions. The aim is to deliver flexible planning instruments, supporting expertise and design assistance, with process-driven participation and implementation that ensures project activities are connected with local procedures and social cultural patterns, and facilitate community building and self-reliance.

Planning investigates scenarios which both the area of Mafraq and the camp might overcome in the near future. At any scale, key drivers are resources, production, connectivity and existence. Key design principles are synergy, adaptability and prototype. Solutions and interventions are developed together with stakeholders for the short-, middle- and long-term: direct interventions, development and empowerment.

Sources: Oral information by AlZaatariWorks, City of Amsterdam and RUAF Foundation.

Dispersed refugees in urban areas

An increasing number of refugees live in urban areas, usually in slum areas, or otherwise face similar challenges as the urban poor. More than 50% of the refugees live in urban areas, and at greater distances than before (UNHCR 2014). The majority of these people stay unemployed, live in poor and overcrowded areas, and depend on international and/or non-governmental organizations. And many refugees become "urbanized" by their experience in camps (Buscher 2011).

Organizations like UNHCR and the International Committee of the Red Cross (ICRC) are changing their policies, but host government legislation and NGO services are slowly adapting to the ensuing situation (and restrictions of movement, access to land and developing businesses still occur). Creating economic opportunities for refugees in urban areas is a challenging and complex undertaking. There are many similarities in working with urban refugees and the urban poor, but as mentioned, also differences. In addition, hostilities may arise between refugees and the local community.

A first step is bringing parties together and to lobby and advocate for recognition of refugee rights in local policy and practice. Support is required to empower vulnerable refugee groups to build small businesses to support themselves and other vulnerable refugees in the community. For this, (short-term) financial assistance is required, until they become more self-reliant. Identification of, and facilitating access to, existing business development services could build refugees' financial literacy and entrepreneurial skills (Betts et al. 2014).

While economic programming in urban environments is complex and local markets and opportunities are often limited, starting with and building on what exists both within the refugee populations and with the local economic service providers would facilitate better practices and ultimately should lead to better outcomes (Buscher 2011). The ability to provide for themselves allows urban refugees to address their own needs without substantive further assistance from the humanitarian community, and thereby also restore some of the refugees' dignity. Thinking in urban development would use humanitarian assistance more effectively and sustainably – supporting local economic development or improving government health and education facilities.

BOX 15.5 ENHANCING URBAN AGRICULTURE IN THE GAZA STRIP

Gaza Strip is a physical, social and economic environment that is almost unique in the world and that is determined by a political deadlock where access to land, sea, water, markets, and human resources is restricted by an intransigent Israeli blockade and isolation politics. Since the second Intifada (2000–2001), access and mobility restrictions have been imposed on Gazans. Since 2007, the Gaza Strip has been even more tightly closed off, resulting in exceptional conditions where both imports and exports of goods are very restricted and irregular. Coupled to the closure and destruction of the tunnels that allowed the traffic of goods to and from Egypt, and a high population growth, the resulting complex socioeconomic situation has dramatically increased poverty and unemployment in the Gaza Strip.

As 90% of all agriculture in Gaza can be considered urban or semi-urban, there is increasing national recognition for urban agriculture to be promoted as a complementary strategy for enhancing urban food security and nutrition, income and employment generation to improve the market. There are production opportunities and demands for locally produced, good-quality produce. However, urban agriculture and especially more market-oriented urban agriculture in Gaza is challenged by various constraints, such as limited access to land and low quality of service providers.

Source: authors.

Guidelines and frameworks

Several frameworks and guidelines have been developed to integrate food productions systems in the planning and design of urban agricultural intentions in post-disaster and emergency situations.

The Livestock Emergency Guidelines and Standards (LEGS) provide a set of international guidelines and standards for the design, implementation and assessment of livestock interventions to assist people affected by humanitarian crises. The guidelines aim to improve the quality of emergency response by increasing the appropriateness, timeliness and feasibility of livelihoods-based interventions and can be found at: www.livestock-emergency.net/.

