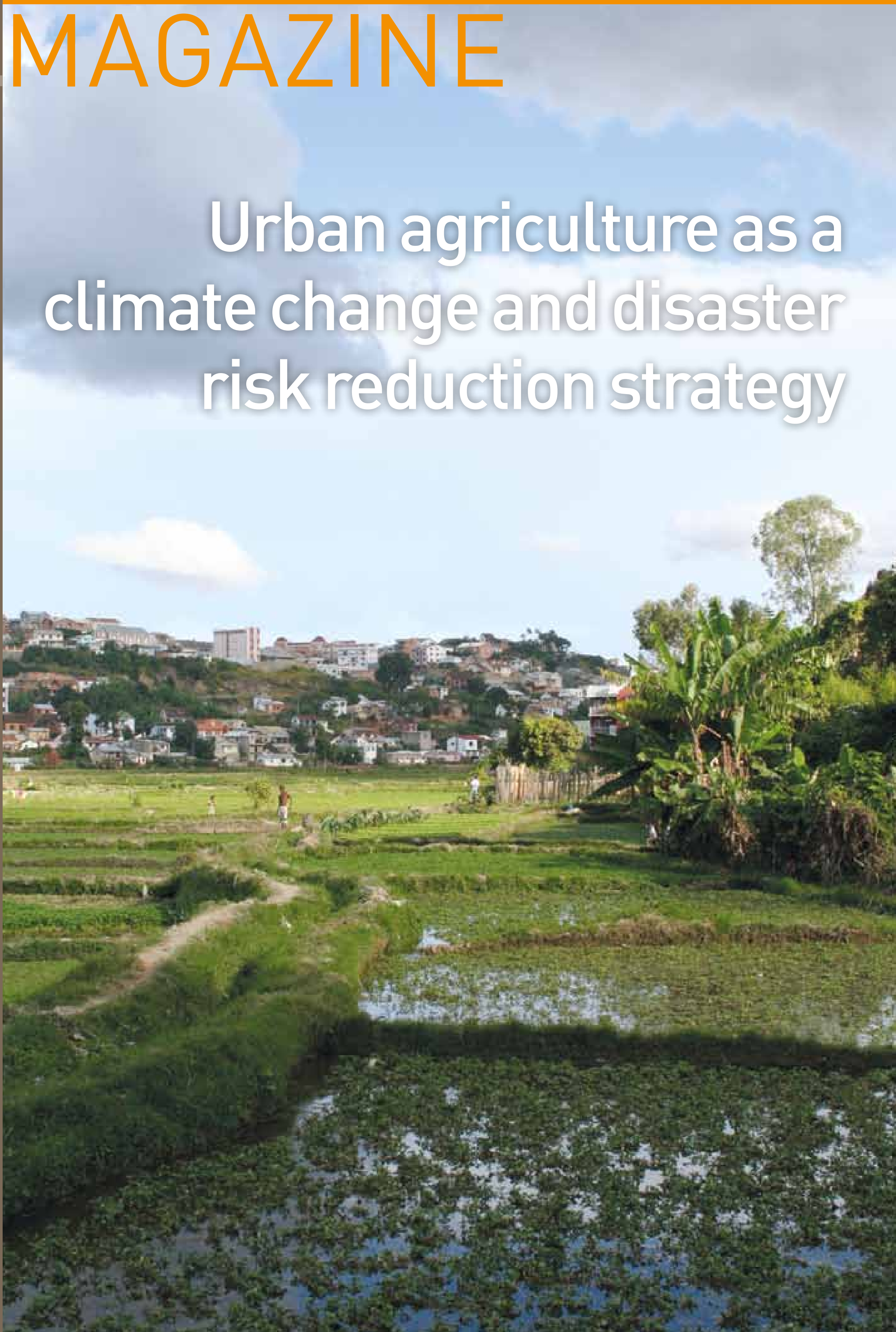
MARCH 2014

# URBAN AGRICULTURE

# UA MAGAZINE

27

# Urban agriculture as a climate change and disaster risk reduction strategy



www.ruaf.org

# 27 Urban Agriculture magazine

## In this issue






This issue is prepared with support of the **UN Habitat Cities and Climate Change Initiative.** It reports on the joint urban agriculture programme implemented by RUAF and UN Habitat. This issue also shares findings of a CDKN funded innovation project on monitoring urban agriculture impacts on climate change.

*Photo: Productive use of low lying flood zones in Antananarivo. Source: Marielle Dubbeling*

# Urban Agriculture as a Climate Change and Disaster Risk Reduction Strategy

Marielle Dubbeling

**Cities and climate change are virtually inseparable. Cities are major contributors to Green House Gas (GHG) emissions and thus climate change. Cities, and their large urban populations, are also directly and indirectly affected by climate change, with the urban poor being most at risk. Cities have an important role to play in climate change mitigation and adaptation and in enhancing the climate resilience of their vulnerable residents. Urban agriculture may be considered an adaptation strategy that can bring multiple benefits.**

*Flooding in Bangkok* Photo: City Farm programme

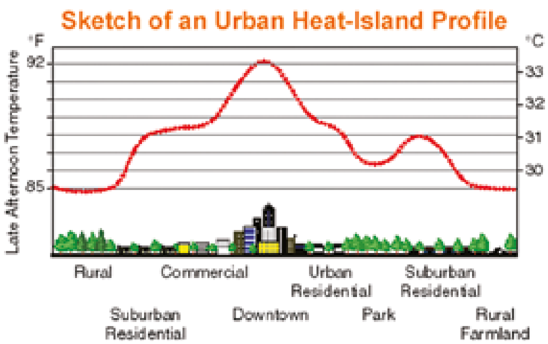
Urbanisation and climate change are closely linked. Carbon dioxide and other GHG are mainly emitted in urban areas. Within a given city, a substantial proportion of the GHG emissions come from burning fossil fuels in transportation (much of it related to food), while another significant percentage comes from energy used for industrial, commercial and domestic consumption.

## Climate change affects cities and specifically the urban poor

Climate change and climate-related disasters are recognised by the International Panel on Climate Change as one of the most serious environmental, societal and economic challenges facing the world today.

Climate change will bring about many shifts: changes in average climate conditions (temperatures and precipitation); sea level rise; more heat waves and an increase in frequency and intensity of events such as drought or flooding. Climate change adds to the many challenges that cities already face. For example, the increased levels of flood risk induced by climate change coupled to reduction of open spaces where excess storm water could otherwise infiltrate and be stored, compounds existing serious deficiencies in provisions for storm drainage in many cities in developing countries (see also the article on the Western Province in Sri Lanka on page 20).

Climate change is also aggravating the urban heat island effect (the increase of mean day temperatures in built-up areas owing to human and industrial activities and reflection of heat by buildings and pavements). Such temperature increases may directly contribute to increased energy demand for cooling, worsening public health (and increase in epidemics), worsening air (smog) and water quality, and water scarcity.




Cities are also highly vulnerable to disruption in critical supplies, including food. Rural production and food imports are increasingly and adversely affected by storms, floods, shifting seasonal patterns, droughts or water scarcity, resulting in temporary or permanent food scarcity and increases in food prices (see also the box on Kathmandu, page 30).

Lotsch (2008) states, for example, that changing rainfall patterns will affect agricultural productivity, especially in African countries. While Southern Africa could risk losing 30 % of its coarse grain output by 2030, Mozambique, Zimbabwe, and Malawi could face as much as a 50 % reduction in yields by 2020. In addition, the share of arable land in tropical regions is expected to decrease.

Battersby illustrates in her article (page 10) that a city's dependence on global food markets increases its vulnerability to climate change. She therefore calls for a more diversified and responsive (local) food system.

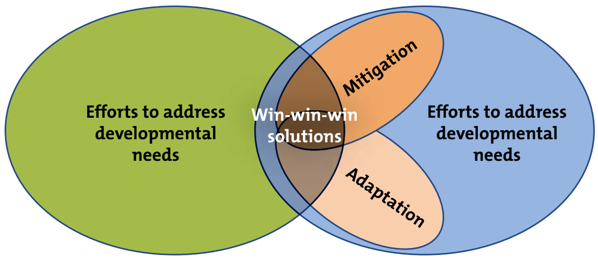
The urban poor, often located in the most vulnerable parts of cities and lacking the capacity to adapt to climate-related impacts, will be hit hardest. Increasing food prices will directly affect the urban poor because they spend a large percentage of their cash income on food. A recent nutrition study on low-income neighbourhoods of five large cities, implemented by the RUAF Foundation, showed that the financial and food crisis resulted in many urban poor households reducing the number of meals eaten and turning to cheaper and less nutritious food, with negative effects on the nutritional status of the family members.
The urban poor furthermore face the most climate hazards, as a larger proportion of them lives in informal settlements located in low-lying and flood-prone areas or on steep and unstable slopes — with the risk of landslides after prolonged rainfall.

## Cities as key actors

Initially, the climate debate devoted most attention to the development of global scenarios of climate change, the projection of its effects and the design of national climate change policies and strategies. Over the last several years cities have become a much more important focus for climate change planning and action. There are at least four reasons for this shift in focus.
Firstly, cities are a major contributor to climate change and thus have to play a major role in finding an appropriate solution to the problem. Cities and local authorities have the potential to influence both the causes and consequences of climate change, and they can contribute to national and international climate change strategies. Ideally, cities need to invest in both local mitigation and adaptation measures.
Secondly, the longer the decision to act is delayed, the more difficult mitigation and adaptation will be to achieve and the higher the costs. The earlier risk-reduction and adaptation efforts are incorporated into city investment and development plans, the lower the unit costs will be. Inaction leading to forced adaptation will often result in significant human costs.
Thirdly, the co-benefits of certain green interventions often more than cover their costs; moreover, those co-benefits may be the largest in cities. Prompt action, e.g., by enhancing energy efficiency, reducing pollution and promoting urban greening, results in direct positive impacts on public health, improved quality of living, and cost savings on energy. Adaptation and mitigation strategies in urban areas also require new and improved infrastructure and basic services. This provides cities with opportunities to address deficiencies in housing, green spaces, infrastructure and services, and to create jobs and other local economic development opportunities.
Fourthly, cities have key competencies to act on climate change. Urban governments often have authority over such urban sectors as land-use zoning, transport, buildings, waste management and water services. Already, cities are implementing a wide range of activities related to energy and transport efficiency, cleaner production, better waste management and urban greening. Cities are well positioned to develop policies that meet specific economic and social conditions. They can also lead by example.

## Building resilience requires an integrated approach

According to the World Bank, city climate change and disaster-risk management plans require an integrated approach, one "that considers mitigation (e.g., strategies to reduce greenhouse gas emissions), adaptation (e.g., reducing the vulnerability to climate change) and development (such as poverty alleviation, income generation and food security)". UN-Habitat also calls for sustainable urbanisation that both addresses climate change and ensures local food security (see the article by Tuts on page 8). Both organisations recognise the importance of the role that urban agriculture can play in making cities more resilient.




*Urban agriculture: a win-win-win approach*

These views match well with concepts in urban development that stress the need for increased rural-urban linkages and for "city-regional development" (as stated by Tuts in his article) that provides spaces for local food production, storage and processing as well as services such as water and waste management. This also includes the planning of urban catchments and watersheds for urban agriculture and forestry land use, as is currently being discussed in Rosario, Argentina (see article on page 44).

## The contributions of urban agriculture and forestry to resilient urban development

Urban agriculture and forestry are increasingly considered a potential climate change and disaster risk reduction strategy. The Asian Cities Climate Change Resilience Network (ACCCRN) has included urban and periurban agriculture as an important strategy for building resilient cities — cities able to respond to, resist and recover from changing climate conditions. The World Bank-supported "City-Wide" Clean Development Mechanism project in Amman, Jordan, includes urban (agro-)forestry as one of the four major components of the project.
Urban agriculture and forestry can help cities to become more resilient by reducing the vulnerability of the most at-risk urban groups and by strengthening community-based adaptive management through:

- diversifying urban food sources, enhancing access of the urban poor to nutritious food;
- reducing dependency on imported foods and decreasing vulnerability to periods of low food supply from the rural areas during floods, droughts or other disasters;
- diversifying income opportunities of the urban poor, and functioning as a safety net in times of economic crisis;
- being a source of innovation and learning about new

*Keeping flood zones free from construction in Antananarivo*
Photo: Marielle Dubbeling

strategies/technologies for high land- and water-efficient food production.

Urban agriculture and forestry also can contribute to maintaining green open spaces and enhancing vegetation cover in the city with important adaptive (and some mitigation) benefits, including:

- reduced heat island effect by providing shade and enhanced evapotranspiration;
- reduced impacts related to high rainfall through the storage of excess water, increased water interception and infiltration in green open spaces, reduction of storm water runoff and related flood risks, and more replenishment of groundwater;
- Conservation of biodiversity, protecting a wider base of plant (and animal) genetic diversity.

Producing food in and close to the city (hence using less energy for transport, cooling, storage and packaging) may contribute to reduction of the urban energy consumption and GHG emissions. Urban agriculture and forestry also enables productive reuse of organic wastes, which will reduce methane emissions from landfills and reduce energy use in production of fertilisers. Reuse of urban wastewater in urban agriculture and forestry will free fresh water for higher-value uses and reduce emissions from wastewater treatment.
However, urban agriculture, if not properly managed, may have some negative impacts on the urban environment. Soil erosion and pollution of groundwater may occur if chemical fertilisers and pesticides are used over an extended period. Ecological farming practices are highly recommended in urban and periurban agriculture to prevent such negative effects.

## What cities can do

Metropolitan, municipal and other local government institutions can play a proactive and coordinating role in enhancing urban food security and city resilience by:

1. integrating urban food security and urban agriculture into climate change adaptation and disaster management strategies;
2. maintaining and managing agriculture projects as part of the urban and periurban 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 water(shed) management plans, and in social housing and slum upgrading programmes; and
5. developing a municipal urban agriculture and food security policy and programme.



As described by Lwasa (page 13), cities can also promote specific types of urban agriculture, such as integrated animal-plant production systems, aquaculture or agroforestry systems. As the impacts of urban agriculture and forestry on climate change cannot be generalised (see also the article on page 40), strategies and policy interventions for specific urban agriculture types or systems should be considered.
In order to strengthen climate change adaptation and risk-reduction strategies in urban areas, various city governments already promote specific urban agriculture interventions. For example, activities promoted by the Amman municipality (Jordan) include the promotion of productive green rooftops, water harvesting and more efficient water use in agriculture, the identification of all vacant open spaces suitable for urban agriculture and the creation of a "land bank" to facilitate owner-user contacts and contracts.

As further illustrated in this magazine, Kesbewa (Sri Lanka) promotes rehabilitation of abandoned rice fields in order to reduce flood risks and increase local food production. The city of Bobo Dioulasso (Burkina Faso) promotes the multi-functional use of greenways, while urban forestry is supported in Eldoret (Kenya).
Durban (South Africa) is promoting productive green rooftops for storm water management, biodiversity and food production; the city is testing possible replacement crops for maize to adapt to lower rainfall and is promoting community reforestation and management.
Brisbane (Australia) included both urban agriculture and green roofs in an action plan to meet predicted global climate change challenges. For Seattle (USA), 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. The city of New York promotes urban agriculture and green infrastructure as part of their storm water management.

*Promoting productive rooftops in Amman, Jordan*
Photo: Municipality of Amman


*Organic waste recycling in Kumasi, Ghana* Photo: IWMI

Besides integrating urban agriculture and forestry as part of climate change strategies and plans, better integration of food policies with land-use and zoning policies, waste management programmes, transportation projects and economic development policies is also called for. Examples may include the integration of urban agriculture in social housing and slum upgrading programmes by including space for home gardens or community gardens, street trees for shade and fruits, "productive parks", as in Sao Paulo (Brazil) and Lima (Peru). Or providing fiscal and tax incentives for land owners who lease out vacant private land to groups of urban poor willing to produce on this land (Rosario, Argentina). Cities can also make municipal land available to groups of urban poor households through medium-term lease arrangements, or by providing occupancy licenses to the urban poor producing informally on municipal land under the condition that they adopt safe and sustainable production practices. Municipal land that is provided might be land that is earmarked for other uses but not yet in use as such, such as land that is not fit for construction. Such land is given on short- or medium-term lease arrangements to organised groups of urban poor for gardening purposes. Often these contracts with farmers include conditions regarding land, crop and waste management practices.

Cities like Rosario, Bobo Dioulasso, Brisbane and Durban are already integrating urban agriculture in their climate change strategies

## Promoting innovations in urban agriculture

There is also a need for better understanding of the interactions between climate stressors and non-climate stressors and their impacts on urban and periurban agriculture (see also: http://start.org/programs/upa). For urban agriculture to keep playing a role in climate-optimised development, innovation of systems and practices is needed for urban agriculture itself to become more resilient to climate change. Increased rainfall, floods and temperature will affect urban and periurban agriculture (e.g., in terms of diseases, yields, crop failures, livestock mortality). Response strategies could include adjustment of production systems, cropping patterns, selection of adapted crop varieties, production under cover, diversification of cropping or farming systems, improved water management and resource efficiency, rezoning of urban agriculture, etcetera. Some of these innovations are illustrated in the article on Kenya (page 24).

Pest and (zoonotic) disease management (including potential livestock mortality due to heat waves) may become even more crucial as a result of changing climate, and further farmer training on the subject is required. Local innovation funds are interesting mechanisms by which farmers can fund testing of new technical, but also social and organisational, innovations (see http://www.prolinnova.net/).

Further integration of urban agriculture in agricultural and extension training programmes is needed to build more extension and technical staff capacity to help urban producers sustainably innovate their production systems. In Ghana and Kenya special urban agricultural officers are trained and employed. In Vancouver (Canada), a partnership between a local environmental NGO and a social organisation, designed as a social enterprise, offers 25 classes in a variety of subjects related to sustainable urban farming systems. Such Urban Producer Field Schools could be more widely promoted (see also related articles on RUAF's approach in this area in Urban Agriculture Magazine numbers 24 and 25).

Another strategy might be the development of insurance systems to reduce impacts of natural and climate change risks and increase investment in urban agriculture, as in Beijing, China, where the local government set up an insurance system for 18 different types of crops and animals that engaged over 1,600 urban farming households in 2007 (see also the related article in the Urban Agriculture Magazine No. 26).

