Chapter 26
Urbanisation, Nutrition and Food Security: A Climatological Perspective

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Abstract In this chapter the effects of climate change on food production are considered with particular reference to urban agriculture and the associated impacts on food security. The value of urban agriculture to the health and nutrition of developing and developed countries is described. The current status of related research by international agencies is outlined and their omissions highlighted. Proposals are made as to how theses overlooked areas of research might be addressed.

Keywords Urbanization • Climate change • Food production • Food security • Health • Nutrition

26.1 Introduction

To climatologists, nutritional security is dominated by the impacts of weather and climate on food systems. With growing urbanisation around our metropolitan cities and regional centres, extreme weather events such as tropical cyclones impact directly on agriculture and on the logistical distribution of food.

Drought affects human life and health as well as impacting dramatically on the sustainable development of society. It represents a pending danger for vulnerable agricultural systems that depend on the occurrence of rainfall, the security of water supply and the integrity of reservoirs. Developed countries are affected, but the impact is disproportionate within the developing world. Drought, especially when it results in famine, can change the life and economic progression of developing nations and stifle their development for decades. *A holistic approach is required to*

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understand the phenomena, to forecast catastrophic events such as drought and famine and to predict their societal consequences.

In the Food Security recommendations of the Rio+20 Forum on Science, Technology and Innovation for Sustainable Development, held as a preparatory scientific meeting to the 2012 UN Conference on Sustainable Development, one of the recommendations states that scientists need "To understand fully how to measure, assess and reduce the impacts of production on the natural environment including climate change, recognising that different measures of impact (e.g. water, land, biodiversity, carbon and other greenhouse gases, etc.) may trade-off against each other…".

The International Union of Geodesy and Geophysics (IUGG) is leading a consortium of international scientific unions to examine weather, climate and food security (WeatCliFS) as well as to look at the interaction of food security and geophysical phenomena. The following fundamental question underpins WeatCliFS: *What technologies and methodologies are required to assess the vulnerability of people and places to hazards [such as droughts that lead to famine] – and how might these be used at a variety of spatial and temporal scales?*

This chapter will consider the potential effects of climate change on urban agriculture specifically and the resulting impacts on food security.

26.2 Urbanisation and Food Security

26.2.1 Urbanisation, Food Security, and Health

Urbanisation is a major driver of land cover change worldwide (Grimm et al. 2008; McDonald et al. 2008) and has large effects on the biophysical and socioeconomic landscape. It is estimated that >60 % of the global population will live in urban areas by 2030 (United Nations 2006), and urban planners are increasingly concerned with food security in cities (Aubry et al. 2012). Many cities contain 'food deserts', areas where access to fresh produce is limited due to reduced proximity to markets, financial constraints, or inadequate transportation (ver Ploeg et al. 2009; Thomas 2010) thereby negatively affecting the health of urban residents (Shaw 2006).

Various actions can improve the health and sustainability of cities (Beniston and Lal 2012), especially in food insecure and under-served communities (Alig et al. 2004). The United Nations Development Programme's (UNDP) review of urban food supply around the globe has indicated that local production increases nutrition, enhances food security, and creates employment opportunities for communities (Smit et al. 1996), and studies have shown that those who participate in urban food production have more adequate nutrition compared to community members who are not involved (Alaimo et al. 2008; Zezza and Tasciotti 2010). Indeed, interest in urban agriculture has escalated due to the motivation to address food insecurity and childhood obesity issues in disadvantaged urban neighbourhoods (Yadav et al. 2012).

Urban agriculture can produce significant amounts of food for urban citizens and have a large effect on urban nutrition and health. Urban agriculture activities are broad and diverse and can include the cultivation of vegetables, medicinal plants, spices, mushrooms, fruit trees, and other productive plants, as well as the keeping of livestock for eggs, milk, meat, wool, and other products in both urban and peri-urban areas (Lovell 2010). Currently, urban food production systems provide an estimated 15–20 % of the global food supply through urban agriculture (Smit et al. 1996; Hodgson et al. 2011), yielding 2–7 kg m^{-2} depending on crop conditions (Beniston and Lal 2012). For example, urban agriculture provides 60 % of the vegetables and 90 % of the eggs consumed by residents in Shanghai (Bhatt and Farah 2009), 47 % of produce in urban Bulgaria (Premat 2005), 60 % of vegetable produce in Cuba (Premat 2005), and 90–100 % of the leafy vegetables in poor households of Harare, Zimbabwe (Mougeot 2005). Such local food production has been important in maintaining the health and wellbeing of residents in these cities.