Instructions for developing and protecting primary food production are given in the Sphere Project Guidelines (The Sphere Project 2011), which also contain the planning and design recommendations for allocating small plots of land for use as kitchen gardens. These Sphere Project Guidelines are often used by donors to indicate the minimum required standards in the development of humanitarian inventions and programmes and have become an important and influential tool for the justification of programme funding. In addition, some UNHRC handbooks

FIGURE 15.2 Rooftop garden, Gaza Strip

have been developed that address the environmental management of refugee camps and settlements with additional livelihood guidelines addressing agriculture, forestry and livestock (UNHCR and CARE 2002 and 2005; UNHCR 2012).

In addition, various organizations like ICRC, the UN Food and Agriculture Organization (FAO), the International Water and Sanitation Centre (IRC), etc., have developed manuals. Applying a combination of these frameworks and guidelines would ensure the participatory design and implementation of appropriate interventions that maximize the benefits of integrating urban food production in emergency responses while minimizing the associated environmental risks. However, the implementation in the harsh reality of refugee situations is a different ball game altogether.

BOX 15.6 THE SPHERE PROJECT GUIDELINES

The Sphere Project guidelines consist of a Humanitarian Charter and Minimum Standards in Disaster Response that are presented in a book format aimed to assist humanitarian relief workers in delivering high-quality and an accountable disaster response (The Sphere Project 2011). The initiative was launched in 1997 through an international collaboration that includes the Red Cross and Red Crescent movements. The collaboration currently consists of over 400 organizations in over 80 countries which have all adopted the Sphere consensus, including donor organizations which now request that emergency funding proposals be written in the context of the Sphere Guidelines.

The combination of food production with food distribution is clearly advocated in The Sphere Project guidelines, which is a handbook designed for use in disaster response situations but has an equal role in disaster preparedness and broader disaster risk reduction programmes, applicable in a range of scenarios, including natural disasters as well as armed conflict in both slow-onset and rapid-onset situations, and urban refugee situations. The Sphere Handbook provides appropriate guidance for agricultural interventions in a range of the key sectors from food security to physical planning of settlements. Important guidance notes are also provided on the viability of primary production, technological development, improving choice, timeliness and acceptability of primary production, seeds, local purchase of inputs, monitoring usage and unforeseen or negative effects of inputs. The guidance notes also address complex issues to ensure programmes are well designed, appropriate to local conditions and sustainable.

Source: The Sphere Project 2011.

The Sphere Handbook highlights that food security responses should aim to meet short-term needs, "do no harm", reduce the need for the affected population to adopt potentially damaging coping strategies, and contribute to restoring longer-term food security. Thus in urban areas a priority may be the re-establishment of normal market conditions, but equally important are small kitchen gardens and primary production methods: such strategies may be more appropriate than food distribution because they uphold dignity, support livelihoods and thereby reduce future vulnerability (The Sphere Project 2011).

Integrating gardening in slum upgrading or in the design and development of new neighbourhoods will support the development of more food-secure and inclusive human settlements. Even in a slum or a densely built settlement, there is space for, and presence of, food growing. Agriculture can be integrated in lane upgrading by leaving small stretches of soil for growing on either side of the road or by applying vertical growing and container gardening along lanes.

Agriculture can also be integrated in housing improvements and design. For instance, housing should cover no more than 50% of a lot area to provide adequate space for growing food. Exterior house walls can be used for agriculture and all windows could have a shelf or window box to accommodate container gardens. Fencing could support growing and rooftops can be designed for water harvesting. Furthermore, the productive use of public areas (multifunctional parks, roadsides, flood zones, waterfront/canal areas) within slums can also be utilized. Urban agriculture can also be integrated in the sanitation systems of a settlement through wastewater recycling for gardening or organic solid waste recycling for growing vegetables.