## Need for impact monitoring

If urban and periurban 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. As described in the article on page 40, both cities and international organisations indeed call for more monitoring data n order to better design climate change strategies, plans and financing mechanisms that include urban agriculture. Most of such data, where available, have been collected with regards to urban forestry.

In response to this request, the RUAF Foundation, with support from UN-Habitat and the Climate and Development Knowledge Network (CDKN), designed a framework for indicators and tools to monitor the actual adaptation and risk-reduction impacts and development benefits of urban agriculture activities in different cities and for different urban agriculture models (see also the article on page 44). The

*Urban farmer field schools in Amman, Jordan* Source: Municipality of Amman

monitoring framework is currently being tested and improved upon in various partner cities. Articles from Rosario and Kesbewa show some initial monitoring data collected. More information on these monitoring activities will be featured in upcoming publications.

## Conclusions

Urban policies need to incorporate food security considerations and focus more on building cities that are more resilient to crises. There is growing recognition of urban and peri-urban agriculture and forestry as an important strategy for climate change adaptation and disaster risk reduction.

It will be important to enhance the awareness of local authorities and other stakeholders involved in urban climate change programmes and other programmes (land department, agriculture and green spaces) bearing on urban agriculture regarding the potentials (and limitations) of urban agriculture and forestry for climate change adaptation and mitigation. Also, the potential of various replicable urban agriculture models for application in city climate change programmes should be better assessed and packaged. Information – be it technical, socio-organisational or financial – on selected "good practices" requires wider dissemination. Interested cities and other local actors can derive inspiration from the pilot and established interventions described in this Magazine that "showcase" replicable urban agriculture models.

**Marielle Dubbeling**
Email: m.dubbeling@ruaf.org

**References**

Dubbeling, Marielle (2013), "Urban and Periurban Agriculture as a Means to Advance Disaster Risk Reduction and Adaptation to Climate Change", in: Disaster Risk Reduction and Resilience Building in Cities: Focussing on the Urban poor. Regional Development Dialogue, Vol 34, No 1, Spring 2013, United Nations Centre for Regional Development, Nagoya, Japan.

International Bank for Reconstruction and Development (2010), "Cities and Climate Change: An Urgent Agenda", in Urban Development Series - Knowledge Papers 10 (Washington DC: World Bank, 2010).

Lotsch A. (2007), "Sensitivity of Cropping Patterns in Africa to Transient Climate Change," (Policy Research Working Paper 4289) (Washington, DC: World Bank, 2007).

Nowak D. J. (2010), "The Role of Urban Trees and Forests in Adaptation of Cities to Climate Change" (Syracuse, NY: USDA Forest Service, 2010).

Prain, Gordon (2010), Effects of the Global Financial Crisis on the Food Security of Poor Urban Households (Leusden, The Netherlands: RUAF Foundation/UN-Habitat/IDRC, 2010) (Available at http://www.ruaf.org/node/2259; retrieved on 11-12-2013).

United Nations Human Settlements Programme (UN-Habitat, 2011), Global Report on Human Settlements 2011 -- Cities and Climate Change (London: Earthscan for UN-Habitat, 2011).

UN-Habitat, Urban agriculture and climate change, (2013) (Available at http://www.ruaf.org/sites/default/files/Flyer%20UPAF%20in%20city%20climate%20change%20strategies.pdf; retrieved on 11-12-2013).

# Cities as Key Actors to act on Food, Water and Energy Security in the Context of Climate Change

Rafael Tuts

**In this article, which appeared last year on the Landscapes for People, Food and Nature Blog (http://blog.ecoagriculture.org/), Rafael Tuts discusses the need for more holistic planning approaches to building resilient cities. He is responsible for the implementation of the UN-Habitat Cities and Climate Change Initiative (CCCI), which is currently active in Africa, Asia and Latin America, and draws on this experience to argue for planning at a level beyond city limits.**

*A fertile river valley in the southern part of Tetouan, Morocco, still gives priority to grazing cattle, though the city has recently permitted limited middle class residential development here.*
Photo: UN-Habitat/Alessandro Scotti

*According to a recent World Bank study, urban population growth is likely to result in the significant loss of non-urban land as built environments expand into their surroundings. Cities in developing countries are expected to triple their land area between 2005 and 2030. As stocks of built up land accumulate, the amount of reproductive and ecologically buffering land available for ecosystems and food production is diminished, reducing the ability of city-regions to support themselves.*

Source: Urban patterns for a green economy: working with nature. Copyright: UN-Habitat.

We are currently witnessing a second urbanisation wave. By 2050, the large majority of the additional 3 billion people will live in Asian and African medium-sized cities. Pressures will be greatest where the urban and institutional infrastructure is weakest. Many of the cities that will be created do not even exist yet. Many of the ones that do exist are ill–equipped to handle such large–scale expansions. This is further exacerbated through the increasing impacts of climate change, whereby cities are not only called upon to address the vulnerability of people, places, and sectors that may be affected by a changing climate, but also have a responsibility to mitigate their greenhouse gas emissions to avoid unmanageable climate change.

The global population is reaching a size which dictates that cities need to start thinking beyond their immediate interests; cities must consider their role as nodes of human consumption and waste production on a finite planet that is struggling to keep pace with humanity's demands. Cities must acknowledge warning signs of ecosystem degradation and build their economies in a manner that respects and rehabilitates the ecosystems on which life depends. If cities are to prosper, they must embrace the challenge of providing uninterrupted access to water, food and energy, and of improving the quality of life of all of their citizens.

## Urban agriculture must be part of global climate change and food security agendas

For such rapid urban growth to be sustainable in the context of climate change and food security, there is a need for "decoupling". Essentially, this means enhancing the quality of life while simultaneously minimizing resource extraction, energy consumption and waste generation, and safeguarding ecosystem services. Decoupling will depend on how cities are planned and also on how city-based energy, waste, transportation, food, water, and sanitation systems are expanded and/or reconfigured. In this regard, there is a clear role for food systems and urban agriculture. Indeed, well planned and managed urban agriculture can play a key role in decoupling, as part of the overall food systems within a city-region.

*The Municipality of Uberlândia in Brazil grants authorisation for construction to private developers only within the perimeter of the city's ring road. The urban planning idea is to develop the city so that all vacant lots are filled before authorising either verticalisation of new buildings or the development of rural areas. Many lots, which are used by locals for agriculture until they are sold, remain available very close to the city centre.* Photo: UN-Habitat/Alessandro Scotti

For this to be meaningful, it is important to consider planning at the city-region level – beyond the boundaries of the urban center itself, including towns, semi-urban areas, and outlying rural lands. 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; optimise and expand existing transportation network infrastructure; construct a built environment that uses water and energy efficiently; and promote compact cities and planned extensions (e.g., designating low-lying areas and flood plains for agriculture to prevent construction and reduce impact of floods). In this regard, agriculture must be considered a key land-use feature in a city-region with such challenges.

Integration of food systems in city-region planning – including regulated urban agriculture in floodplains, incorporation of rooftop gardening into building codes, or inclusion of home gardens in either social housing schemes or in slum upgrading – requires support from a full suite of urban management and governance measures. 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, particularly women, youth, and migrant workers, to have a voice in a transparent decision-making process.

The work of the Megacities Project in Casablanca (see http://uac-m.org/) has begun to address some of these issues. UN-Habitat and RUAF Foundation are exploring, in Burkina Faso, Nepal and Sri Lanka, various dimensions of the urbanisation–food security–climate change nexus (see further related articles in this Magazine). Meanwhile, as the UN-Habitat series of guides on Urban Patterns for a Green Economy shows how, in such cities as Dar es Salaam, Hangzhou and Berlin, working with nature is essential to planning for ecosystem health. They are focusing on allowing sufficient space for natural systems to continue providing crucial goods and services like fresh water, food, fuel, and waste conversion. Much more work is needed to build up a credible data set that allows decision makers to integrate these issues in various spheres of policy development.

Ultimately, policy measures at multiple levels will underlie the success of linking food systems to urban planning. Urban agriculture must also be a part of the global climate change and food security agendas and, as such, the co-benefits of climate change adaptation and mitigation must be better articulated. There is obviously great potential to address the dual issues of urbanisation and food security, and we can aim for great impact through scaling up urban food security planning from the neighbourhood to the city-region level.

**Rafael Tuts**
Chief of the Urban Environmental Planning Branch, UN Human Settlements Programme (UN-Habitat), Nairobi, Kenya

# The Need for a Diverse and Responsive Food System

Dr Jane Battersby

**We have all been warned about "putting all of our eggs in one basket". We are constantly advised to keep our options open. Financial managers recommend investors diversify their portfolios to manage risk. So why doesn't this logic follow through when considering what kind of food system works best to ensure food security?**

The economist Paul Seabright recalls a conversation with an ex-Soviet official:
*"About two years after the breakup of the Soviet Union I was in discussion with a senior Russian official whose job it was to direct the production of bread in St. Petersburg. "Please understand that we are keen to move towards a market system", he told me. "But we need to understand the fundamental details of how such a system works. Tell me, for example: who is in charge of the supply of bread to the population of London?" There was nothing naive about his question, because the answer ("nobody is in charge"), when one thinks carefully about it, is astonishingly hard to believe. Only in the industrialised West have we forgotten just how strange it is." (Seabright 2010, 10)*

## Food systems undergoing transformations

Food systems, particularly within Africa, are undergoing rapid and profound transformations, and yet little consideration has been given to what these transformations might mean for the food security of urban residents who depend on the food system for their food security. Even less thought has been given to what these changes might mean in the context of climate change.

The logic of leaving food to the market to deliver is based on the assumption that an efficient market will ensure positive food security outcomes (guaranteeing reliable access of nutritious food to all consumers). Is this necessarily the case? This article is based on the idea that household food security is built on five pillars: availability, accessibility, acceptability, adequacy and agency. Are current trends in the food system moving to being able to create an environment in which this kind of food security can be achieved?


*Local traders buy from a range of sources* Photo: Caron von Zeil

## The emergence of supermarkets

One of the most significant changes in the food system within Africa has been the emergence of the supermarket as a key component of the system. The South African company Shoprite opened its first non-South African store in 1995, and by the end of 2012 it had 131 non-South African stores in 16 African countries. The increased presence of the supermarkets impacts the whole food chain, from production to consumption. Some have argued that the entry of supermarkets may prove to be an "urban food security boon" as they have the capacity to deliver food at lower prices than other forms of market (Reardon & Minten 2011). It is further argued that they provide better quality and safer food to consumers. They are also argued to have benefits for farmers, as they guarantee prices and often provide on-farm investment. On the other hand, some have expressed concern about the impact of the rise of the supermarkets on food sovereignty and food security. The control of the food chain by these large players undermines the autonomy and viability of small farmers, processors and other actors along the food value chain. Small traders are often unable to compete with the supermarkets on per-unit price. The economic viability of local small traders, precarious to start with, is furthermore undermined by the supermarkets that often enter new locations with a series of opening discounts. Concerns have also been expressed that, although these stores might provide cheaper access to food, they are also serving as gateways to mainly highly-processed, unhealthy foods. What, then, do the changes in the urban food system — most evident in the expansion of the supermarket, but also characterised by a suite of production and consumption transitions — mean for the resilience of the system to climate change and other shocks and stresses? To answer that question it is necessary to look at the everyday practices of residents as they engage the food system, and the practices of the informal traders. The focus here is on case studies conducted in Cape Town, South Africa, but many of the experiences here are not unique to the city.

## The importance of local traders

Work conducted by The African Food Security Urban Network (AFSUN) in 2008 asked households in three low-income areas of Cape Town where they accessed food. Virtually every household accessed some food in supermarkets, but with low frequency. On a day-to-day basis households got food from informal traders and street food sellers. There were also substantial proportions of households that got food through various social networks, borrowing food from neighbours and sharing meals with neighbours, for example (Battersby 2011). Less than five percent were eating any food they had grown, in part due to the poor soil and particular climatic conditions of the region. Further research found that households navigate their different sources of food according to product and time. The supermarkets were preferred at the start of the month when households would buy non-perishables in bulk, but the informal traders were viewed as better when money was short and they could only afford to buy the bulk-broken units sold by the traders. The informal traders were also seen to be more responsive to local needs in terms of their longer opening hours which were more attuned to the long working hours and commuting times of residents; in terms of their locations that could be more easily accessed on the way from work to home or closer to home; and through their granting of credit to "buy" food when the money inevitably ran out as the month's end neared. Residents also preferentially bought meat and fresh produce from informal traders. Having this wide range of possible sources of food made it possible for poor households to have some form of resilience to shocks such as price increases in one retail sector, or the monthly shock of running out of money.

*In South Africa there is an ad hoc approach to food planning on national level. Food is more seen as a rural issue – with a focus on production – and there is little consideration for urban food challenges. Cape Town struggles with a general lack of knowledge and understanding regarding food system issues and opportunities. Does the current food system respond to the needs of the rapidly expanding city, and particularly to the needs of the poorest of the poor? What should be the response of the City Council to food governance (food planning, regulation, food security interventions, etc.)? Which department should be the main driver? To answer these questions the City Council has recently commissioned a comprehensive study on the city's food system and food security to inform its firm and decisive response to food system governance and food system failures.*

Source: Stanley Visser, Municipality of Cape Town

Food systems are undergoing rapid changes. Little consideration has been given to what these changes might mean in the context of climate change

The practices of fresh-produce traders illustrate another layer of resilience embedded in the food system. These fresh-produce traders have to be responsive to customer needs in terms of both price and quality. Their customer base cannot afford to pay high prices for fresh produce, so the traders must locate the best quality produce at the lowest price. Because both customers and traders lack refrigeration, they must re-stock frequently to ensure good quality produce. In order to meet demands of quality and price, the traders buy their stock from multiple sources a number of times per week. Informal traders have a range of buying strategies and are therefore able to respond on a day-to-day basis to changing conditions. They buy from the official Cape Town Fresh


*Local food trader in Cape Town* Photo: Andreas Barth

Produce Market, from the large traders who operate outside of the market, from local wholesalers and directly from local farms and urban agriculture. Because price fluctuations ripple through these different sources at different rates, the traders are able to navigate the food system to ensure the lowest possible prices.

## Resilience within the local food system

There is therefore considerable resilience within the local food system that enables traders and customers to access food from a range of sources with a range of supply chains. The food system is therefore able to meet the needs of households as they respond to changing circumstances — be it through accessing food via different market sources, or through the dense social networks that exist around food. In the longer term, the multiple sources of food and the multiple means by which food reaches the city, through the formal and informal trade systems as well as local and distant production, generate a more systemic resilience. If an extreme weather event destroys either local crops, as it did in Cape Town's hinterlands in November, or crops from more distant production locations, it is still possible to get those products from elsewhere. If food prices in the formal sector spike because of fuel price increases, or as a result of climate change negatively affecting crop yields, the local networks of the informal traders may mitigate against these price shocks. To return to the metaphor: having eggs in multiple baskets creates some form of resilience in the food system.
In the context of this system, how then can the entry of the supermarkets be understood? While the supermarkets undoubtedly provide a means for often cheaper, generally safer food to enter the market, there are concerns that their presence undermines the local food retailers. The problem is that, although the supermarkets provide one means to buy food, they are far less responsive to the needs of low-income households in terms of the volumes they trade in, the hours they operate, their location and their inability to offer credit. Should the smaller retailers be lost, the most vulnerable to food insecurity will lose a vital source of food, and the smaller farmers will lose a vital market.

## Planning for a diverse food system

Policy makers and planners have been blind to the impact of supermarkets on the food system and have assumed that market efficiency has downstream benefits for the poor. This is simply not the case. Not only are the supermarkets not always accessible to the poor, but they also undermine the viability of systems that have developed in response to local needs and local food value chains. If we fail to plan for a food system that is self-consciously diverse and responsive to local needs and a range of systemic (and future, projected, increased climate change) shocks, we are in danger of creating one very large, very shiny and very fragile basket to put all of our eggs into.

**Dr Jane Battersby**
University of Cape Town.
Email: jane.battersby.lennard@gmail.com

**References**
Battersby, J. (2011) The state of urban food insecurity in Cape Town, *AFSUN Urban Food Security Series No. 11*, AFSUN, Queens University, Kingston, CA.
Reardon, T. & Minten, B. (2011) Surprised by supermarkets: diffusion of modern food retail in India, *Journal of Agribusiness in Developing and Emerging Economies* 1(2)134–61.
Seabright, P. (2010) [2004] *In the Company of Strangers: A Natural History of Economic Life*, Princeton University Press, Princeton.

# Policy Considerations for Urban and Periurban Agriculture's Role in Adaptation and Mitigation of Climate Change in African Cities



Shuaib Lwasa

**An estimated 40 % of Africa's total population live in urban areas. Future trends indicate an increasingly urbanising Africa with increased wealth but vulnerable to climate variability and change. The key concern is how climate change impacts are likely to reinforce poverty and exacerbate food insecurity. This article presents a short synthesis of scalable policy strategies for urban agriculture that have a potential to address both food security and climate change mitigation and adaptation.**

The impacts of sea level rise, storm surges, saline water intrusion, coastal erosion, floods and droughts are likely to have implications on urban systems, urban infrastructure, public health, economic development, local environmental resources, food security and water supplies. These impacts will mostly affect the urban poor, women, the elderly and the young due to their vulnerability. As urbanisation exacerbates these vulnerabilities, there is growing evidence that urban and periurban agriculture and forestry (UPAF) can play a role in poverty alleviation and potentially reduce vulnerability to climate change. Studies on UPAF have often focused on the issues of livelihoods, poverty reduction, environmental pollution, health risks and urban policy, emphasising how cities can better provide safeguards from the potential negative consequences of UPAF (including, particularly, biological-chemical risks from grey water and heavy metal contamination). There is a more recent shift to the ecological importance of UPAF, focusing on the provision of ecosystem services and biodiversity conservation along the urban-rural gradient to support mitigation and adaptation to climate change.

*Tree cover protecting slopes in Nairobi* Photo: Andrew Bradford

## Why policy for UPAF?

The extent to which UPAF is successful, particularly in enhancing food security and ecosystem services, depends largely on how it is perceived by city officials and on its level of integration with other urban polices. The key entry sectors for UPAF relate to urban poverty alleviation, ecosystem management, water and sewage management, and landscape management policies. UPAF still remains illegal in many cities and this stems from concerns about health and other risks. This has resulted in the disregard of UPAF as a formal land use and the development of restrictive UPAF policies in many cities. Two levels of UPAF targeted policy are described in this article to enable policy makers to adapt strategies that are appropriate for their specific cities.