26.2.2 Vulnerability to Climate Events

Climate variability and extreme climate conditions have increased in frequency in the last century (Porter and Semenov 2005). Figure 26.1 shows the number of climatological, meteorological, hydrological, geological and biological disasters recorded in the EMDAT database of disaster trends from 1980 to 2012. Extreme and variable climate conditions, such as stronger and more irregular precipitation or increased temperature, lead to significant declines in crop yields and crop stability (Lansigan et al. 2000; Olesen and Bindi 2002; Wollenweber et al. 2003). Unfortunately, despite the extreme impacts of climate conditions on agroecosystems and the broad implications for food supply and production, climate variability and climate extremes are rarely studied outside of rural agroecosystems. Specifically, there is a large gap in research on climate effects, and especially the effects of extreme climatic effects such as tropical storms on local urban food production. This is of particular concern given that urban landscapes frequently exhibit more extreme climate impacts than rural areas due to increased impervious land cover.

A number of environmental changes that have already come with urbanisation and affect the agronomic conditions necessary for food production (Pickett et al. 2001; Kaye et al. 2006) include changes in patterns of water availability, nutrient supply, soil degradation, and pest pressure affecting crop growth in urban areas (Eriksen-Hamel and Danso 2010). Extreme climate events add another layer of complexity affecting local production. However, urban agriculture systems may provide services that help regulate climate impacts. For example, many private and community gardens provide storm attenuation services to the urban landscape by decreasing the amount of impervious surface in cities. In German cities, allotment gardens used on green belts have been shown to facilitate drainage and reduce local flooding from storm events by allowing for a greater infiltration potential of precipitation (Drescher et al. 2006). In contrast, hard paving increases impervious surfaces,

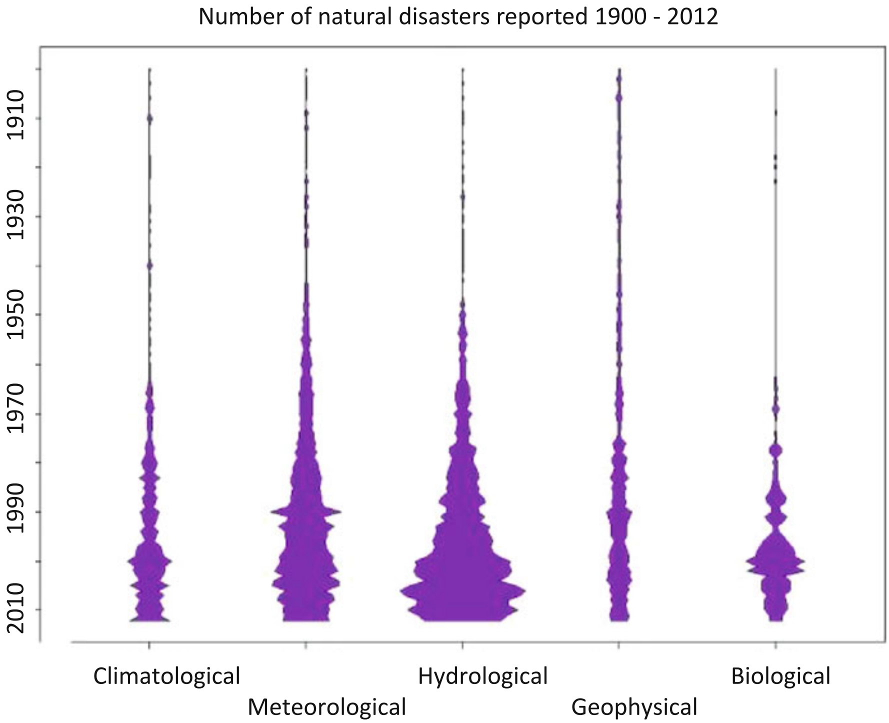

Fig. 26.1 Number of climatological, meteorological, hydrological, geological and biological disasters recorded in the EMDAT database of disaster trends (http://www.emdat.be/disaster-trends)

and in Leeds, United Kingdom (UK), increased hard paving in residential front gardens has been linked to more frequent and severe local flooding (Perry and Nawaz 2008).

Little is presently known about the effect of climate events on urban food production or the resilience of urban agriculture and urban food supply to extreme climate conditions (Eriksen-Hamel and Danso 2010), however, considering the increasing incidence of extreme climate events in many cities, and the potential threat to local food production, this presents an important area of future research to protect food access within cities.

26.2.3 Requisite Services

The wide range of urban agriculture types allows for urban agriculture systems to provide a broad variety of services to the city and to play a significant role in improving food security around the world (Smit et al. 1996; Pearson et al. 2010).

Two types of services are important to urban residents, especially in poor and under-served communities:

(1) ***Provision of improved nutrition***: Providing better nutrition to local residents by improving access to nutritious foods such as fruits, vegetables and medicines that may not be otherwise available. This will have a large impact on the health of local residents.
(2) ***Storm attenuation***: The additional green space infrastructure provided within urban food gardens may help protect urban residents and crop production from the damaging effects of storms (e.g. rain and wind damage, flooding).