In the longer-term, gardening also generates income and improves associations and linkages with other refugees or local communities, while contributing to the broader development of the area and building resilient cities, where refugees are hosted by stimulating local markets and trade. In addition, natural resources can be conserved and protected by promoting sound agricultural practices and introducing waste-recycling systems appropriate to the local conditions. In this context the project aims may start initially as conflict-prevention, with secondary objectives including improvements in environmental sanitation and food production. Generating livelihoods and youth employment has been identified as a key strategy to prevent the radicalization of the youth and this is not only important in refugee camps but also with refuge and host populations in many urban centres, particularly in North and East Africa and in the Middle East.

Despite the above-mentioned guidelines and calls for innovative local food production solutions, the mainstreaming of urban agriculture in disaster and emergency response settings is still woefully inadequate, thus resulting in lost opportunities to protect and promote, and when necessary rehabilitate, local food production systems, thus building resilience at a wider local level.

Integrating urban agriculture and planning for resilience

Insecurity in specific regions can continue for many years. Refugee camps gradually convert into "shanty towns" and are better seen as becoming permanent settlements, allowing planning and using resources accordingly. Many displaced people will never return to their original "home" areas for a variety of reasons, and would rather seek new livelihood opportunities in and around nearby cities. Urban agriculture can play an important role in all aspects of the disaster management cycle and is a multifunctional policy instrument and tool for practical application; it is valid for integrated design and management of refugee camps, as well as in creating resilience in urban areas.

Various approaches in preventing and coping with disasters have developed in the course of time. In the text below two project-based disaster risk management approaches are briefly discussed, which are already applied to urban and peri-urban areas and are including urban agriculture in planning for resilience and disaster risk management programmes.

Linking relief, rehabilitation and development

As illustrated in the disaster management cycle (see Figure 15.3), emergency interventions are still too often delivered in isolation and fail to address longer-term development goals. The need to fill the gap between humanitarian aid and development is frequently debated and is addressed in an approach called Linking Relief, Rehabilitation and Development. The European Union (in its European

Commission Humanitarian Aid (ECHO) programme) emphasizes the importance of this linkage. The primary objective of LRRD is to address the gaps between emergency relief and longer-term development aims and objectives. In this LRRD process attention to self-reliance is also important: this is the capacity of a community to produce, exchange or claim resources which are necessary to ensure its sustainability and resilience against future disasters.

The introduction of the concept of sustainable livelihoods also moves away from perceiving disaster victims and/or refugees as vulnerable people entirely dependent on external relief aid. For example, a livelihoods approach in emergency settlement camps focuses on strategies that facilitate beneficiaries to meet their basic needs, while also identifying the constraints that prevent them from enjoying their (human) rights and thus developing their livelihoods. The concept of human security finally promotes a shift from focusing on state security (i.e., mainly on the protection of state territory), to focusing on human issues and rights (e.g., the right to food, and the right to shelter).

In doing so, it widens the scope of interventions from governments and international organizations and addresses issues such as increasing access rights of displaced people to land, rather than just addressing food security and human protection. Human security further pays attention to the array of issues behind the complex international causes of population movements, explaining the causes and linking them to development and poverty. Increasingly, there is an emphasis on preventive strategies, such as the development of good governance.