## Policy strategies for adaptation and mitigation of climate change in cities

Moderation of microclimates, water filtration, nutrient reuse, biodiversity and supporting services for food production are critical for sustaining the local resource base upon which urban residents will increasingly depend. UPAF needs to be evaluated not only in terms of its contribution to food provisioning and to food security, but in relation to associated benefits for making cities resource efficient. These benefits of UPAF, including storm protection, erosion control, flood regulation, microclimate moderation and carbon sequestration have not been adequately integrated into urban policies. In the cities of Ibadan, Kampala, Dakar, Douala, Nairobi and Addis Ababa, Accra, Kampala and Dar es Salaam, UPAF has demonstrated flood-reduction capabilities by extending the time lag between floods and storm run-off. In the case of coastal flooding, agroforestry has contributed to the reduction of coastal inundation during extreme events, for example, through the cultivation of mangrove forests in Douala, Cameroon. In addition to reducing run-off, more porous land surfaces support recharge of water tables and increase groundwater flows. (Productive) wetland ecosystems are increasingly becoming recognised as economically sound and effective alternatives to traditional water treatment practices. City-specific policies are needed to integrate management approaches that could help improve the provision of multiple ecosystem services through UPAF.

## Pathways for climate mitigation and adaptation

There are several pathways for climate mitigation and adaptation policy through urban agriculture. To reduce the carbon footprint of food consumed in cities, production of food close to cities or within city-regions has potential to reduce the footprint. Likewise, instead of the traditional overhaul of organic wastes to landfills, cities can also promote nutrient recycling utilising the biomass from green and rural areas. The recycling of waste and sewage sludge for UPAF can enhance environmental quality and the functioning of ecosystem services. Urban agriculture, especially city tree planting of multiple functional trees has a potential to sequester $CO_2$, and to reduce impacts of heat waves. These policies and strategies would have to include conservation of urban forest patches to sustain the ecosystem services they provide. A strategy for tree species mix is also equally important since carbon sequestration capacity varies through the growth cycle of individual crop species.

## Need for long term planning, scaling up and policy review

The resilience of sub-Saharan African cities will depend partly on how institutions, individuals, and authorities respond to reduce the climate change impacts. Effective local adaptation is key and this requires short- to long-term planning. Although knowledge of UPAF's adaptation potential exists, this knowledge has been scattered in reports and project documents, and are mostly site specific. Evidence on micro-scale adaptations exists on how urban agriculture is helping communities and cities to adapt but these require scaling up. Adapting to climate change impacts associated with extreme events such as flooding has been evaluated for a range of agro-enterprises, including productive greening strategies with fruit trees, herbal shrubs, high-value vegetables on hill slopes and in valleys to increase water infiltration and to reduce potential flood occurrence. Increased urban agriculture and forestry also has potential to moderate microclimates. UPAF has demonstrated scalable adaptation strategies including creation of jobs, enhancing food security and supporting livelihoods. In this manner, UPAF links poverty and climate change if strategies are designed to address both types of impacts. Cities have begun to take steps to review bylaws and regulations that have long restricted urban agriculture. For example, colonial zoning bylaws have been revised to allow for specific production systems in specific zones in Kampala, Uganda and Kumasi, Ghana. Agriculture has been incorporated into urban expansion plans for Kinshasa, Dar es Salaam, Dakar, Bissau and Maputo. In Lagos and Ibadan, state governments have embarked on urban greening programmes involving tree and grass planting in strategic public open spaces including road islands and road setbacks as well as roundabouts. Although the aim is to promote city aesthetics, this practice of policy support has indirect benefits to building resilience for climate change. Recognition of UPAF as a formal land-use

> Planning for specific climate change contributions requires promotion of integrated urban agriculture systems

*Productive use of low-lying areas in Bobo Dioulasso* Photo: Marielle Dubbeling

*Tree planting and nursery production along roadsides in Dakar, Senegal* Photo: Marielle Dubbeling

is an important step towards its incorporation with more comprehensive and tailored city strategies to reduce their overall ecological footprint and increase resilience to climate change.

## Policy strategies for integrated systems

Integrating UPAF in city plans and development for resilience will require UPAF enterprises that are designed to recycle nutrients, improve water and pollution management, reduce waste streams to landfills and create value chains that can create economic opportunities or enhance food security for urban dwellers, especially the poor. Four integrated systems are important for policy in building urban resilience.

1) *Integrated crop-livestock systems:* This type of UPAF system can be practiced with benefits of enhancing food production and security and enhancing nutrient recycling.
2) *Urban agroforestry systems:* This type of UPAF system can occur in two forms. The first is planting multi-purpose trees and shrubs for food production that would sequester $CO_2$. The second is in the form of periurban agroforestry, requiring more land for production.
3) *Aquaculture-livestock-crop systems:* This type of system hinges on nutrient recycling and utilisation and has a potential to reduce organic wastes that would otherwise emit GHGs. This type has a high potential to contribute toward food security and enhance livelihoods while mitigating climate change by adding fish production to the urban agriculture and livestock industry of cities.
4) *Crop systems:* This fourth strategy is associated with cities that have extensive periurban green zones or institutional land patches. These cities still have a high potential to contribute significantly toward food security. Urban crop systems of a wide range of more permanent crop types can play a significant role in addressing the urban heat island, coastal erosion and flood control.

## Conclusion

UPAF plays a variable but often substantial role in sub-Saharan African urban livelihood strategies. While challenges and risks exist, especially in relation to health, conflict with other land uses and out-dated planning regulations, well-managed UPAF policy-supported strategies of crop systems, crop-livestock integrated systems, crop-forestry systems and aquaculture-livestock-crop integrated systems have considerable potential to promote urban mitigation of, and adaptation to, climate change. UPAF contributions to adaptation come in several forms of sustainable employment, resource efficiency and urban food security promotion. This will support adaptation to threats by building long-term resilience with supporting infrastructure, while climate mitigation will be achieved through $CO_2$ sequestration and avoidance of methane from landfills.

**Shuaib Lwasa**
Email: shuaiblwasa@gmail.com

**References**

D. Roberts, R. Boon, N. Diederichs, E. Douwes, N. Govender, A. McInnes, et al. "Exploring ecosystem-based adaptation in Durban, South Africa: "learning-by-doing" at the local government coal face". *Environment and Urbanization* (2011).
S. Lwasa, M. Tenywa, G.J. Majaliwa Mwanjalolo, G. Prain, H. Sengendo. "Enhancing adaptation of poor urban dwellers to the effects of climate variability and change", in IOP Conference Series: *Earth and Environmental Science* 2009, Vol 6, 3 p. 332002.
H. De Zeeuw, R. Van Veenhuizen, M. Dubbeling. "The role of Urban Agriculture in Building Resilient Cities". *Journal of Agricultural Sciences*. (2011) 153–163.
"Action Aid, Climate change, urban flooding and the rights of the urban poor in Africa: key findings from six African countries". Action Aid, London, 2006.
I. Douglas, K. Alam, M. Maghenda, Y. Mcdonnell, L. Mclean, J. Campbell. "Unjust waters: climate change, flooding and the urban poor in Africa". *Environ. Urban*. 20 (2008) 187 –205.

# Urban Agriculture as Green Infrastructure: The Case of New York City

Nevin Cohen
Katinka Wijsman

**Efforts to reduce storm water through innovative green infrastructure projects may provide unique opportunities for cities to finance urban agriculture. Since 2011, New York City has been able to provide funding to four urban agriculture projects, including a one-acre commercial rooftop farm, through its Green Infrastructure Grant Program.**

*Different forms of green infrastructure*
Source: New York City Department of Environmental Protection

New York's experience suggests that if productive landscapes are integrated into storm water management planning, cities may be able to both reduce storm water flow and resulting water pollution and at the same time support the creation of farms and edible gardens, at a lower cost than traditional storm water adaptation measures would require. The organisational challenge in New York and elsewhere is to affirmatively support urban agriculture projects in green infrastructure programs by prioritising the multidimensional benefits of edible landscapes, including their function as a climate change adaptation strategy as well as for their capacities for storm water absorption.

## Combined sewer overflow

Most cities have combined sewage systems in which sewage and storm water are conveyed to water pollution control plants in a single pipe during wet weather. Because these treatment facilities are engineered to handle only dry-weather flows, during rain events the excess of the combined flow is often diverted, untreated, into nearby waterways to avoid inundating the facilities. In the case of more extreme weather events — which may occur more frequently due to climate change — heavy rains cannot be absorbed and may flood roads and properties. In cities with inadequate or poorly maintained sewerage infrastructure the flooding may be even more frequent and more severe. Both types of events lead to high social and environmental costs, including significant pollution of urban waterways with potential public health consequences (Walsh et al., 2009). Cities are under increasing pressure to adapt to climate change in general and to reduce combined sewer overflow (CSO) pollution in particular. In the USA the federal Clean Water Act mandates action to stem this source of water pollution (Adler et al., 1993).

A conventional strategy to address CSO is to invest in "grey infrastructure": expanded water pollution control facilities; increased-diameter sewage pipes that hold larger volumes of storm water; or tanks to store sewage until it can be pumped back through the water pollution control plants after it stops raining. These options are both costly and politically unpopular in communities faced with the prospect of hosting this infrastructure. A potentially more cost-effective option that avoids facility siting conflicts and can offer host communities benefits beyond reduced flooding and pollution is to increase the permeability of the cityscape through diverse forms of "green infrastructure": parks, landscaped median strips on roadways, permeable pavement, and agricultural sites. Green infrastructure not only absorbs and slows storm water to reduce the quantity that enters the sewer system; it can increase biodiversity, reduce the urban heat island effect and, in the case of urban farms and gardens, provide all of the benefits associated with urban agriculture.

## New York City's Green Infrastructure Program

New York City is under a consent order to reduce CSO pollution. In developing a management 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 (DEP, 2010). New York City's Department of Environmental Protection (DEP) committed to investing USD 192 million in green infrastructure by 2015 (DEP, 2012), 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 the types of grey infrastructure mentioned above (DEP, 2010). 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.

| Land Use | % of Combined Sewer Watershed | Potential Strategies and Technologies |
|---|---|---|
| New development and redevelopment | 5.0 % | Stormwater performance standard for new and expanded development |
| | | Rooftop detention; green roofs; subsurface detention and infiltration |
| Streets and sidewalks | 26.6% | Integrate stormwater management into capital program in partnership with DOT, DDC, and DPR |
| | | Enlist Business Improvement District; and other community partners |
| | | Create performance standard for sidewalk reconstruction |
| | | Swales; street trees; Greenstreets; permeable pavement |
| Multi-family residential complexes | 3.4% | Integrate stormwater management into capital program in partnership with NYCHA and HPD |
| | | Rooftop detention; green roofs; subsurface detention and infiltration; rain barrels or cisterns; rain gardens; swales; street trees; Greenstreets: permeable pavement |
| Parking lots | 0.5% | Sewer change for stormwater |
| | | DCP zoning amendments |
| | | Continue demonstration projects in partnership with MTA and DOT |
| | | Swales; permeable pavement; engineered wetlands |
| Parks | 11.6% | Partner with DPR to integrate green infrastructure into capital program |
| | | Continue demonstration projects in partnership with DPR |
| | | Swales; permeable pavement; engineered wetlands |
| Schools | 1.9% | Integrate stormwater management into capital program in partnership with DOE |
| | | Rooftop detention; green roof; subsurface detention and infiltration |
| Vacant lots | 1.9% | Grant programs |
| | | Potential sewer change for stormwater |
| | | Rain gardens; green garden |
| Other public properties | 1.1% | Integrate stormwater management into capital programs |
| | | Rooftop detention; green roof; subsurface detention and infiltration: rain barrels; permeable pavement |
| Other existing development | 48.0% | Green roof tax credit |
| | | Sewer charges for stormwater |
| | | Continue demonstration projects and data collection |
| | | Rooftop detention; green roofs; subsurface detention and infiltration; rain barrels or cisterns; rain gardens; swales; street trees; Greenstreets; permeable pavement |

*New York green infrastructure plan: Opportunities, strategies and technologies* Source: New York City Department of Environmental Protection

Green infrastructure absorbs and slows storm water run-off, increases biodiversity, reduces urban temperatures and can provide food and economic benefits

In addition to these benefits, green infrastructure simultaneously provides natural resource sinks that reduce air pollution and assist in urban climate control by cooling the city during hot summer months. It also provides important green networks in urbanised areas, enhancing the quality of life of urban dwellers and increasing their property values by an average of 2–5 % (NRDC, 2013). When the green infrastructure is a garden or farm, it supplies fresh fruit and vegetables and many other social and economic co-benefits to communities, including the health benefits of increased access to produce, the physical benefits of gardening, garden-based educational opportunities, job creation and the creation of safe spaces (Cohen et al., 2012). Community gardens increase the value of nearby properties (Voicu and Been, 2008).

## Urban agriculture as green infrastructure

As part of New York City's Green Infrastructure Grant Program, DEP provides funds to private property owners and organisations to build green infrastructure projects. In order for projects to receive funding, they must demonstrate feasibility and be designed to capture and retain a minimum of 1 inch (2.54 cm) of storm water from the impervious tributary area. In the first round of green infrastructure grants, the city provided USD 592,730 to the Brooklyn Navy Yard, a collection of industrial buildings on the waterfront that served as a shipyard during the Second World War, and the Brooklyn Grange, a rooftop farming company, for the funding of what the Grange calls "the world's largest rooftop soil farm". Covering approximately one acre (0.4 ha), the farm is located on the rented roof space of Building No. 3 in the Brooklyn Navy Yard. The Grange grows a variety of produce according to organic principles, including tomatoes (40 varieties), salad greens, carrots, herbs, peppers, beans, radishes, and chard. In addition, they keep egg-laying hens, and bees in a commercial apiary. Brooklyn Grange sells its produce to local restaurants and retail stores, to their community supported agriculture (CSA) members

*Brooklyn Grange farm* Photo: Brooklyn Grange (http://brooklyngrangefarm.com)

and to the larger public via weekly farm stands in various neighbourhoods. The Grange has expanded its farm business to include an educational non-profit (providing educational tours and workshops) and urban farming and green roof consulting and installation services to others interested in urban (rooftop) farming. As a result of its permeable rooftop farm and agricultural activities, the Brooklyn Grange manages over 1 million gallons (3,785,411 litres) of storm water per year, helping to reduce the amount of CSO flowing into New York City's East River.

The DEP has also provided more than USD 770,000 to support the creation of three additional farms and gardens (and two others that have been approved but not yet funded) with some edible landscaping (see table 1). The amount of food production of these sites varies significantly (from a vegetable garden to a plot for herb cultivation that is part of a non-edible landscape design for a recreational space), but they share a focus on multidimensionality in terms of the benefits stemming from the project. Although the DEP views urban agriculture or edible landscaping as a positive feature of a project proposal because of the co-benefits of food production, the focus of the Green Infrastructure Grant Program on storm water management dictates that a project's ability to retain at least one inch of water during rainfall is the primary criterion for funding. (The DEP actively monitors the retention capacity of green infrastructure interventions citywide, though individual projects are not necessarily monitored.)

## Discussion

While the number of urban agriculture projects co-funded by the DEP Green Infrastructure Grant Program is small, the potential for supporting the construction of many more farms and gardens as part of this programme is substantial.

Municipalities should coordinate green infrastructure investments with municipal urban agriculture goals to most effectively support both

In the communities in New York City with significant CSO problems, there are an estimated 2,000 acres (809 ha) of vacant land with mostly impervious surfaces and approximately 3,000 acres (1,214 ha) of flat rooftop space on buildings that have the potential to accommodate farms and gardens. As in many other cities, funds for water and sewer infrastructure in New York come from bonds issued by a public authority and paid for by water and sewer rate payers rather than from the general municipal capital budget, which makes it somewhat more politically feasible to finance these projects and makes them less subject to municipal budget cuts that result from fiscal downturns.

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 in part because the consent orders driving green infrastructure are about managing storm water, and agency mandates do not include supporting urban agriculture. Benefits such as the nutritional value of fresh vegetables, the educational opportunities of urban gardening, or the creation of communally managed open space are valued, but are subsidiary to water retention capacity. While the DEP has been an innovator in supporting urban agriculture through its Green Infrastructure Program, its prioritisation of storm water management has meant that the onus is on the city's urban agriculture community to propose new farming projects for funding under this programme.
A second challenge to expanding the use of urban agriculture as a green infrastructure 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 organisations, 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. In contrast, other green infrastructure projects, such as landscaped median strips or porous paving stones, often require less intensive maintenance to reliably stem storm water run-off.

Finally, while New York City's Green Infrastructure Grant Program is a valuable source of funds for individual farm and garden projects, it is not yet part of an overall municipal urban agriculture strategy. Planning that addresses the urban agriculture system as a whole would identify opportunities to make available sites for farms and gardens, capital for their construction (including but not limited to green infrastructure funds), and opportunities for non-profit and for-profit farming ventures to secure operating revenue.

*Table 1:* **Edible landscaping projects funded by NYC's Green Infrastructure Grant Program. (All sites are privately owned, yet most are accessible upon request.)**

| Year | Site | Funding GI grant program |
|---|---|---|
| 2011 | Brooklyn Navy Yard rooftop farm | USD 592,730 |
| 2011 | Lenox Hill rooftop gardens | USD 40,000 |
| 2011 | Carroll Street Community Garden | USD 244,920 |
| 2012 | Natural Resources Defense Council | USD 485,132 |
| 2013 | South Bronx Overall Development Corporation – The Venture Center | Under review |
| 2013 | South Bronx Overall Development Corporation – The Jasmine Court | Under review |

## Key lessons

- Green infrastructure interventions to prevent storm water run-off (or storm-water flooding due to extreme weather events) can be less costly than grey infrastructure interventions.
- Green infrastructure has the additional benefit of assisting in urban climate control and increasing the quality of life of urban dwellers.
- Urban agriculture as a green infrastructure has additional benefits of providing fresh fruits and vegetables and other social and economic co-benefits to communities.
- Urban agriculture can be a multi-dimensional productive strategy of climate change adaptation.
- Green infrastructure grants are valuable sources of funds for urban agriculture projects and an opportunity for cities to support projects that simultaneously address multiple public needs.
- Municipalities should coordinate green infrastructure investments with municipal urban agriculture goals to most effectively support both.