There is a great diversity of food production available within cities, and different management methods will have different levels of service provision. The different types of urban food production systems include, but are not limited to, allotments gardens, community gardens, rooftop gardens, community orchards, as well as private gardens in household lots (McLain et al. 2012). It is expected that these various types of gardens will have different abilities to provide health/nutrition services and storm attenuation services.

A number of urban planners, architects and building designers are incorporating schemes for advanced urban agriculture in their current developments through various forms of Vertical Farms (Despommier 2010).

In regards to health/nutrition services, the various types of gardens may provide a good diversity of fruit, vegetables, proteins, and medicines that impact on local health and nutrition. For example, in Santarem, Brazil, a total of 98 plant species were identified in 21 sampled urban gardens and included a large diversity of fruit trees and shrubs (comprising 34 % of garden cover), ornamental plants (10 %), vegetable/herb plants (13 %), and medicinal plants (45 %) (WinklerPrins 2002). In another example from Leon, Nicaragua, 293 plant species belonging to 88 families were recorded across 96 surveyed patios/home gardens, ranging in habit and taxonomic origin (González-García and Sal 2008). In Toronto, surveys in community gardens showed that besides the typical local vegetables (cabbage, tomatoes, peppers, and eggplant), farmers grew an additional 16 vegetable crops to supply the local community with foods that were difficult to find in local grocery stores, including specialty, Asian, Indian, and Ethiopian vegetables (Baker 2004). Such studies point to the need to provide culturally appropriate food to communities in order to maintain health and nutrition. In their discussion of food security the FAO (n.d) note that the provision of a greater diversity of produce is critical to food security.

In regards to the second service, storm attenuation, resilience to climate events may increase by providing different levels and types of storm attenuation and water storage services through green infrastructure. Cities with vegetation, trees especially, intercept intense precipitation and hold water temporarily within their canopy, thus reducing peak water flow, easing demand on storm drains, reducing flooding, and minimising flood damage (Xiao and McPherson 2002). If developed in urban gardens, the green vegetation can contribute to climate resilience for the city as well as increasing the resilience of local gardens to storm damage. For example, tropical home gardens in and around cities have stratified vegetation similar to those seen in multi-stratified agroforestry systems (Moguel and Toledo 1999), and such systems have been shown to protect crops from storm damage when compared to systems with less canopy cover (Philpott et al. 2008). Many private and community gardens also provide storm attenuation services to the urban landscape by decreasing the amount of impervious surfaces in cities. In addition to the food supply, urban agriculture and even gardens also supply physical exercise and improved social contact for residents who might otherwise be very isolated even in a crowded city.

26.3 International Co-operation

As a general rule in relation to disasters, a major difference between the response in developing countries and developed countries is that in developing countries, fatalities dominate. In developed countries, infrastructure and property losses dominate. In relation to food issues, a major disaster in a developing country, such as a large scale drought, wildfire, or extensive flood has the potential to lead to famine whereas an analogous disaster in a developed country will lead to price increases (Fig. 26.2).

26.3.1 Future Earth

'Future Earth', previously known as the Earth Systems Science Partnership, is a major new initiative of the International Council of Science (ICSU) that brings together the existing work of four interdisciplinary programs – the International

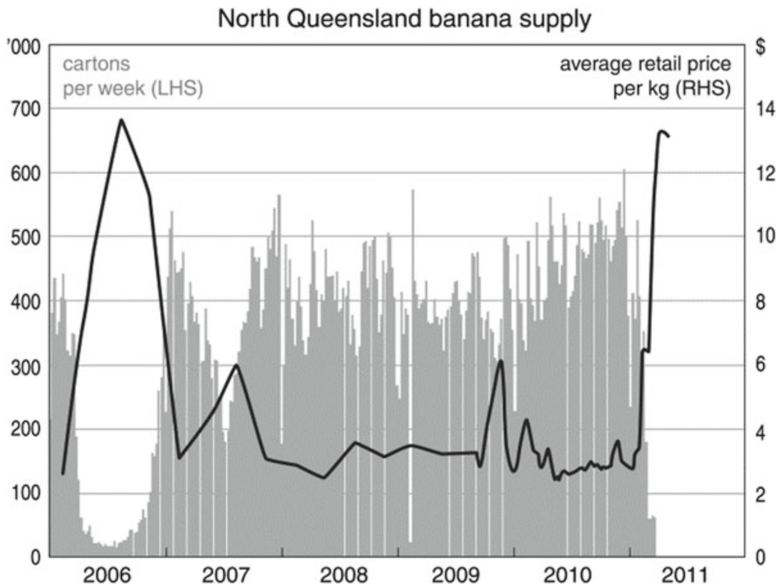

Fig. 26.2 Graph of the banana supply and banana price from the north eastern part of Australia demonstrating the sharp price rises in banana price following Tropical Cyclones Larry (*left*) and Yasi (*right*) both of which destroyed most of the Australian banana crop

Fig. 26.3 The research program Future Earth envisages Food Security as being composed of three components – utilisation, access and availability

Geosphere Biosphere Program (IGBP); IHDP, the International Human Dimensions Program (IHDP); Diversitas, an international biological program; and the World Climate Research Program (WCRP).