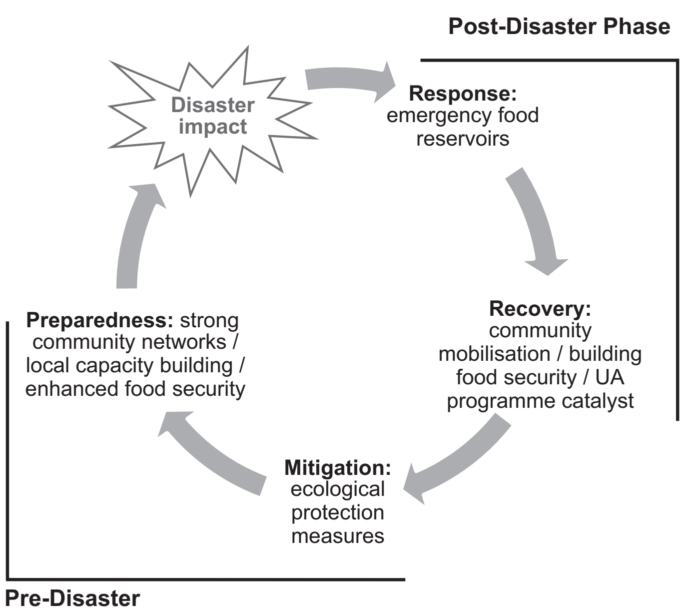

FIGURE 15.3 Disaster management cycle with linkages to urban agriculture

Source: authors.

The LRRD process involves a thorough context and political analysis with the objectives of identifying the root causes of vulnerability and poverty. The process also works directly with local institutions to build capacity so that inequality and access to resources can be addressed through continued programming and intentions. Then the linkages between relief and long-term development can be made. For urban agriculture this starts by recognizing the practice as a formal urban process and identifying the positive role it can play; this can then lead not only to policies to promote safe practices but also to practices that incorporate risk reduction measures.

BOX 15.7 THE ROLE OF URBAN AGRICULTURE IN REBUILDING LIBERIA

Since the end of the war that raged from 1989 to 2003, Liberia has suffered from chronic food insecurity. With much of its agricultural sector destroyed, over 40% of Liberians are still estimated to be food insecure. As the economy slowly recovers, the urban population is growing quickly, but a generation without education is struggling to survive and prosper amidst the wreckage of devastated infrastructure. Access to local food is paramount. This need has been aggravated by the 2014 Ebola crisis.

In Greater Monrovia, over 5,000 households are engaged in urban and peri-urban agriculture, mostly for domestic consumption (WHH/RUAF 2012). Urban farmers (75% of whom are women) generally produce vegetables and fruits, with staple crops such as rice and cassava produced on larger open spaces and swamps in peri-urban areas. But there are no clearly defined areas for urban agriculture and land rights are uncertain. Restaurants, hotels, mining companies, supermarkets and hospitals are increasingly sourcing urban agricultural produce, but improved storage facilities and post-harvest technologies are needed. Farmers also lack reliable access to proper tools, good seeds and formal credit systems.

Urban agriculture provides a strategy to help reduce urban poverty, improve food security and enhance waste management. But urban agriculture also plays a wider role in developing the city of Greater Monrovia, as well as in smaller towns like Gbarnga and Tubmanburg. Women play a critical role in the production and processing sectors and are often dynamic entrepreneurs. Therefore improving women's involvement in and access to credit, farming inputs, extension services and business opportunities must be prioritized.

RUAF Foundation, with Welthungerhilfe, collaborated with Monrovia Municipality and other stakeholders to promote urban agriculture, to develop and strengthen linkages and to support policy change, by facilitating a multi-stakeholder policy formation and action planning (MPAP) process and supporting urban farmers and processors.

Source: RUAF Foundation.

Disaster risk reduction (DRR)

Disaster risk reduction (DRR) is a systematic approach to identifying, assessing and reducing the risks of disaster. A DRR programme can be implemented at any time so that it differs from LRRD in that it may not be making strong linkages to any relief programme, although DRR programmes are also sometimes implemented in the aftermath of a disaster or emergency. DRR is a planning and implementation tool that addresses the practical issues of vulnerability through the building of resilience and local capacity to respond to natural hazards and anthropogenic disasters (Pelling and Wisner 2009). The United Nations International Strategy for Disaster Reduction (ISDR 2004) defines disaster risk reduction follows:

> The conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development. The disaster risk reduction framework is composed of the following fields of action:
>
> - Risk awareness and assessment including hazard analysis and vulnerability/capacity analysis.
> - Knowledge development including education, training, research and information.
> - Public commitment and institutional frameworks, including organizational, policy, legislation and community action.
> - Application of measures including environmental management, land use and urban planning, protection of critical facilities, application of science and technology, partnership and networking, and financial instruments.
> - Early warning systems including forecasting, dissemination of warnings, preparedness measures and reaction capacities.
>
> *(ISDR 2004: 23)*

Resilience is a measure of a household, city or nation's ability to absorb shocks and stresses. Enhancing the role of urban agriculture includes not only improving linkages to food security but also income and environmental management (see other chapters on the linkages to urban planning and climate change). Urban agriculture itself is characterized by innovation and adaptation to specific urban needs. Examples are micro-gardens, which can provide an emergency food source in the context of disaster risk management; green rooftops, which represent a built environment adaptation to climate change impacts; planting of trees, which serve as green "lungs" contributing to improved air quality; and rainwater harvesting systems, which can help lessen the effects of flooding. Urban agriculture can keep environmentally sensitive and dangerous urban lands from being used for illegal residential development. It mitigates the adverse effects on the urban poor of financial and food crises through job creation; offers opportunities for small-scale income generation; increases food security and enables self-sufficiency; and improves nutrition and health.

DRR programmes can build capacity of urban farmers to take risk reduction measures that are integrated into their urban farming-based livelihoods, and building of local resilience in vulnerable urban communities. However, urban agriculture, in addition to other green urban infrastructures, can make wider contributions to disaster risk reduction at the landscape level through urban land-use planning and zoning. This would include the allocation of marginal land, such as steep slopes, riverbanks and flood-prone areas to agricultural land use. It is also proven that once secure land tenure is issued to urban farmers, then they become excellent land stewards who prevent urban encroachment from informal settlements and commercial enterprises. Thus marginal land such as steep slopes and flood-prone areas remain free from settlement. In addition farmers can then be supported to adopt specific land management techniques that then reduce the risk of landslides and floods through the adoption of risk reduction measures such as the planting of trees on contours, etc.

Enhancing the role of urban agriculture in building resilience

Experiences show that agriculture is not only a survival strategy for displaced people to obtain food on a temporary basis, but also a valuable livelihood strategy for those who settle permanently, and for those who eventually return to their home cities or countries. Many displaced people, both in camps and in and around cities, engage in agriculture for subsistence and market production. Increasingly, international organizations and relief agencies include agricultural production as part of their development strategies, as expressed in various guidelines. And although there are still various obstacles for refugees in terms rights and access, local and national authorities are not only increasingly allowing it but also, intentionally, supporting it.

Urban agriculture can play an important role in all aspects of the disaster management cycle and is a multifunctional policy instrument and tool for practical application. It is also valid for integrated design and management of refugee camps, as well as in creating resilience in urban areas.

Policies and interventions to promote agriculture by refugees need to be included in planning and design. At the camp level this should include the following:

a. Adequate camp and slum arrangements (such as the Sphere Project guidelines).
b. Promotion of low-space crops and animal production and water saving technologies.
c. Organizational support and training, both in technology and marketing, as well as in reintegration and rehabilitation activities.
d. Provision of inputs and financial support (which becomes especially important in longer-term settings, and when farmers move towards producing for the market) when displaced persons want to move from self-consumption to market production.

e. Maximize the safe utilization of organic wastes for compost production and grey water for the irrigation of gardens and trees.

Income generation from agriculture-based livelihoods will play an increasingly important role in developing economic self-reliance amongst refugee populations, and will help create an effective transition between emergency relief and longer-term development. It is likely that the availability of capital equipment or loan capital for small businesses will improve the ability of displaced people to pursue livelihoods and food security, and it is likely that the benefits will eventually also reach the host community.