**Nevin Cohen**
Assistant Professor, The New School, New York.
Email: cohenn@newschool.edu
**Katinka Wijsman**
Email: wijsk799@newschool.edu

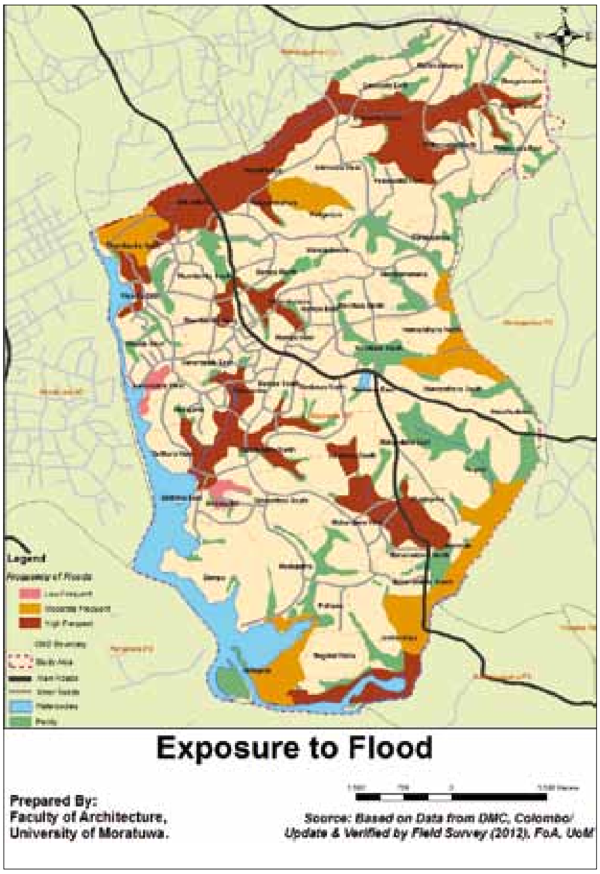
**References**
Adler, Robert, Jessica Landman, and Diane Cameron. 1993. *The Clean Water Act, Twenty Years Later.* Washington: Island Press.
Cohen, Nevin, Kristin Reynolds, and Rupal Sanghvi. 2012. *Five Borough Farm: Seeding the Future of Urban Agriculture in New York City.* NY: Design Trust for Public Space.
DEP (2010). NYC Green Infrastructure Plan. A Sustainable Strategy for Clean Waterways, available at http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_LowRes.pdf
DEP (2012). NYC Green Infrastructure. 2012 Annual Report, available at http://www.nyc.gov/html/dep/pdf/green_infrastructure/gi_annual_report_2013.pdf
NRDC (2013). The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value. Available at http://www.nrdc.org/water/files/commercial-value-green-infrastructure-report.pdf
Voicu, Ioan, and Vicki Been. 2008. "The Effect of Community Gardens on Neighboring Property Values". *Real Estate Economics* 36 (2): 241–283.
Walsh, C., Fletcher, T. and Ladson, A. 2009. "Retention Capacity: A Metric to Link Stream Ecology and Storm Water Management". *Journal of Hydrologic Engineering* 14: 399-406.

# Promoting Urban Agriculture as a Climate Change Strategy in Kesbewa, Sri Lanka

Lafir S. Mohamed
Jayantha Gunasekera

**The Western Province in Sri Lanka is the first provincial government starting to include urban agriculture in their provincial climate change adaptation action plan. Rehabilitation of flood zones through their productive use is promoted as an important strategy to enhance storm water infiltration and mitigate flood risks. Home gardening is supported as well to improve local food security and livelihoods.**

Kesbewa is situated about 21 km south of Colombo, in the Colombo District, Western Province of Sri Lanka. With close to 6 million people, the Western Province is the most urbanised province in Sri Lanka, home to about 25 % of the total national population on only 5 % of its surface area.




*Flood risk map Kesbewa Urban Council* Source: University of Moratuwa

## Urbanisation of agricultural areas

Historically, Kesbewa has been an agricultural area endowed with the excess water resources of the bordering Bolgoda lake. A relatively large area of paddy lands can still be found in its lower-lying zones. However, as a result of the continuous growth of Colombo and expansion of the urban boundaries of Colombo Metropolitan Region, Kesbewa Urban Council became an attractive residential area for commuters, now hosting over 244,000 inhabitants (2012 census) on 49 km$^2$ of land. Many of the agricultural areas were gradually converted to non-agricultural areas, resulting in about 60 % of the land now being used for residential purposes and related amenities (2011 land use map).

A recent study by the national NGO Janathakshan, implemented in the context of a UN Habitat- and RUAF-supported programme, confirms this trend and shows that between 2000 and 2010, 14 % of agricultural lands have been converted to residential areas (Kekulandala, 2012). Of this converted land, 4.7 % is paddy lands in low-lying areas.

## Paddy cultivation

In the ancient land use system in Sri Lanka, low-lying lands are kept free from construction for drainage of rainwater and/or are utilised for paddy cultivation. In 2011, Kesbewa still counted over 600 hectares of paddy lands (see green areas on the 2011 land use map). 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 some parts of Kesbewa area (University of Moratuwa, 2011). This problem is aggravated in areas were paddy lands are abandoned and drainage systems not maintained. In 2011, 32 % of the total paddy lands were abandoned (Kekulandala, 2012) because paddy cultivation in this part of the country is less economically profitable in comparison to production in the north of the country, where labour costs are lower. Furthermore, there is an increasing problem with salt water ingress, resulting in lower crop yields and incomes to paddy farmers.

## Promoting urban agriculture as a climate strategy

The Western Province Ministry of Agriculture realised that well-maintained and drained paddy areas function as buffer zones, where water is stored and drainage regulated, thus reducing flood risk in nearby areas. The ministry also realised that, as a result of the land use changes, Kesbewa increasingly has to rely on food supply from other provinces. Large amounts of food are brought into the city from distant production centres and sold in wholesale and retail markets. This has resulted in longer transporting distances and storage, increased refrigeration, and air conditioning, all leading to higher Green House Gas (GHG) emissions. Finally, and as a result of projected climate change and decrease in lush vegetation, a significant increase in extreme hot-temperature days is predicted for the area, with projected severe impacts on energy demand for cooling and heat-related illnesses (University of Moratuwa, 2012).

Since 2005, the Western Province has already promoted home gardening and urban agriculture as part of the country's policy to achieve food sovereignty for the country and promote domestic food production. This, however, was never done from a climate change perspective. In 2012, the Ministry of Agriculture from the Western Province asked RUAF — in partnership with the International Water Management Institute (IWMI), UN-Habitat, Wageningen University-PPO and the School of Forestry-University of Florida and with funding from the Climate and Development Knowledge Network (CDKN) — to make an assessment of the potential impacts of urban and periurban agriculture and forestry (UPAF) on climate change adaptation, mitigation and developmental benefits.

Based on this assessment, Janathakshan conducted a further diagnostic study: to identify appropriate UPAF models that fit well within the present and future land-use patterns in Kesbewa, and to identify the wider context within which these UPAF models could be replicated and guided by relevant policies and interventions. The diagnosis and assessment included five interrelated studies to identify the most feasible UPAF models: vulnerability mapping, land use mapping, food flow mapping, policy scan and a feasibility scan.

## Two pilot projects

Supported by RUAF and UN-Habitat, the Western Province, Kesbewa Urban Council and Janathakshan then selected and financed pilot projects on two promising urban agriculture models that were considered to have the highest potential (a) to reduce GHG emissions associated with transporting food into Kesbewa from distant sources, distribution, and storing; and (b) to reduce vulnerability to climate change and increase city liveability and livelihoods. The land-use pattern study suggested that home gardens and abandoned paddy lands (in low-lying flood zones) are the most appropriate and promising spaces to be preserved for urban agriculture. The food flow mapping identified five vegetable varieties and two fruit varieties that can be locally grown in Kesbewa but are at present imported from distant locations.

The first project included the promotion of more salt-resistant varieties of paddy, alongside the cultivation of vegetables in raised bunds, and involved 47 farmers in four different locations in Kesbewa. Altogether, 43 acres (17.4 Ha) of paddy field have been put into cultivation, including 13 acres (5.2 Ha) of abandoned fields located in medium- to high-risk flood zones, that have been abandoned for more than 20 years.
The second project looked at the intensification of home gardening units, coupled to promotion of rainwater harvesting and organic waste composting. The 2011 data

*Rehabilitated paddy areas with vegetables growing on raised bunds* Photo: Janathakshan

*Intensification of home gardens* Photo: Marielle Dubbeling

show that in total 410 ha are cultivated with home gardens in Kesbewa, while another 285 hectares are still available for cultivation (Kekulandala, 2012). Home gardening is practised by around 30 % of the population for both home consumption of food and income generation. In view of future urban development and increasing competition over land, home gardens were to be designed with a view towards future space restrictions. The vegetables and fruit varieties to be promoted in home gardens were selected with regards to their potential to replace food imports, as identified by the food flow analysis mentioned above (Gunasekera, 2012).

## Space-intensive home gardening

150 Home gardeners from 10 divisions are actively participating in this second project, with a high participation of the elderly community (57 %). Space-intensive techniques like biointensive farming, vertical structures and certain irrigation methods, like solar drip irrigation and micro irrigation methods, were introduced. The gardeners are provided with technical training on space-intensive farming and business planning, seed materials and home gardening kits to actively take part in the project.

A demonstration home garden plot was established at the Agrarian Services Centre and successfully attracted the public, government officers, politicians and school children. A series of six television programmes was broadcast at this demonstration plot, on one of the national channels. More demonstration plots are now being established to further enhance awareness raising and uptake of the practice.

In both projects, the participation of project stakeholders has been high, with governments, agricultural institutions and the urban council taking a leading role.

## Monitoring data

Preliminary impact monitoring data, collected and analysed by the University of Moratuwa and the University of Colombo, shows that households involved in production and sale of urban agriculture can increase income or reduce expenditures on food and improve food security and dietary diversification. Flooding incidences and impacts are lower when paddy lands are preserved and well managed, as they play an important role in storm-water infiltration and management. Reducing the transport of vegetables over longer distances

> Preserving low-lying lands for urban agriculture has both climate change as well as food security benefits

by increasing local production of vegetables (specifically: gourd, cucumber, eggplant, okra, chilli and capsicum) in home gardens, while at the same time improving organic waste reuse, can reduce GHG emissions by 4133 tons/year. (This amount was calculated, computing the difference between the amount of GHG released during the production and transportation of a ton of a specific food commodity to Kesbewa and the amount of GHG emitted when that ton of food was produced locally.) Emissions of GHG could be further reduced if home gardens were used more intensively, yields increased and nutrient management improved (as only low quantities of compost are used), which would require extension and technical support (University of Colombo, 2013).

*A review session with farmers* Photo Janathakshan

## Policy uptake

In parallel to project implementation and monitoring, policy review revealed three levels of policy where intervention was needed if uptake and upscaling of these models were to follow:

- At the local level: promoting the integration of urban agriculture into the Kesbewa Urban Development Plan (preserving low-lying lands for urban agriculture and designing such areas based on the results of the pilot projects) and, in the municipal programmes and budgets for example, providing financial incentives for rainwater harvesting in home gardens or for rehabilitation of drainage canals in paddy areas.
- At the provincial level: development — with contributions from all stakeholders — of a provincial climate change adaptation action plan that will prepare Western Province to better live and cope with climate change. The Western Province is currently elaborating such a plan that seeks to integrate UPAF in each of the 5 sectors to be covered: food security, biodiversity, health, water and human settlements.
- At the national level: a revision of the "Paddy Act", regulated by the Department of Agrarian Services, Ministry of Agriculture, that previously only allowed for paddy cultivation in assigned areas. This revisionwas effected in order to promote and support new models and forms of production of mixed cultivation of rice and vegetables that will increase income, promote and revalorise agro-ecological forms of production and traditional salt-water resistant rice varieties, and maintain natural drainage functions of the areas. Based on the project results, a recent circular adds value to this policy, and supports the promotion of short term crops as an alternative to paddy. However, adoption of the new practice is lagging behind. A clear implementation plan will be developed in the coming months, alongside further awareness-raising and information provision for interested farmers, and leverage of financial support for rehabilitation of drainage systems.

Climate change adds to the existing challenges faced by cities. For example, the increased levels of risk of flooding induced by climate change, comes on top of already serious deficiencies in provision for storm drainage in many cities in developing countries. Experiences in Sri Lanka have shown that urban agriculture can help reduce the vulnerability of the urban poor and enhance their coping capacity: by diversifying food and income sources, and keeping low-lying zones free from construction so that floods have less impact, storm water run-off is reduced, and excess water is stored and infiltrated in the green open spaces. At the same time, local production may contribute to reductions in urban energy use and GHG emissions. It may thus be a low-cost and appropriate adaptation strategy, bringing with it potentially significant co-benefits in the form of food security and job creation.

**Lafir S. Mohamed**
Project Manager, Janathakshan (lafir@janathakshan.lk)
**Jayantha Gunasekera**
Team Leader, Janathaksan

**References**

Bhathiya Kekulandala, Nandana Ajith and Vajira Hettige (2012). Land Use Mapping for Promoting Urban and Periurban Agriculture and Forestry in Kesbewa Urban Council Area. Janathakshan Gurantee Ltd, Colombo, Sri Lanka. Report prepared for RUAF Foundation and UN-Habitat.
Faculty of Architecture, University of Moratuwa (2012). Vulnerability Mapping- Kesbewa Urban Council Areas, Sri Lanka. Report prepared for RUAF Foundation and UN-Habitat.
Jayantha Gunasekera (2012). Food Flow Mapping. Janathakshan Gurantee Ltd, Colombo, Sri Lanka. Report prepared for RUAF Foundation and UN-Habitat.
University of Colombo (2013). Report on Food Miles, Kesbewa project. Report prepared for RUAF Foundation and CDKN.

# Innovations in Urban Agriculture and Energy for Climate-Smart Cities in Kenya

Mary Njenga
Paula Braitstein
Courtney Gallaher

**The rapid, often unplanned urbanisation of cities around the world has resulted in widespread growth of informal settlements (slums) and an increase in urban poverty. Estimates suggest that by 2030 the world will be over 60% urban, with most urbanisation taking place in developing countries (UN-Habitat 2003). Poverty, food and energy security will have to be addressed in an integral way by promoting climate-smart livelihood strategies.**

## Urbanisation, food and cooking energy insecurity in the face of climate change

In many cities in Sub-Saharan Africa (SSA), slums account for three-quarters of urban residents. Kenya's capital, Nairobi, has a population of 3.2 million, and nearly three-quarters of the 7% per annum urban population growth is absorbed by the slums. These people rely on the sparsely available insecure employment that is paid for on a daily basis. Slum dwellers have also to deal with poverty, lack of adequate water and sanitation services, and increased costs of food, health and education services and cooking energy.

Cooking food is an important proponent of food security. Poor households often opt to cook foods that take a shorter time while abandoning the more nutritious traditional diets that take longer to process. Food and energy insecurity issues must therefore be addressed as a single problem. Further poorer populations cannot afford to use electricity and/or Liquid Petroleum Gas (LPG) for cooking because of the high costs of fuel and cooking appliances. Many of them therefore rely on charcoal for cooking. Charcoal provides energy for 82% of urban households in Kenya with a national annual per capita consumption of about 2.5 million tonnes of wood charcoal. The negative health effects of household indoor use of biomass fuels are significant. It is therefore worrisome to see that increasing costs of cooking fuels are pushing poor urban households to rely increasingly on unhealthy materials such as old shoes, used plastic containers and old plastic basins. This aggravates the risks of indoor air pollution, which causes 4 million deaths globally; in Eastern SSA, it is ranked second in burden of diseases, and mostly affects women and children.

## Innovations in urban agriculture in Kenya

In Nairobi, almost 300,000 households — about 60% of the population — depend partly on urban agriculture for food security and income. More than 650 hectares of land is estimated to be in use for urban and periurban agriculture. Urban agriculture is practised in backyard farms, open spaces under power lines, on the roadsides, beside railway lines and along river banks, as well as on institutional land.

In places where space is limited, as in the slums of Nairobi, communities grow vegetables in recycled containers such as nylon or sisal sacks right outside the houses. These sack gardens supply vegetables that are used at home, and surplus is sold for income. This activity also brings communities in the informal settlement together to work and share food stuffs.

> Urban agriculture innovations include forms of low-space gardening, resource recycling and urban tree planting and conservation

Growing vegetables in recycled containers next to the houses allows the vegetables to benefit from the shade provided by the roofs of the houses. This type of farming uses little water for irrigation and supplies food throughout the year. It increases vegetable dietary diversity among these households while reducing expenditure on the same.

## Turning urban pollutants into resources

The costs of farming inputs such as irrigation water and

*Wastewater farming opposite Kibera, Nairobi* Photo: Mary Njenga

*Sack gardening in Antananarivo* Photo Marielle Dubbeling

chemical fertiliser are out of reach for the majority of urban farmers. They source water and soil nutrients by tapping raw sewage, which provides both of these resources. Through experience, wastewater farmers have learned that using furrow irrigation, in which water flows by gravity with limited contact to crops, reduces health risks associated with biological contamination, as the water does not come in direct contact with the leaves.

In addition, women's and youth groups in Nairobi have organised themselves into entities that earn a living by turning organic waste into biofertiliser or compost. The groups collect and compost the waste from households, vegetable markets, institutions, food kiosks and hotels. Some groups also co-compost livestock manure with organic waste, which has the added benefit of cleaning up the footpaths and drainage channels where manure is dumped in poor neighbourhoods. The main customers of the compost include urban and rural farmers, urban landscapers such as golf clubs and urban plant nurseries.

Composting groups reduce the environmental and financial burdens of waste management in Nairobi, using approximately 1% of the organic component of the 3000 tonnes of waste generated daily. Even though a small percentage, this recycled waste does not have to be transported to landfills, reducing related energy costs. Decreasing the amounts of organic waste also contributes to reducing methane emissions in landfills. Safe reuse of wastewater for agriculture brings a source of nutrients and allows communities to produce food throughout the year. It also frees fresh water for higher value uses.