It was recognised that Food Security would be an important part of Future Earth (n.d) (Fig. 26.3) and thus Future Earth and the Consultative Group on International Agricultural Research (CGIAR), agreed that the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) would become one of the initial research programs of Future Earth. Thus it may be stated that at an international level the Climate and Food Security link has been made in terms of Climate Change – Agriculture – Food Security through the work of CCAFS. Less international effort has been devoted to examining the Climate – Fisheries – Food Security link or the Climate – Supply Chain – Food Security link which is a particular concern of the International Union of Food Science and Technology (IUFoST).

There is also ongoing work on weather and food security, especially the role of seasonal forecasting in improving agricultural yields (IIzumi et al. 2013) which has more recently shown that improved forecasts can be achieved worldwide if the state of ENSO, the El Nino Southern Oscillation, is incorporated into yield forecasts. However, work by Asseng et al. (2013) indicates that a greater proportion of the uncertainty in climate change impact projections of crop yields is due to variations among crop models rather than to variations among the downscaled climate models.

26.3.2 WeatCliFS

The International Union of Geodesy and Geophysics (IUGG) is leading a consortium with the International Union of Food Science and Technology (IUFoST) and the International Union of Nutritional Sciences (IUNS) to examine weather, climate and food security. The consortium, known as the WeatCliFS Consortium has held symposia and workshops in Cancun (Mexico), Brisbane (Australia) and Granada (Spain) at which it was determined that the fundamental question that underpins WeatCliFS is: *What technologies and methodologies are required to assess the vulnerability of people and places to hazards [such as droughts that lead to famine] – and how might these be used at a variety of spatial and temporal scales?*

However when the focus is specifically on the urban aspects of weather, climate and food security then other questions also arise:

Does an increase in local urban food production increase the nutritional health of local residents?

Does an increase in vegetative cover and structure in urban gardens increase the resilience of urban residents and local food supply to storm events?

26.3.3 Research Tasks

Given increasing global food demands, climate-related crop failure, and consistent limitations in fresh food access within urban centres (ver Ploeg et al. 2009; Thomas 2010), the resilience of the urban food supply is becoming increasingly important to food security, yet increasingly vulnerable to climate effects. In order to understand how to design urban food production systems that are protected from climate events and provide healthy, nutritious food to local residents, the requirements are:

(1) Survey urban gardens across a city to document the types of gardens in the city as well as the types of crops grown in each of the urban gardens – maintaining cognizance of the cultural needs and desires of the local residents.
(2) Study spatially how these gardens are distributed across the cityscape and look for patterns of local food production (types of crops, amount of food produced) in relation to health variables of the local community.
(3) Survey the vegetative structure of urban gardens to observe which gardens are more resilient to storm damage.

    (a) For crops – establish a baseline level of production from each particular urban garden (with the assistance of those working the garden) and monitor rates of change in food production after storm events
    (b) For flood damage impacts – assess areas within the city that are prone to flood damage and compare flood damage levels to green infrastructure levels. Survey urban gardens to assess vegetative structure and use this data to investigate if urban gardens with greater area of green space or greater vegetative structure have an impact on flood damage.

26.4 Results

The results of such studies are expected to provide urban planners and local councils with a better understanding of how the management of urban food production systems impact local health and resilience to climate events. Such a study will provide guidance on what types of urban gardens provide greater health/nutrition benefits and which gardens provide greater storm attenuation benefits. It is possible that the two services may be provided by very different types of food production systems.

26.5 Conclusions

Despite the existence of the ICSU research program Integrated Research on Disaster Risk, the science plan for IRDR (ICSU 2008) indicates that food security is not an aspect of its research mandate. Thus the international aspects, including the urban aspects, of the agricultural disruption, economic disruption and logistical disruption to food availability, food access and food quality as a result of natural disasters remains an under-researched topic.

Climate change is affecting (and will affect) global food production and hence global food security. Urban agriculture plays a significant role in maintaining and improving the health of city dwellers, particularly those disadvantaged. Climate changes are likely to impact more severely on urban environments with associated negative effects on food security, as has been discussed. Existing research programmes are not addressing these aspects of climate change effectively and deserve immediate attention.

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