The choice of food relief strategy must be made to suit the conditions on the ground rather than external factors such as donor influence, NGO technical expertise or lack of access to basic, appropriate food aid. Food distribution must be planned in conjunction with food-producing options so that transitions from food dependency to food security can be made at the earliest opportunity and with minimum risk to the beneficiaries that the food distribution supposedly serves.

Facilitating the change from emergency relief operations towards rehabilitation, sustainable development (by building resilience) requires innovative approaches and changes in current rules and legislation. It requires putting in place participatory mechanisms, such as farmer or gardening groups and farmer field schools, bringing refugees and host communities together, and enhancing a sense of community. Multi-stakeholder processes involving public and/or non-government actors can help build governance, which is especially important in fragile states that lack government capacity and willingness to perform key functions and services.

Growing food in camps and cities, when appropriate to the local conditions, reduces dependency on external food supplies, improves the availability and access to more nutritious food, and in the longer term may increase the resilience of people and cities. Both refugee camps and urban refugee settlements and slums require integrated planning approaches with a long-term perspective, and doing so would make humanitarian assistance more effectively and sustainably.

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ABOUT THE RUAF FOUNDATION

The RUAF Foundation (Resource centres on Urban Agriculture and Food security) is an international network with member organizations in Africa, Asia, the Middle East, Latin America and Europe, together constituting a leading centre of expertise in the field of (intra- and peri-) urban/city region food and agriculture systems research, planning and development. The RUAF Foundation is a not-for-profit organization legally registered in the Netherlands and in operation since 1999.

The RUAF Foundation seeks to contribute to the development of resilient, equitable and healthy urban/city region food systems, in the global South and North, by facilitating awareness raising, knowledge generation and dissemination, capacity development, policy design and action planning.

The RUAF Foundation has assisted local governments, urban producers and consumers organizations, local entrepreneurs and social enterprises, non-governmental development organizations (NGDOs), local universities and other stakeholders in the urban food system in over 30 countries.

In addition, we support advocacy, sharing and learning activities at national and international levels. The RUAF Foundation has implemented international projects in cooperation with the EU, FAO, UN Habitat, World Bank, ICLEI, DGIS, IDRC, Sida, GTZ and other international and national organizations as well as with NGOs like CARE, Welthungerhilfe, Action contra la Faim and Cordaid.

The RUAF is publishing the *Urban Agriculture Magazine,* books, technical and methodological guidelines and working papers on urban agriculture and city region food systems reaching about 800,000 readers globally today.

More information on the activities of the RUAF Foundation is available on the website: www.ruaf.org. The website also provides access to all RUAF publications, an online bibliographic database on urban agriculture and various other resources (manuals, policy documents, etc.).

ABOUT THE INTERNATIONAL WATER MANAGEMENT INSTITUTE (IWMI)

IWMI is a non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries. It is headquartered in Colombo, Sri Lanka, with regional offices across Asia and Africa. IWMI is a member of CGIAR, a global research partnership for a food secure future and a long-term partner in the RUAF network.

IWMI's Mission is to provide evidence-based solutions to sustainably manage water and land resources for food security, people's livelihoods and the environment.

Most of IWMI's research on urban and peri-urban agriculture takes place within its research division on "Resource Recovery, Water Quality and Health", which aims at a better understanding of rural-urban resource flows and competition, the safe recovery of water, nutrients and energy from domestic and agro-industrial waste streams, related drivers and business models, and the support of ecosystem services under urban pressure.

IWMI works through collaborative research with many partners in the North and South. The research division on Resource Recovery works under the CGIAR programme on Water, Land and Ecosystems closely with the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), United Nations University (UNU), the Water and Sanitation Program of the World Bank, and many national and international partners across the globe, ultimately targeting development experts, investors and other stakeholders in the research for development continuum.

IWMI staff authored or co-authored only in the domain of urban agriculture and/or wastewater use nearly 400 publications from peer-reviewed journal articles to textbooks, videos and reuse manuals.

More information on the work of IWMI is available at www.iwmi.cgiar.org.

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