## Increasing resilience by tree planting and conservation in urban areas

Tree planting has been adopted as a strategy to rejuvenate degraded urban environments and reinforce urban sustainability by reducing erosion, enhancing green cover and replenishing the decreasing water table. Water shortages are common in urban areas in Kenya, and regional climate models suggest that urban areas will become drier, placing even greater stress on available water. In Nairobi, water shortages already affect most residential and industrial areas. During the dry season, the problem is so severe that Nairobi Water and Sewerage Company rations water deliveries such that some residential areas receive water only twice a week. Water shortages are associated with the degradation of water catchment areas as well as river pollution resulting from unabated waste disposal. Pollution of rivers, which is most severe during the rainy season, also results in a loss of aquatic biodiversity and directly affects human and livestock health. To address the shortage of clean water and the degradation of catchment areas, several groups, including the Nairobi River Basin Programme and the late former Minister of Environment, the Honourable John Njoroge Michuki, have championed planting of trees along riverbanks in Nairobi.

Nairobi has seen a significant increase in tree cover as a result of Nairobi City Council's tree and flower planting and beautification programme. Other tree planting efforts include Kazi Kwa Vijana (jobs for the youth). Trees improve the aesthetics of urban areas while recycling nutrients, fixing nitrogen and regulating the macro- and microclimate. Trees stabilise river banks, infrastructure and steep slopes in urban areas by reinforcing the soil. Trees, and importantly fruit trees, in urban areas increase the resilience of livelihoods and ecosystem. Trees provide urban residents (both human and livestock) with food and medicine as well as wood fuel and construction material.

Various community-based organisations have come together to save urban forests. One example is that of the Pombo-Sabor (Kaptagat) Forest Users Conservation Group working on rehabilitating and conserving the Kaptagat Forest officially called the Pombo-Sabor Forest. The forest is located in the southeast periurban area of Eldoret town, about 350 kilometres northwest of Nairobi, as presented in Box 1.

## Charcoal briquettes

Charcoal briquettes are another important innovation for urban sustainability. Their use mitigates climate change and energy insecurity while improving the lives of the urban poor. Charcoal briquettes complement / substitute for lump

*Pressing briquettes using a plastic container* Photo: Mary Njenga

charcoal and firewood for cooking and space heating. Cooking with charcoal briquettes made from charcoal dust (80 %) and soil (20 %) and burning for four hours (compared to 2.5 hours of lump charcoal) results in an indoor air concentration of carbon monoxide (CO) of 14.5 ppm and fine particulate matter ($PM_{2.5}$) of 30µg/$M^3$: 1/3 and 1/9, respectively, of what is emitted by lump charcoal. Briquettes are 9 times and 15 times cheaper than lump charcoal and kerosene respectively. In areas where they are produced, such as in Kibera slum, 70 % of households within a radius of 250 metres from the production zone use them for cooking and save up to 70 % of income spent on cooking energy (Njenga et al., 2013).

Because briquettes burn more efficiently and recycle organic waste, they save the trees that would otherwise be cut down for production of lump charcoal. Their low emissions helps mitigate global warming by reducing overall carbon emissions from cooking fuel, and reduces health risks associated with household indoor air pollution.

### Promoting local innovations

Urban agriculture builds resilient urban livelihoods by supplying food, generating income, creating jobs and building social capital. By using recycled urban wastes and wastewater for urban agriculture production, the practice furthermore contributes to reductions of emissions and the ecological footprint through reduced energy expenditure, decreased contamination of water bodies, and less clogging of open drainage systems — a climate-smart livelihood strategy worth supporting. Briquetting organic residues could provide a cleaner and affordable energy solution to the millions of urban poor in the developing world.
The use of alternative sources of water in urban agriculture will furthermore help to adapt to drought by facilitating year-round production and reduce the competition for fresh water between agricultural, domestic and industrial uses. Additionally, the use of water-saving and water-harvesting

## Pombo-Sabor Forest Users Conservation Group

*Pombo-Sabor forest is the primary watershed for Eldoret town, currently the fastest-growing town in Kenya. Pressure on the surrounding forests is heavy, with charcoal burning, illegal harvesting of firewood and timber, and other unsustainable activities, including, notably, livestock grazing. As a result the forests are dwindling, with potentially devastating consequences: reduced rainfall in a heavily agricultural area, low water supply for Eldoret town, heavy soil erosion in and around the forest, and increased hardship on local community members because of lack of access to firewood and grazing. To tackle this problem the local community came together and formed the Pombo-Sabor (Kaptagat) Forest Users Conservation Group. Since May 2011 the group has planted 150,000 indigenous trees, established an indigenous tree nursery, and fenced off more than 7000 metres of replanted areas to protect the seedlings from predation by livestock. They plan to fence off all 500 hectares of government-designated indigenous watershed forest, expand the indigenous tree nursery from 20,000 to 50,000 seedlings, establish an exotic tree nursery for income generation, plant 50,000 indigenous trees per year, halt and reverse soil erosion in and around the forest, establish an ecology education centre for children and youth, establish ecotourism services in and around the forest and support Kenya Forest Service patrols by supporting local youth as assistant forest patrols.*


*Women selling cooking briquettes in Kibera* Photo: Mary Njenga

technologies, and of less water-demanding (or more drought-resistant) crops and species is key in urban agriculture to minimise water demand.

Trees in urban areas provide biological products, recycle nutrients and fix nitrogen, conserve biodiversity and regulate micro- and macroclimate, all of which are crucial for sustainable cities. However, not all urban forest systems (including street trees, parks, urban or periurban forests) have the same impact. Impacts differ for different systems and in different locations. For example, in tropical areas, fast-growing trees contribute to $CO_2$ sequestration, but may put higher demands on water use. Native species may demand less water but are generally more shrub-like and provide less shade. Besides the potential benefits, costs also have to be considered. Abundant, (ever)green, dense urban and periurban forestry can reduce urban temperatures, but needs to be maintained and watered. Urban and periurban forestry needs to be low-maintenance and long-lived, and require little energy (e.g., for maintenance, fertilisers, etcetera) and water inputs.

The continuous innovations by the poor city dwellers require support from governments and other organisations to help them access information, modern technology, finance, water, space, infrastructure and marketing services. Recognising local innovation is one promising entry point to empowering farmers and laying the foundation for improving farmers' livelihoods and, ultimately, enhancing the development of more sustainable cities.

**Mary Njenga, Paula Braitstein and Courtney Gallaher**
Email corresponding author: M.Njenga@cgiar.org

Recognising local innovation is a promising entry point to empowering farmers and enhancing the development of more sustainable cities

**References**

Gallaher C. M., Kerr, J. M., Njenga, M., Karanja K. N. and Antoinette M. G. A. WinklerPrins (2013). *Urban agriculture, social capital and food security in the Kibera slums of Nairobi, Kenya.* Journal of Agriculture and Human Values. 30 (3) 389-404.

Njenga. M., Yonemitsu, A., Karanja, N., Iiyama, M., Kithinji, J., Dubbeling M., Sundberg, C and Jamnadass, R. (2013). *Implications of charcoal briquette produced by local communities on livelihoods and environment in Nairobi, Kenya.* International Journal of Renewable Energy Development (IJRED). 2 (1) 19-29.

UN-Habitat (2003). *The challenge of slums: Global report on human settlements.* London and Sterling, VA: Earthscan.

World Bank (2013). *Urban Agriculture Findings from Four City Case Studies.* Urban development series knowledge paper. Urban Development & Resilience Unit. World Bank Washington, DC.

Zhao M., Kong Z. H., Escobedo F. J., Gao J. (2010). *Impacts of urban forests on offsetting carbon emissions from industrial energy use in Hangzhou, China.* Journal of Environmental Management 91. p.807-813, Elsevier Ltd.

# Rooftop Agriculture in a Climate Change Perspective

Marielle Dubbeling
Edouard Massonneau

**Rooftop agriculture is the production of fresh vegetables, herbs, fruits, edible flowers and possibly some small animals on rooftops for local consumption. Productive green roofs combine food production with ecological benefits, such as reduced rainwater run-off, temperature benefits such as potential reduction of heating and cooling requirements (resulting in reduced emissions), biodiversity, improved aesthetic value and air quality.**

Three primary types of food-producing green roofs can be distinguished:

- Agricultural green roofs or direct-producing green roofs on which crops are directly grown in (shallow) beds in a soil-based growing medium that is possibly placed on top of a waterproof membrane or additional layers such as a root barrier, drainage layer and an irrigation system.
- Rooftop container gardens or modular green roofs that involve the growing of vegetables, herbs, fruits and flowers in pots, buckets, containers, bottles or raised beds which contain a soil-based growing medium.
- Rooftop hydroponic systems which involve growing plants using water-based nutrient solutions in place of soil. These require on-going fertiliser inputs. There are exposed hydroponic systems used in open-air settings, as well as hydroponic systems grown under cover (glass or plastic) to help increase yields and extend growing seasons.

Rooftop gardens can be placed on individual homes, institutional and office buildings, and roofs of restaurants and serve either home consumption, use of fresh produce in restaurants or institutional kitchens or commercial production.

*Rooftop garden in Toronto, Canada* Photo: Joe Nasr

## Climate change impacts of rooftop agriculture

Cities concentrate impermeable surfaces like pavement and concrete, impeding storm water drainage as well as absorbing and converting solar radiation to heat. Green roofs can offset these phenomena, depending on the type of production system and local climatic conditions, and make urban areas more sustainable and viable in the long-term. If well designed and maintained, green roofs may also double or triple the life span of the typical roof. This results in reduced maintenance costs and decreases the amount of waste material to be disposed at a landfill site. The initial expense of a green roof may thus be earned back in energy and cost savings and avoided environmental damage.

Green roofs also offer an opportunity to promote inner-city biodiversity on underutilised, empty roofs and to address food security issues through the production of food.

Information on the impact of green roofs on climate change is provided by several researchers, though mainly from the global North. There are minimal surveys to date which deal with the combination of green and productive roofs. It is more difficult to get the same impacts with rooftop agriculture gardens as with green roofs. Unlike green roofs without production of food, the coverage of rooftop agriculture is often not continuous, particularly with seasonal crops. For agricultural roofs there are also additional demands for safety and access, and inputs have to be supplied more regularly.

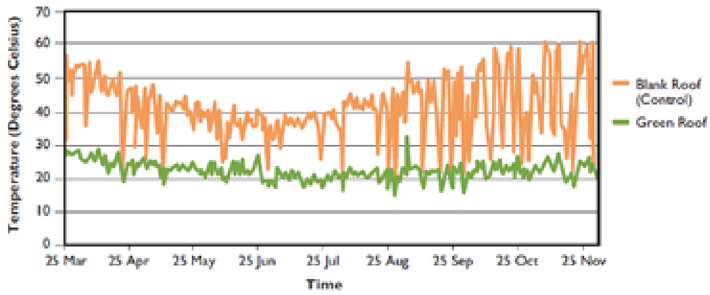
There are also differences among the different rooftop garden systems. In hydroponic systems for instance, due to the lack of soil or an organic growing medium, water run-off is not reduced. Hydroponic systems also require a higher level of (initial) investment and maintenance, thus increasing related energy costs. However, when placed under permanent cover (greenhouses), hydroponic systems will contribute to insulation. As agricultural yields can be high under these systems, contributions to food security will also increase, as well as the related impact on reducing GHG emissions related to transport from food grown outside the city.

## Can rooftop gardens reduce the urban heat island effect?

An important problem in cities is the urban heat island effect, or the overheating of cities due to dense concentrations of asphalt (including rooftop and pavements) that absorb solar radiation. On average, temperatures can be between 5°C and 15°C higher in urban areas than in rural areas.

The urban heat island effect contributes to pollution and increased energy consumption. The more temperatures increase, the more people rely on energy-intensive artificial cooling.

Large-scale roof planting can help reduce the urban heat island effect in the inner city through shading, absorption of heat in plant thermal mass and evaporational cooling. Green roofs reduce the air temperature above the rooftops as a result of solar reflection and evapotranspiration. Durban studies showed that the air temperature above a blank roof is higher than above a green roof. The average ambient air temperatures above the green and blank roof were 22°C and 41°C respectively from 24 March 2009 to 24 November 2009.




*Average temperature readings taken on blank and green roofs from 24 March 2009 to 24 November 2009. All temperature readings were taken at 13:00 (Van Niekerk et al., 2011)*

According to the city's Department for the Environment, on summer days in Chicago temperatures atop the green-roofed City Hall are typically 14 to 44°C cooler than the adjacent county office building, which has a black tar roof.
During summer, green roofs can thus have an impact on cooling homes and buildings. As a result the need for energy-intensive artificial cooling (air conditioners) inside buildings can decrease. Studies in Germany have shown that a green roof habitat can decrease the ambient temperature in underlying rooms by 3–4°C. Canadian researchers found that green roofs reduce the daily energy demand for cooling by 95% compared to a conventional roof: from 19.3 kWh per m² for a building under a conventional roof to 0.9 kWh per m² for a building under a green roof.

> The impacts of green roofs on climate change are well researched. Information on productive/agricultural rooftops is however very scarce

During winter, green roofs may diminish the energy use for heating by absorbing solar radiation and diminish the heat loss through the roof by providing insulation. The Canadian study found that green roofs can reduce the heat loss from a building by approximately 26% during the winter months.

Most of the studies referred to, however, have been implemented in temperate and northern climates. The question remains whether similar effects will be observed in tropical climates. Only the Durban study gives insight in the potential positive impacts of green rooftops in a city that experiences a subtropical climate with high temperatures and

### Factors influencing the reduction of the urban heat island effect

*In order to lower air temperature on the rooftop, best effects are found when a permanent green soil/vegetation coverage on the roof is maintained. Generally, more than 75 % of the roof would have to be under soil/vegetation to have any measureable effects on the urban heat island/energy use and storm-water run-off. Plants with a high leaf surface area, perennial crops, self-seeding plants, and fast-growing plants contribute to maintaining such permanent green cover.*

high levels of humidity, particularly in summer. Results of the studies done so far demonstrate that there exists a significant opportunity to reduce the urban heat island effect in Durban by creating green roof habitats on empty roof tops. This refers not only to empty roof tops in the city centre, but also in densely developed suburban areas.

Reductions in energy use and emissions will, however, be offset against energy use and GHG emissions related to maintenance, production and transport of needed materials and inputs. 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?). More research is needed to understand effects on urban temperature and the urban heat island for different types of agricultural green roofs in different localities.

## Reducing rainwater run-off

Cities generate a substantial amount of accelerated storm water run-off as a result of large areas of impervious surfaces, such as roof tops and roads. In the case of heavy rainfall, this can result in the capacity of the city's storm water drainage systems being exceeded, resulting in the flooding of rivers, streams, and possibly houses and roads. Projections suggest that climate change will exacerbate this situation by increasing the frequency and intensity of rainfall events.

### Factors influencing rainwater run-off

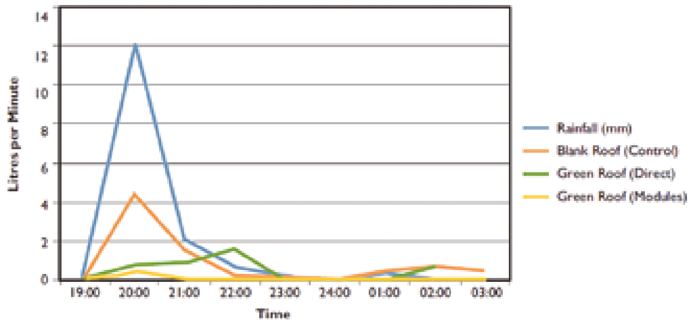
*The efficiency to reduce rainwater run-off depends on three factors:*

- *soil depth: deeper soil retains more water.*
- *type of plants grown: plants with high leaf surface area intercept more rainwater, plants with a large root mass absorb more water, seasonal crops are less efficient at times of the year when plants are absent or in the development stage (the leaf area is reduced).*
- *green roof surface area and cover: a greater surface area retains more rainwater; year-round coverage is more effective than seasonal coverage.*

Green and productive roof systems may contribute to storm water drainage by reducing the velocity and the amount of rainwater run-off, through the absorption of water by the soil media and plant roots. Impacts depend on the depth of soil or type of substrate used, and the extent and type of vegetation cover.

Experiences in the USA have shown that green roofs may capture 50–95 % of summer rainfall, while peak run-off flows can be reduced approximately 50 %. Other research has shown that 7.5–12.5 cm of soil or growing medium can absorb 75 % of rain showers that are 1.5 cm or less.

According to eThekwini Municipality's Environmental Planning and Climate Protection Department studies on Durban, the amount of the storm water run-off from green roofs is eight times less than the amount from blank roofs. As well, the peak flow from a green roof habitat is far lower than that of a blank roof during a rainfall event. It is important to note that green roofs can also substantially delay the peak run-off. A green roof retains the storm water and releases it slowly over a longer period of time. This reduces the pressure on storm water infrastructure during heavy rainfall events. Germany has started introducing tariffs for storm water run-off that accumulates on impervious surfaces such as roof tops. German studies have shown that a green roof habitat with a soil depth of 10cm can reduce annual storm water run-off by as much as 50 %, thereby effectively halving the amount of roof run-off, which would be subject to annual fees.




*Comparison of rainfall run-off from a green roof and blank roof (Van Niekerk et al., 2011)*

## Biodiversity

Green roofs can add to biodiversity. Compared to a blank roof, a hundred times more insects were identified on a Durban green roof system. Insects were — logically — also found in higher density. In turn, the insects attracted birds. A diverse choice of plants, depth and composition of the growing medium can attract a greater variety of insects and birds. Use of perennial plants, flowering at different times of the year, will be important to offer a permanent source of food and shelter for the insects.
An advantage of the container roof systems is that some small containers can be used as ponds. This creates small aquatic habitats which attract water-loving insects.

*Rooftop gardens in Kathmandu, Nepal* Photo: ENPHO

| Systems | Surface area (ha) | Conservative Estimated Yields (kg/ha) | Produce requirements of 10.000 people (%) |
|---|---|---|---|
| Productive green roofs (without hydroponic system) | 2.75[1] | 26 000 | 4.4 |
| Productive green roofs and hydroponic greenhouses | 4[2] | 346 000 | 59.5 |

*Vancouver's estimates for food production of green roof systems (Holland Barrs Planning Group et al., 2002)*

[1] *half of Vancouver's usable rooftop space*

[2] *hydroponic greenhouses surface area: 1.25 ha*

## Reducing food insecurity

Agricultural productive green roofs contribute to food security by producing local fresh food. They provide an interesting opportunity to grow food in inner city and densely built-up areas otherwise often lacking (open) space for food production.

If half of Vancouver's usable rooftop space were used for urban agriculture, it could generate around 4 % of the food requirements of 10,000 people. When combining this with hydroponic greenhouses, this figure could be increased to 60 %.

In 2003, the City of Toronto owned approximately 1,700 buildings. Researchers proposed to convert 20 % of all city-owned rooftops into agricultural green roofs over three to five years. Assuming a modest average food garden surface of 465 m², it would further make approximately 16 hectares available for food production and for moisture absorption.

### Tulasi Subedi, Nursing Teacher, Subidhanagar Kathmandu

*Despite her hectic schedule, Tulasi Subedi always finds time to work in her rooftop garden, where she has been growing many vegetables recently. Vegetables grown in her own garden cover food needs for her family. She also shares vegetables among her neighbours and relatives. She is not worried anymore about frequent strikes (when shops are closed). "We don't have to buy vegetables during festivals. People praise me after visiting our rooftop garden. There was strike during Constituent Assembly Election. That was not a problem for us as we had spinach, brinjal, radish, carrot, coriander, tomato and other vegetables in our garden," says Subedi.*

Food grown on a rooftop, which is consumed by the household or in the neighbourhood, will positively contribute to increased diversification of food and income sources and reduced vulnerability to food price increases and economic crisis.

To address this, KMC and the local NGO Environment and Public Health Organization-ENPHO , supported by UN-Habitat and RUAF Foundation, are promoting productive rooftops, coupled with harvesting rainwater, recycling organic household waste and using climate-smart production technologies, among 139 households. Also, two demonstration gardens have been set up and a demonstration rooftop garden model was developed. In addition, Kathmandu Metropolitan City has trained another 100 households with a view to reaching an additional 500 households in the course of this year. For this purpose, KMC has allocated around USD 30,000 for a rooftop garden program for the upcoming fiscal year 2014/2015. In total, over 14 ha of rooftops would be available in the KMC area. A draft rooftop garden policy has been formulated by the KMC Department for Environmental Management and discussed with local and national policy stakeholders and other urban actors in December 2013. The policy will need to be submitted to KMC for formal approval. Support to the operationalisation of the policy, specifically in other sectors than the environmental management department (e.g., building sector; climate change policies and action plans) is needed to ensure its wider uptake and expansion of activities.

**Marielle Dubbeling and Edouard Massonneau**
RUAF Foundation
Email corresponding author: m.dubbeling@ruaf.org

MARKET
11
República

According to officials of Kalimati Fruits and Vegetables Market Development Board, vegetables prices have increased mainly because of supply constraints.

Veg prices increase as supply drops

*Vegetable prices increase as supply drops* Source: República, April 2, 2012

## Promoting Rooftop gardening in Kathmandu, Nepal

*For many years, Kathmandu has faced large numbers of immigrants from rural areas. Over one million people live in Kathmandu Metropolitan City (KMC), while the rest live in four other municipalities and the surrounding periurban areas.*

*Uncontrolled and rapid urbanisation has resulted in an increase in environmental pollution, ground water scarcity, waste and water management problems, as well as a rapid decrease in agricultural land. Loss of these production areas, that traditionally provided Kathmandu city with rice, grains, vegetables, poultry and dairy, made it more vulnerable to disruptions in food supply. The city now has to depend on the produce of either rural areas or imports from India or China. The only major access road is often blocked owing to floods or landslides, while the changing climate is likely to increase the frequency of such natural disasters. Climate change has also already affected rural production, resulting in steep increases in vegetable prices in 2012. Protection and preservation of remaining periurban agricultural lands is deemed highly necessary. Additionally, the potential of using built-up spaces, and specifically rooftops, could provide an interesting opportunity to grow food in inner-city areas, otherwise often lacking (open) space for food production.*

**References**

Holland Barrs Planning Group, Sustainability Ventures Group (2002) Southeast False Creek Urban Agriculture Strategy. City of Vancouver, Canada.

Keane L. et al. (2006) Chicago Green Roofs, Guide for building Green Roofs in Chicago. The City of Chicago and The School of the Art Institute of Chicago.

Kisner C. (2008) Green Roofs for Urban Food Security and Environmental Sustainability. In : International Actions. Climate Institute.

Liu K. and Baskaran B. (2003) Thermal Performance of Green Roofs Through Field Evaluation. NRCC-46412, National Research Council, Ottawa, Canada.

Nasr J., MacRae R., Kuhns J. (2010) Scaling up Urban Agriculture in Toronto: Building the Infrastructure. Metcalf Foundation.

Quesnel A., Foss J., Danielsson N. (2011) Solutions from Above : Using Rooftop Agriculture to Move Cities Towards Sustainability. School of Engineering Blekinge Institute of Technology, Karlskrona, Sweden.

Van Niekerk M., Greenstone C., and Hickman M. (2011) Creating space for biodiversity in Durban : Guideline for designing Green Roof Habitats. In : The Official Website of the eThekwini Municipality, Environmental Planning and Climate Protection.

# Multiple Use of Green Spaces in Bobo-Dioulasso, Burkina Faso



Moussa Sy
Hamidou Baguian
Narcisse Gahi

**In Bobo-Dioulasso, the municipal authorities have considered the full extent of climate change impacts on their city and have decided to implement initiatives for limiting their consequences. In this context they set up a Municipal Unit for the Management of Climate Change and are promoting productive multiple uses of their green spaces.**

Bobo-Dioulasso is the second-most important city of Burkina Faso, after its capital, Ouagadougou. It is located in the southwest of the country, 360 km from Ouagadougou, in the Houet province and the Hauts-Bassins region.

Bobo-Dioulasso was home to about 800,000 inhabitants in 2012. The Municipality of Bobo-Dioulasso covers a surface of 160,000 ha, of which approximately 30,000 ha are classified as urban areas. The city is characterised by high levels of urban poverty and food insecurity.

Bobo-Dioulasso municipality, with the support of UN Habitat's Cities and Climate Change Initiative phase 3 and under the coordination of the RUAF Foundation, committed to promoting urban and periurban agriculture and forestry (UPAF) as a climate change adaptation strategy. This article highlights the project activities implemented and also the preliminary results at technical and policy levels.

## Climate change impacts Bobo-Dioulasso

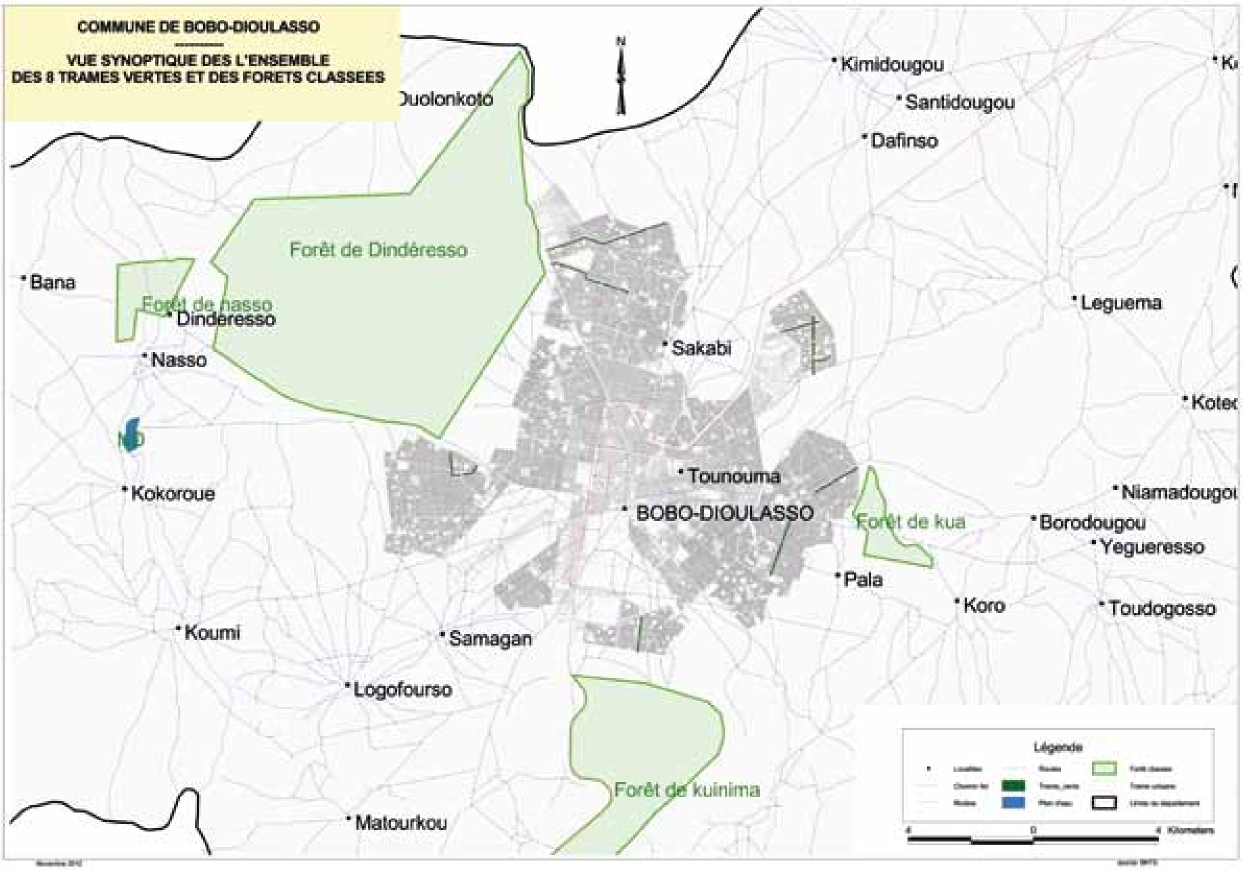
The climate in Bobo-Dioulasso can be classified as tropical-savannah. Like other cities in Burkina Faso, Bobo-Dioulasso faces the impacts of climate perturbations that reinforce provisions made in the National Action Plan for Adaptation to climate change in Burkina Faso (PANA). This Plan forecasts a decrease of 3.4 % to 7.3 % in rainfall, respectively, by 2025 and 2050, as well as an increase in average temperature of 0.8°C by 2025 and of 1.7°C by 2050. The projected increase in extremely hot days is predicted to have severe impacts on energy demand for cooling and heat-related illnesses.

Evidence of climate change in Bobo-Dioulasso includes the late start of the farming season which, in comparison with the 1950s, shows current delays of about two months; the shortening of the rainy season and changes in spatiotemporal distribution of rainfall; temperature rise; and greater incidences of floods and dust storms. The most striking impacts are the increase in pollution; the variation in agro-silvo-pastoral productivity from one year to another; the reduction in animal watering places and the degradation in pasture areas related to drought. As a result of this greater vulnerability of agricultural activities, we see an increase in rural-to-urban migration, increasing prices of many primary foodstuffs, an outbreak of various diseases that had almost disappeared (tuberculosis, poliomyelitis, meningitis, etc.) and an increase in urban poverty. Also, more frequent floods can be witnessed, with corresponding housing, agricultural and infrastructural damage as well as worsening urban living conditions (dust storms, hot conditions).

> The municipality of Bobo Dioulasso promotes urban agriculture and forestry as a climate change adaptation strategy

## Multifunctional use of greenways: an adaptation strategy

Urban and periurban agriculture occupies 7 % of the population of Bobo-Dioulasso that are involved in cereal farming in the periurban areas and in market gardening along the Houet stream and in intra-urban areas. Despite pressure from illegal construction and other land uses as well as waste dumping, brick-making and illegal cutting of wood, the city has still managed to maintain 60 hectares of so-called *Trames Vertes*, or greenways, large open spaces that connect in various places to the periurban forested areas. In order to promote a more sustainable urban development model, the Municipality of Bobo-Dioulasso has agreed to preserve and protect the border zones between the city and its forests and to preserve the greenways as areas with multifunctional and productive land uses.
By regulation, the greenways function: (i) to restore, (ii) to protect and (iii) to manage the biodiversity in situ, by favour-




*Synoptic view of the greenways and protected forests of the city* Source: Municipality of Bobo-Dioulasso

ing the preservation of the minimal conditions of life and traffic necessary for the survival of species. The greenways distinguish themselves by a relative connectivity with the periurban forests. Greenways are subjected to the regulations applicable to green spaces, which allow for their public management and preserve them from seizure.

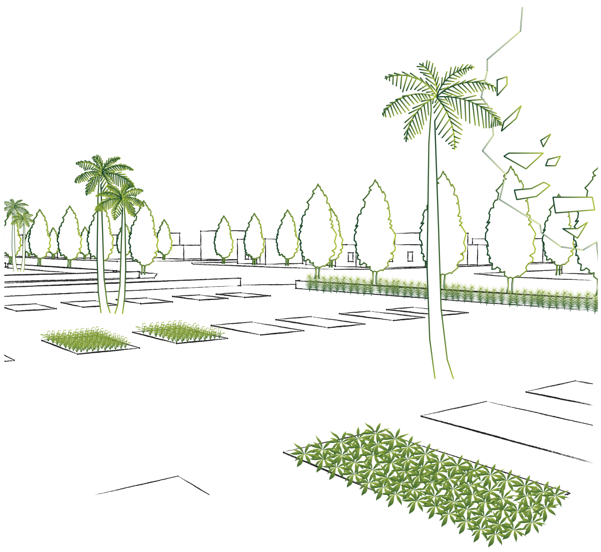
The main objective of the project is to demonstrate the contribution of greenways in reducing climate change impacts, while improving the living conditions of the neighbouring population.
The greenway of district 33, which covers 6.9 hectare, was chosen as a pilot project and designed with the following functions: forest production (acting as windbreaks, providing shade, retaining run-off and providing a source of fuel and fodder), market gardening, and development of recreational and environmental education areas.

The project aims to contribute to (i) the reduction of temperature and run-off by mitigating the urban heat island effect and serving as "green lungs" for the city; and (ii) the improvement of the resilience of the population by increasing and diversifying their food and income sources. The project will also have beneficial impacts on the maintenance of urban biodiversity and other ecosystem services.

## Project implementation

The multifunctional development of the greenway in sector 33 required the set-up of a multidisciplinary team composed of municipal technicians and agents from the municipal and the decentralised governmental services in charge of climate change; parks and gardens, and environment and agriculture. The project team also includes researchers responsible for the monitoring of the project's impacts.

From the start, the project sought the direct involvement of decision makers by signing a partnership agreement between the municipality and RUAF. The agreement stipulated the formal (mayors') decision authorising the project and the municipal counterpart budget of EUR 20,000 as well as the assignment of three technical staff to the project.



*Design of the greenway* Source: Frida Skarp

*Market gardening on the greenway* Photo: Moussa Sy

Several consultation meetings and exchanges with municipal authorities were organised.
At the same time, community mobilisation was conducted through meetings with local leaders, household surveys and awareness-raising for community associations. These activities facilitated the selection process of the beneficiaries in a participatory and interactive manner. A list of forty direct project beneficiaries was established.

## Civil engineering work

The civil engineering work involved the demarcation of the site with a surface area of 6,994 hectares, with a length of 1,650 m and a width of 50 m. The demarcation has allowed the area to be divided into 10 small "islands" that each were attributed with a different land use. A low wall made of local stones was constructed to surround the perimeter.

## Market gardening and forestry activities

The market gardening and forestry activities involved the digging of water points: two concrete-cased wells and three ordinary hand-dug wells for irrigation. Forest and fruit-tree seedlings were ordered and provided to the beneficiaries to establish orchards, hedges, windbreaks and an arboretum. In the agricultural plots, gardening beds were located and a first crop cycle started during the rainy season.

## Preliminary results

It is not easy to obtain tangible results from an agroforestry project in a relatively short period of time (early 2013 - February 2014). Nevertheless, there are some preliminarily interesting results that should be appropriately maintained and supported to lead to larger and sustained impacts. Indeed, the preliminary results show that the multifunctional development of the greenways is likely to have a significant and positive impact on the physical and social environment and at the political-institutional level.

> Development of legal texts for the management of greenways will allow for upscaling of project results to other neighbourhoods in the city

## Political-institutional advances

Throughout the course of the project, the municipality managed to (i) install and institutionalise a municipal committee for the management of the greenways, (ii) draft and adopt a technical statute for the greenways promoting their productive and multifunctional use, and (iii) adopt a set of specifications applicable to the exploitation of the greenways. The draft legal texts were submitted to the Environment and Local Development Commission of the Municipality at the time of its ordinary meeting on December 27th, 2013. On the basis of their suggestions and observa-


*Urban greenways -important areas for enhancing access to green spaces in dense cities*

tions, the documents were revised and will be submitted again to the environment commission and the municipal council for formal approval and adoption.

Moreover, the involvement of the decentralised state services in the planning and implementation of the project has reinforced their capacity and partnership with the Municipality. These services are now sufficiently equipped to support the replication of the project on a larger scale.

## Environmental indicators

All the environmental indicators show positive changes. The run-off coefficient has been reduced by 4 %, thus potentially impacting the reduction of flood risks and increased infiltration and replenishment of subterranean water sources. The potential of $CO_2$ sequestration by the planted mango and cashew trees over the coming hundred years is calculated to be 1835.36 tons of $CO_2$ per hectare. This corresponds to a potential sequestration of 975,923 tons $CO_2$ for the whole area (60 ha) of greenways over the same period.

The evaluation of the future impacts of UAF greenways in terms of mitigation of the effects of high urban temperatures has been carried out by analysing satellite images. It consisted of comparing the effects of the temperatures among zones with good vegetation cover (periurban areas) and those with high levels of urbanisation (urban areas). The results show that temperatures over these last years are (increasingly) higher in the urban areas. This underlines the relevance of UPAF installations to temperature reduction in the urban environment.

## Food and nutritional diversity

The productions obtained during the first phase of production from August to October 2013 show that the UPAF project can contribute to at least 6 % of the monthly food expenditures of the agricultural households involved in the project. In the same way these productions contribute to a more permanent availability of home-produced food for these households.

Such increased diversification of food and income sources helps to increase the resilience of poor households, which are generally vulnerable to increases in food prices.

## Conclusions

Even though the described results are still preliminary, and future actions should be undertaken to ensure continuation and improved functioning of the project, they can be used as a reference to enhance the urban dialogue on the multifunctional development of greenways in the fight against climate change in Bobo-Dioulasso and Burkina Faso.

Further technical assistance to the field activities, motivation of beneficiaries and, especially, political support are required. There is a relatively high potential of replicating the sector 33 project in other greenways in the city, especially if the draft legal texts are approved and effectively applied. The existence of the new “Fund for Interventions in the Environment/ Fonds d’Intervention pour l’Environnement” also offers opportunities for promoting UPAF on a national scale as a strategy for nutritional and food safety and adaptation to climate change.

**Moussa Sy**
Email: msy2870@gmail.com
**Hamidou Baguian**
Email: h_baguian@yahoo.fr
**Narcisse Gahi**
Email: gahi_z@yahoo.fr

**References**

IAVS, 2014. Rapport des activités scientifiques (Aout-Novembre 2013) du projet d’intégration de l’Agriculture et de la Foresterie Urbaine et Périurbaine dans les stratégies d’atténuation et d’adaptation aux changements climatiques de la ville de Bobo-Dioulasso.
PANA, 2007 Programme d’Action National d’Adaptation à la variabilité et aux changements climatiques. Burkina Faso.
Programme des Nations Unies pour les Etablissements Humains au Burkina-Faso, Rapport 2009.

# Coping with Flooding in Bangkok



Piyapong Boossabong

**From late 2011 to early 2012 many areas in Bangkok, the capital and the biggest city in Thailand, faced the most terrible flooding in roughly 70 years. Even though flooding is common in some areas in the city, this time more than half of the city was flooded with water levels reaching up to more than 2 metres. Food shortages occurred as a result of this disaster. Policy networks on urban agriculture played an important role in dealing with the urban food problems that emerged during the floods.**


*Food distribution during the flooding in Bangkok*
Photo: Health-Me Organic Delivery

## Floods and food shortages in Bangkok

Bangkok's inhabitants mainly depend on food transports from outside the city, especially dominated by a few monopoly food corporations. Such corporations own discount and convenience stores, which can be found everywhere. A survey by Rapijun Phoorisumboon (2012) found that these stores control food production and distribution, shape consumer food culture, and also contribute to a reduction of local food variety.

When flooding converted the main road into a river, transportation of goods was interrupted. Many food industries and distribution stores were flooded as well. As a result, consumer demand for food could no longer be met, and food prices increased. On average, food prices increased by 3-4 times, while in the case of vegetables, prices were even ten times higher.

As a consequence, about 41,500 households could not access enough food, while others lacked specific types of food (mainly fresh products) (surveyed by Bangkok Metropolitan Administration in 15 October 2011). Certainly, the urban poor and marginalised people were the most vulnerable and affected.

## The mainstream food aid system and its problems

The mainstream aid system responded to the food crisis by providing food through public agencies with the support of many corporations and international organisations. Mainly dried and processed food items such as instant noodles and canned fish were provided, while fresh food was rarely available. Because of the centralised allocation units, "one-size-fits-all" approach and political bias of food allocation, food aids did not reach and meet the need of many vulnerable groups.

## Urban agriculture: an alternative strategy for dealing with the urban food agenda during floods

Small-scale farming in the city is one of the cultural identities of Bangkok. Not only are there still 13,774 full-time farming households out of a total population of 5.7 million, who cultivate over 70,000 acres located in Bangkok's periurban fringe (Policy and Planning Division, 2012); there are also many communities, organisations and households growing vegetables in the inner city. The awareness on city farming has clearly developed since 1997, when Thailand faced a harsh economic crisis known as the 'Tom Yum Kung' crisis. At that time, the King, who is generally respected by Thai people as a father of the country, made a speech about growing food in limited areas by low-input methods and for self-reliance. His speech promoted Thai people to grow food everywhere. Even though inner city farming is of small scale and only contributes to a minor extent to an alternative food system, in many respects it is able to play an important role, specifically for the urban poor and marginalised groups. City farming has been supported by many actors, especially since 2010 when the City Farm programme was endorsed by the National Health Promotion Foundation, the Prime Minister's Office. The various actions implemented by different actors under the umbrella of the City Farm programme are defined here as *policy networks on urban agriculture* (for more on the concept of policy networks see Marsh, 1998, p.8).

The City Farm programme was funded under the food and nutrition programme of the National Health Promotion Foundation and managed by many non-governmental bodies led by the Thailand Sustainable Agriculture Foundation, Centre of Media for Development, Working Group on Food for Change and the City Farm Association (a cooperation of different social enterprises). The programme involved a variety of actors, such as the District Administration offices (local government), Green Market Networks, Slum Dwellers Networks and Informal Labour Networks, green food corporations, social enterprises, social activists and community based organisations.

Policies should adequately respond to the urban food agenda that is at stake during extreme climate events

At the beginning of the programme the policy networks promoted urban agriculture as an activity to enhance city dwellers' livelihoods. However, the extreme flooding led the policy networks to rethink and reshape their strategies. During the floods, the policy networks worked intensively and collectively to respond to the urban food shortages that had occurred. They realised that urban agriculture not only contributes to enhancing livelihoods, but can also be promoted as a strategy for climate change mitigation and adaptation.

In dealing with the food agenda during floods, the policy networks filled the gap that was left by the mainstream food aid system. They did so by mobilising local actor networks and by utilising the capacity of the local food system. The following are some examples of the interventions supported by the policy networks during the floods.

### Providing food for the most vulnerable people during the disaster

While the most vulnerable households, such as the urban poor and the marginalised groups, did not receive specific attention from the mainstream food aid system, the policy networks on urban agriculture prioritised support to them. As vegetables were rare and very expensive during the flood period, the policy networks mainly provided vegetables collected from local sources and the urban agriculture projects developed by them.

### Providing materials and training on producing emergency food

The proverb "to teach somebody to fish is better than to give him fish" became one of the principles of the work of the policy networks. Next to food distribution, the policy networks provided a set of materials, training and assistance to the flood victims on simple and short-period food production, such as sprouts and mushrooms. Each household could produce 3 kilogrammes of sprouts every 3 days, while they could produce 20 kilogrammes of mushrooms from 20 chunks provided to them. To cook food without electricity, victims were provided a solar power cooking box.

### Developing food innovations for living with water

Once the floods were forecasted to persist longer, many of the policy networks organised meetings and focus groups for sharing experiences and to develop food innovations for living with water. They established the temporary movement named "GOD": "Growing Out Disaster". They tried to

*Training on growing sprouts at Kehatungsonghong-Samsoonhok* Photo: Centre of Media for Development

*Illustrating how to produce mushrooms during flooding*
Photo: Nardsiri Gomonpun, City Farm programme coordinator

teach and share food innovations for living with water and promoted these amongst the city dwellers. Some of the innovations include rooftop gardening, vertical gardening, growing food in containers, hanging gardens, floating gardens, and applying a farming technique called "EM ball" (an effective microorganism ball for flood water decontamination).

## Supporting mutual aid during floods

Another contribution of the policy networks was the support to mutual flood aid between city farm consumers and producers who had joined the Community Supported Agriculture (CSA) programme facilitated by the policy networks. For example, the green restaurant called "Health-Me Organic Delivery", in cooperation with the Green Market Network and the Working Group on Food for Change, established free cafeteria nodes located near the places of the farmers that were flooded. The temporary cafeterias became a space for daily cooking and eating food from these producers. The green restaurant provides information that these cafeterias could feed roughly 2,100 victims from 5 different areas. The policy networks also mobilised collective actions to share seeds with the involved city farmers and to support the farmers to re-establish and habilitate their plots and farms.

Moreover, the policy networks also played an important role in criticising the priorities of the government, under which farm areas were poorly protected, and the role of monopolised and centralised food distribution in the mainstream food system. They played a role in raising awareness on urban food security, food sovereignty, environmental sustainability, and adaptation to climate change.

## Discussion

The possibility of urban agriculture to enhance the adaptive capacity of the city to respond to the urban food agenda during an extreme climate event has now been demonstrated in a country that always considered itself to be a land where food is abundant. Nevertheless, the policy networks on urban agriculture in Bangkok are still insufficiently recognised as alternative food governance mechanisms and can only contribute on a small scale, mainly as a result of continued government priorities to support the industrial food system, and the absence of international recognition for urban agriculture as a disaster risk reduction strategy. Apart from that, the policy networks on urban agriculture are hindered by contradictory roles of the national and regional governments. For example, while they agree with the development of food innovations such as floating gardens, they do not allow any objects that may obstruct the water flow in the river. The policy networks are also challenged by the problem of accessing land for farming in the city and securing the land rights of the city farms. The policy networks are not able to respond to such challenges alone as this requires a transformation of the formal land ownership structure in Bangkok.

A positive outcome however is that city dwellers have become more aware of the issues of food insecurity and the right to food. The number of requests for training is increasing. The policy networks are also expanding, as many new actors become engaged. An important question that remains is how to further enhance the collaborative governance of the policy networks on urban agriculture to respond adequately to urban food agendas that are at stake during possible future extreme climate events.

**Piyapong Boossabong**
Head of the Thai City Farm Programme Monitoring and Evaluation Team, PhD. Candidate, Development Planning Unit, UCL
Email: piyapong.boossabong.10@ucl.ac.uk

**Note**
This article is a summarised version of a full paper that was presented at the RGS-IBG International Conference on Governance of Urban Environmental Risks in the Global South, Edinburgh, Scotland, 3-5 July 2012.

**References**
Boossabong, P., 2012, *Growing Cities for Growing Life: Ideas and Practices of Urban Agriculture*, Bangkok: National Health Promotion Foundation and Thailand Sustainable Agriculture Foundation.
Hutapate, K., 2011, Green Life Bag, *Natural Agriculture Magazine*, Vol.14, No.10, pp.5-7.
Marsh, D. (ed.), 1998, *Comparing Policy Networks.* Buckingham and Philadelphia: Open University Press.
Phoorisumboon, R., 2012, The centralisation of food distribution and its impacts on food security during Thai floods. *The national conference on seed freedom, food sovereignty and food security*, Kasetsart University, 16-17th May 2012.
Policy and Planning Division, 2012, *Agriculture in Bangkok*, Research Report, Department of City Planning, Bangkok Metropolitan Administration.

# Needs and Requirements for the Monitoring of UPAF Impacts

RUAF Foundation

**Urban and periurban agriculture and forestry (UPAF) is often credited with the following benefits: reducing "food miles" by producing fresh food close to urban markets; reducing fertiliser use and energy consumption by productive reuse of urban organic wastes; enhancing rainwater infiltration and reducing the urban heat island effect by increasing the surface of green areas; enhancing carbon sequestration (urban forests); and providing better diets, urban food security, jobs and income. However, for UPAF to be promoted as an effective component of climate-compatible development strategies and climate change financing, there is a need for greater empirical evidence and quantification of these benefits.**

An interactive exchange among northern and southern research institutions and content experts, decision makers and international organisations was facilitated as part of a CDKN-funded and RUAF-coordinated innovation project called "Monitoring the impacts of UPAF on climate change adaptation and mitigation". An electronic discussion took place during the period March 1–May 15, 2012 and evolved around the following questions:

- What are the needs and requirements of city and other governments and international organisations regarding the monitoring of UPAF impacts on climate change adaptation and mitigation?
- What monitoring data do they need in order to allow for decision making on, and possibly financing of, UPAF interventions?
- How would they use UPAF monitoring data in order to integrate UPAF into climate-compatible development strategies and financing?

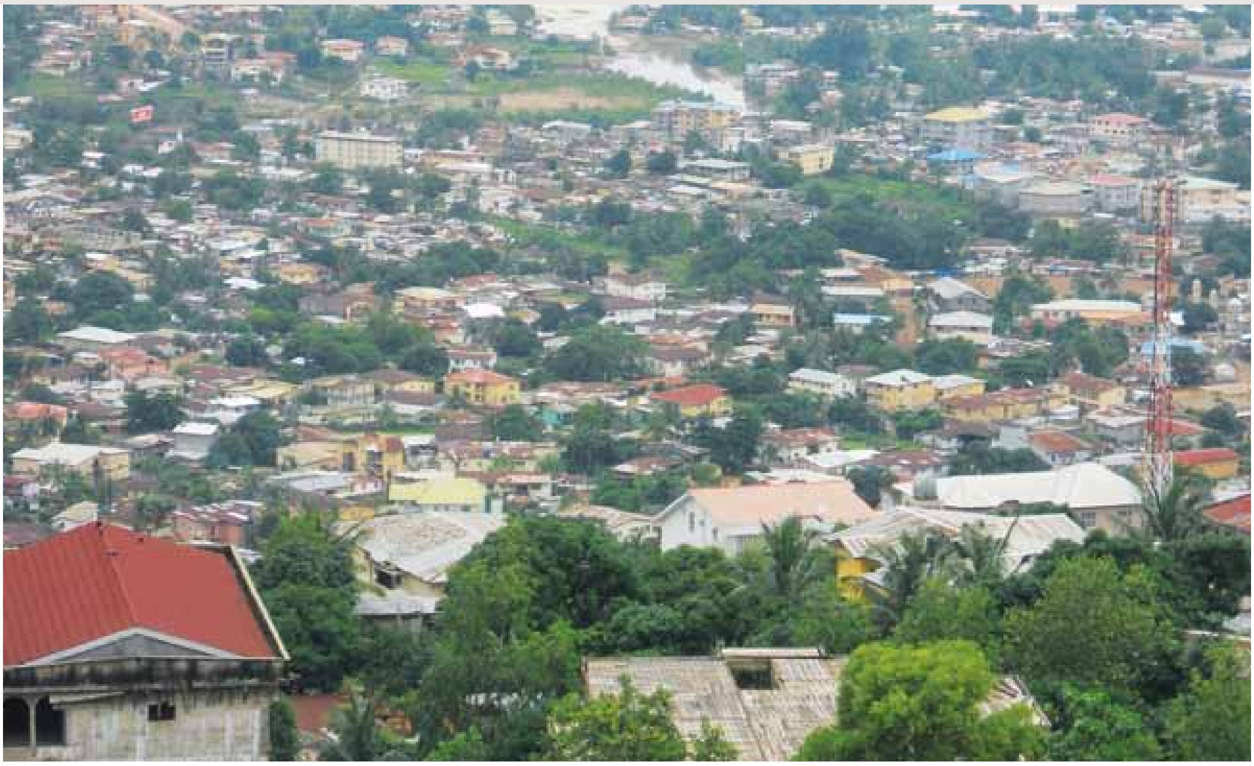
This article provides a short summary of the main discussions and responses.

## UPAF as part of international climate change programmes

Few cities/countries and international organisations have already integrated UPAF into their climate change (or disaster risk management) strategies and programmes. Reasons for this lack of integration include:

- Many cities still lack a local climate change action plan.
- Urban food security has long been ignored as part of urban vulnerability assessments. In the recent National Sri Lankan climate change action plan (2011-2016) for example, resilient urban settlements and rural agriculture are two separate key areas for intervention. There is no mention yet of urban food security or urban agriculture, nor of its potential linkages to urban waste and water management.
- There is a general lack of awareness and data on the possible role that can be played by UPAF in climate change adaptation and mitigation.
- There is a lack of international financing mechanisms for UPAF.


*Sectors of intervention* Source: World Bank, 2010



*Constructions in low-lying areas in Freetown damaged by flooding* Photo: Marielle Dubbeling

More recently however, and as part of their "city-wide approach to carbon finance", the World Bank proposes technological and policy interventions in five sectors (see Figure 1), three of them with possible indirect and direct bearings on UPAF:

- Solid waste recycling linked to UPAF: composting and anaerobic digestion is likely to gain importance as municipal solid waste management options due to their ability to reduce methane and produce a useful soil conditioner.
- Using rainwater and recycling treated or partially-treated wastewater in UPAF (while carefully managing potential health risks) in order to free up water sources for other uses (domestic and industrial consumption) and reduce treatment-related GHG emissions.
- Promoting urban forestry and green areas that can act as a carbon sink, reduce the urban heat island effect, improve storm water drainage and help improve the living environment.

This new approach aims to expand the CDM (Carbon Demand Management) programme of activities, giving cities the flexibility to create their own GHG mitigation strategies and access carbon finance. Amman, Jordan, is the first city that actually included an Urban Forestry and Agriculture component in its CDM-financed "Green Growth Strategy".

## Cities including UPAF in their climate change strategies and plans

Strategies looking at the interface between UPAF and climate-change/ disaster risk reduction have been implemented in:

- **Cities that have included UPAF in their city climate change action plans**, such as Toronto (Canada), where the city's climate change plan includes financial support for doubling the existing tree canopy by 2020; for community-based UPAF projects, e.g., community orchards and gardens, home gardens; for promotion of composting organic wastes and rainwater harvesting; as well as for reduction of the city "food print" by requiring shipping distance on food labels, promotion of regional products, support of farmers' markets and preferential procurement of locally produced food.


*Promoting local food in Toronto* Source: Toronto City Council

- **Cities that promote UPAF for reasons of food security, local economic development or environmental management.** In these cases UPAF is not supported by climate change programmes, actors or funding, though they do have a bearing on climate change adaptation or mitigation. One example is the city of Freetown (Sierra Leone) which has zoned all wetlands and low-lying valleys for urban agriculture to increase water infiltration, reduce flooding, keep the flood-zones free from legal and illegal construction and promote urban agriculture production for food supply and job creation.

- **Cities that promote sustainable urban and low-carbon development with potential connections to UPAF policy and implementation measures.** An example is the city of Beijing (China) which, as part of its Urban Master Plan (2005-2020), aims to protect farmland; to preserve green spaces and designate permanent green areas in city fringes and corridors; to promote waste water recycling and rain and flood water harvesting; to protect and promote forest areas and parks and certify and subsidise energy-saving production. In order to promote UPAF as part of these policies/plans, the ways in which UPAF can actually contribute to the above-mentioned policy objectives should be made visible, as well as how these measures relate to climate change impacts and what their possible effects on climate change mitigation or adaptation would be.

In none of the cases, however, are UPAF impacts on climate change adaptation and mitigation monitored or quantified; this underlines the need for the development of a practical and locally applicable monitoring framework.

Much more work is needed to build up a credible data set that allows decision makers to integrate urban agriculture in various spheres of climate change policy development

## Understanding the impact of UPAF on climate change

Project participants highlight that more knowledge and data are needed on:

1. The potential of UPAF to contribute to climate change mitigation and adaptation:
   - The potential climate change and developmental benefits (lie food security, income generation) of UPAF should be compared to rural agriculture and forestry and to other potential climate change strategies (investments/measures in infrastructure, transport, energy).
2. The capacity of and strategies for UPAF to adapt to climate change by, for example:
   - selection of new crop and animal species (e.g., more drought-resistant species, or species resistant to salt-water intrusion);
   - changes in growing seasons;
   - changes in production and storage practices.
3. Policies and (spatial) planning measures for promotion of UPAF as a climate-compatible development strategy:
   - Which UPAF typologies (home gardens, community gardens, agroforestry) are best promoted where (e.g., on rooftops, in backyards, in periurban fringes);
   - What are the related barriers and enablers (e.g., regulations, incentives, zoning)?

To allow for integrating UPAF in climate change policies, programmes and financing, specifically more quantifiable data on the following variables are required:

1. Data on the past, current and potential future presence of different forms of UPAF:
   - various types of UPAF and species/practices used;
   - land (surface) area covered by (or potentially be used for) various forms of urban and periurban agriculture and forestry, parks and green spaces;
   - area of land under specific UPAF systems in relation to the total built-up area in (various sectors in) the city and periurban zones. GIS-based land-use maps can be developed calculating (changes in) the area of land (under various forms of UPAF) in relation to other land uses and built-up areas;
   - the presence of certain UPAF systems/typologies in correlation with the wider urban context (e.g., population growth, density, spatial growth) and the presence or absence of land use and other regulations and incentives.
2. Data on UPAF production volumes:
   - its contribution to urban food security at household and city level;
   - comparisons of the amount of food (or certain types of food) produced locally versus that which is imported (from rural areas or abroad).

3. Data on (reduction in) urban GHG emissions, energy use and air pollution over specific time intervals and in relation to population size:
   - emission data including emissions related to fertilisers used, consumer transport for food, and storage, distribution and transport of locally produced versus imported food;
   - volumes of organic waste going into landfills and per capita waste treatment in relation to disposal and decomposition of organic wastes;
   - changes in air pollution/air quality (e.g., $SO_2$ ppm) and moisture;
   - comparing situations before and after UPAF interventions (with or without UPAF);
   - comparing efficacy of different UPAF systems (horticulture, pasture, forestry);
   - comparing data from specific UPAF pilot sites to generic baseline emissions from producing the same amount of food on newly-cleared rural land away from the city.

4. Data on the reduced vulnerability (or increased resilience) to climate change:
   - looking at food availability and prices for different commodities in situations where climate change affects rural agricultural production;
   - UPAF impacts on rainfall infiltration and storm-water drainage as well as ambient temperatures (urban heat island effect);
   - comparing UPAF and non-UPAF producer households;
   - comparing before and after incidence/severity of climate-induced events (landslides, flooding) with or

*This article and the one following it are based on project reports prepared for and funded by the Climate and Development Knowledge Network (www.cdkn.org). They summarize contributions made by the following project partners: The Institute of Geographic Sciences and Natural Resources Research/ Chinese Academy of Science, China; Ministry of Agriculture, Agrarian Development, Minor Irrigation, Industries and Environment, Western Province, Sri Lanka; Municipality of Rosario, Argentina; Ministry of Water, Public Services and Environment, Santa Fe Province, Argentina; The International Water Management Institute, Sri Lanka; The National University of Rosario, Argentina; Institute of Physics – CONICET Rosario, Argentina; Applied Plant Research International (PPO/PRI) of the Wageningen University and Research Centre, the Netherlands; Adaptify, the Netherlands; The School of Forestry of the University of Florida, USA; RUAF Foundation, the Netherlands; World Bank, USA and UN HABITAT, Kenya.*

without UPAF;
- measuring institutional capacity in managing climate risk (human and technical capacity, knowledge, funding, institutional policies and partnerships).

## Use of monitoring data

It is felt that if research would plausibly demonstrate attribution between UPAF, climate change mitigation and reduced climate vulnerability while identifying appropriate indicators and tools to do so, then this would elevate the profile of UPAF as a mitigation and adaptation instrument and increase both political and financial support and also demand for UPAF. Data - as mentioned above - could be effectively used to develop plans to reduce GHG emissions and air pollution, considering UPAF as well as other interventions; develop local food system strategies or urban afforestation/ reforestation programmes (selecting species that can adapt to changing climates) and integrate UPAF in urban planning as an appropriate use for vulnerable sites. In addition., data can be used to enhance awareness among citizens, the private sector and policy makers on UPAF and climate change; obtain national and international support and funding for mitigation and adaptation measures involving UPAF; and mainstream UPAF in the international agenda by showing that UPAF is — and has always been — part of urban infrastructure, and that this can be enormously improved with clear social, economic, environmental and climate change benefits.

## Comparing UPAF to other interventions

Overall, UPAF may be more cost-effective than many engineered technologies. However the biggest advantages of UPAF, compared to other intervention measures and to non-edible/ornamental green infrastructure, are its overall co-benefits, such as its contribution to urban food security — especially in the face of climate-induced disruptions to rural food supply— and its contribution to income generation and to improved city liveability. Proper planning and management is, however, needed to maximise these benefits.

**RUAF Foundation**
Email corresponding author: m.dubbeling@ruaf.org

*"If research plausibly demonstrates attribution between urban and peri-urban agriculture (UPA), climate change mitigation and reduced climate vulnerability, then this would raise the profile of UPA as a mitigation and adaptation instrument and increase political and financial support as well as demand for UPA. Data can then be effectively used to develop climate change action plans, considering UPA next to other interventions, as well as to integrate UPA in urban planning as an appropriate use for physical vulnerable sites and viable response to climate change effects such as excess storm-water"*

S.T.Kodikara, Former Secretary, Ministry of Agriculture and Environment (WP), Colombo, Sri Lanka

**References**
World Bank (2010) *A city-wide approach to carbon finance*. Carbon Partnership Facility Innovation Series, World Bank, Washington, DC, USA

# A First Framework for Monitoring the Impacts of Urban Agriculture on Climate Change

RUAF Foundation

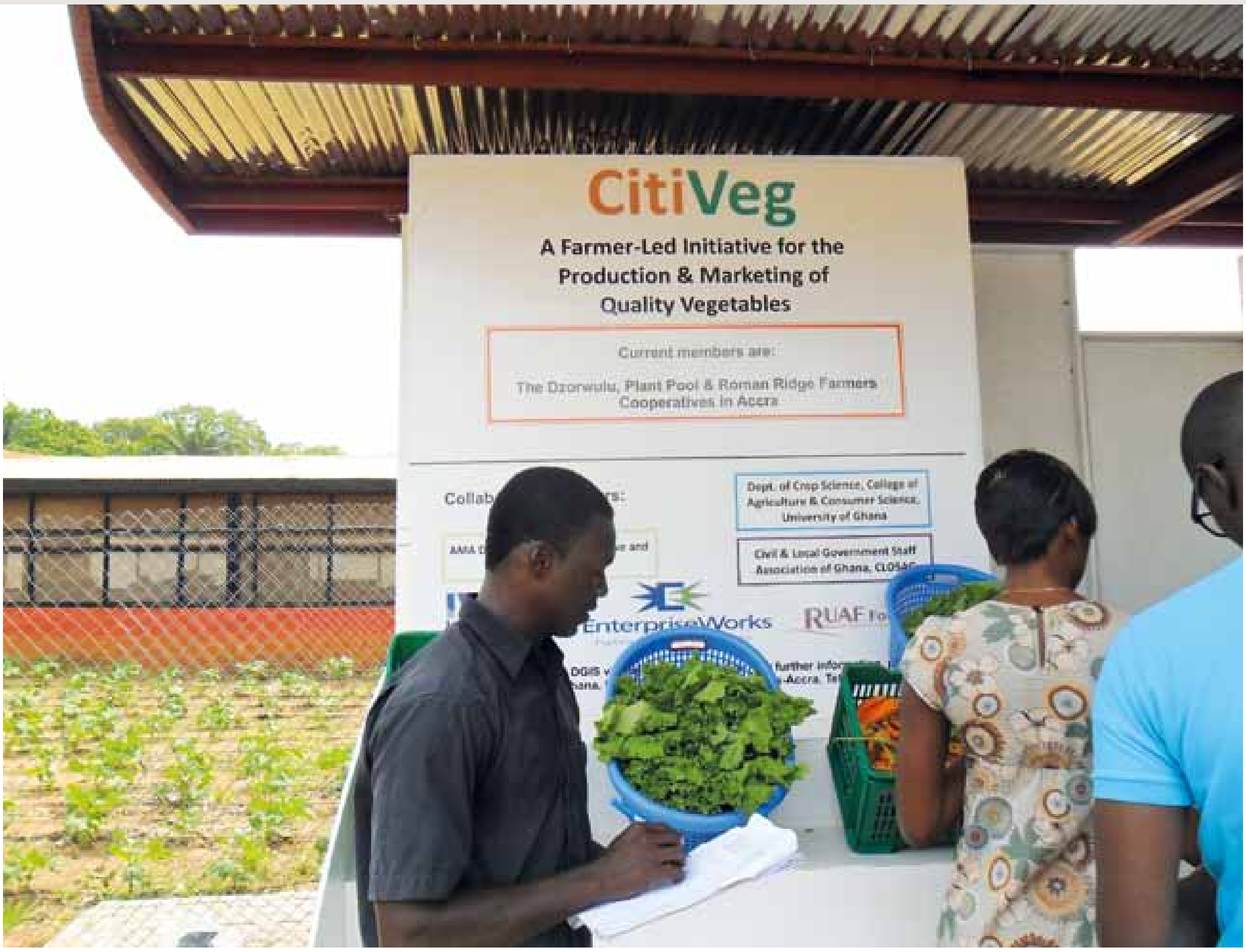
**Impact categories of UPAF (urban and periurban agriculture and forestry) include climate mitigation, climate adaptation and co-developmental benefits (food production, income generation, sustainable resource management, etcetera).**

Indicators that may be used to further analyse these various impact categories include

- mitigation: (fossil) energy use; carbon storage, carbon sequestration, GHG emissions ($CO_2$, $CH_4$, $NO_2$, HCFC), food miles, heat island effect, (chemical) fertiliser use, landfill volumes and per capita waste generation; and
- adaptation: diversification of food and income sources, amount of locally produced food versus imported food, food availability and food prices, amount of green space, water storage/infiltration capacity, storm water run-off, drought resistance, incidences of floods/erosion/landslides, biodiversity, competition for water/use of alternative water sources.

However, impacts of UPAF cannot be generalised because they differ among various UPAF types (for example, the carbon sequestration potential of urban and periurban forestry will be far higher than that of community gardens in which mainly annual crops are grown). Impacts also depend on the crops/species used in UPAF and the management techniques applied (e.g., individual street trees provide less shade and cooling effect as compared to larger areas of forests; UPAF systems using organic or agro-ecological production methods will have a different impact on overall GHG emissions as compared to production systems where large(r) amounts of chemical fertilisers and pesticides are used) and they depend on a set of trade-offs and related factors, e.g., the emission benefits of localised and fresh food

*Promoting community gardening in intra-urban areas in Santo André, Brazil* Photo: Yves Cabannes




*To what extent does local food production reduce food transports and related emissions?* Photo: IWMI

production (less transport, processing, storage and packaging) may be offset against larger consumer transport for picking up — small amounts of — food. Finally, impacts depend on the geographic location and local context (e.g., rooftop gardens have a different relative effect on temperatures — and related heating/cooling requirements — in temperate climates as compared to tropical climates. Also, in tropical climates more water may have to be pumped up to the roof for irrigation, related energy costs thus offsetting potential energy savings).

> *"Monitoring UPAF as a climate mitigation or adaptation strategy can contribute a lot to understanding its ecosystems functions and contribution to city environmental management"*
>
> Feifei Zhang; Integrated Planning Division, Chinese Academy for Environmental Planning, Ministry of Environmental Protection-China

The type of UPAF systems to be promoted depends on local climatic and spatial conditions, with some systems being more suitable or relevant for certain urban areas then others. Spatial system boundaries also need to be introduced to allow for measurement of production areas and boundaries, for example, for specific UPAF systems.

Other variables influencing the extent to which certain UPAF impacts can be achieved include total surface area; extent to which external inputs and materials are used; low or high maintenance; product choices (animal products have far higher GHG emissions per calorie than vegetable products); consumer food distribution networks; water and waste management (recycling of organic wastes; use of grey or rainwater; use of water-saving and irrigation technologies); use of organic versus conventional production techniques and seasonality of production.

Policy arrangements and interventions that can be put in place to promote certain UPAF systems/measures include the creation of local food hubs; preferential local food procurement; preservation and promotion of productive green spaces; incentives for rainwater harvesting technologies and open plot cultivation, etcetera.

In order to analyse UPAF impacts on climate change adaptation and mitigation, an initial analytical framework was proposed by Sukkel and Jansma from the Wageningen University and Research Centre. This framework was modified with inputs from other project partners to serve as a basis for analysing potential impact categories for different

UPAF types and measures. The UPAF measures included in the table are not mutually exclusive but rather have certain overlap. This implies that when assessing the impacts of certain packages of UPAF such overlaps have to be taken into account.

The table below is an attempt to summarise and provide an overview of all these aspects in order to facilitate further discussions on actual quantification of impacts and the measurement and collection of such quantitative data, and to prepare the way for the development of an actual monitoring framework and tools.

*Table:* **Potential impacts of various UPAF measures on climate change mitigation, adaptation and developmental benefits in city regions**

*Terminology used*

*City zone: A = Inner city; B= Suburban (less densely built up); C:= Periurban (mainly open spaces)*

*UPAF measures: certain types of urban and periurban agriculture and other food-related measures with high potential for climate change programmes in city regions.*

*Mitigation benefits: the mitigation effects expected to be obtained from each UPAF measure. 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 UPAF measure. The number of plusses indicates the expectations regarding the magnitude of these impacts at city level.*

*Developmental benefits: the expected developmental benefits of each UPAF measure (on food security, on income and employment creation, on city liveability, etc.).*

| City zone | UPAF type/ measure | 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 | Promotion of **backyard and community gardening** | ++ | Less energy use and GHG emission due to reduced food miles<br><br>Reduction of waste volumes due to on-the-spot composting / reuse<br><br>Minor carbon storage and sequestration | +++ | Less vulnerability 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<br><br>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<br><br>Positive effect on urban biodiversity and liveability<br><br>Educational and recreational opportunities | Food import and consumer transport distances for buying food<br><br>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 | Promotion of **green productive rooftops** | ++ | Less energy use and GHG emission due to reduced urban temperatures and insulation: Less energy use for acclimatisation of homes and offices<br><br>Minor carbon storage and sequestration | +++ | Minor: Less vulnerability due to enhanced local production and diversification of food (and income) sources<br><br>Enhanced water retention capacity and reduced run-off<br><br>Reduced urban heat island effect<br><br>Positive effects on urban biodiversity (e.g., migratory stops) | Enhanced food security and<br>nutrition due to improved access to nutritious food close to consumer<br><br>Educational and recreational opportunities<br><br>Multifunctional use<br><br>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 ) |

| City zone | UPAF type/ measure | 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-B | Promoting **food and biomass production (e.g., agro-forestry) 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<br><br>Carbon storage and sequestration | +++ | Less vulnerability due to enhanced local production and diversification of food (and income) sources<br><br>Enhanced water storage and retention capacity<br><br>Reduced flooding incidences/ lower water peaks; lower impacts of floods due to prevention of housing in flood plains<br><br>Positive effects on urban biodiversity | Food production (volumes)<br><br>Enhanced food security and nutrition due to improved access to nutritious food close to consumer<br><br>Employment<br><br>Positive effect on urban biodiversity and liveability<br><br>Multi-functional use | Seasonality of production<br><br>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 | Promoting **forestry and agro-forestry** (especially **on steep slopes** and other areas susceptible to erosion and landslides) | +++ | Carbon storage and sequestration<br><br>Less energy use for cooling/refrigeration/acclimatisation due to reduction of urban temperature (in warmer climates)<br><br>Reduction of air pollution | +++ | Less incidence of floods and landslides due to reduced run-off and enhanced water storage and retention capacity<br><br>Positive effect on biodiversity conservation | Production of food (crops, fruit, nuts) /fuel / wood<br><br>Liveability enhanced (shade, aesthetics, temperature, air quality)<br><br>Less health problems due to less heat stress (heat stroke, skin diseases, and heart problems) and air pollution | % under high- / low-density production<br><br>Degree of combination with food production<br><br>Choice of tree species (growth rate; water needs, maintenance requirements; retaining leaves year-round or not, long- or short-living, etc.)<br><br>Degree of maintenance and maintenance techniques applied and related energy costs and GHG emissions<br><br>Forest fires and other causes of reduction of tree coverage |
| B-C | Protecting and promoting **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<br><br>Less cost in maintaining infrastructure for transport, storage and cooling<br><br>Carbon storage and sequestration | +++ | Improved health of biodiversity for appropriate habitats and species, especially in conjunction with organic, low-till agriculture<br><br>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<br><br>Employment<br><br>Positive effect on urban biodiversity and liveability | Seasonality / Lower production per unit of energy<br><br>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) |

| City zone | UPAF type/ measure | 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-B-C | Promoting recycling and **reuse of organic wastes in UPAF** (from households, agro-industry, vegetable markets, wood and crop biomass, etc.) | ++ | Reduction in energy use due to lower waste volumes and related transport<br><br>Reduced methane emissions due to less organic materials in landfills and less uncontrolled burning of wastes<br><br>Less energy use and GHG emission due to reduced fabrication and use of chemical fertilisers<br><br>Delayed emissions and carbon sequestration due to higher organic matter in soils<br>OR: Additional energy production (biogas production through fermentation of organic wastes) | + | Improved water-holding capacity due to more organic matter in soils | Reduced air/water pollution<br><br>Fertile agricultural land and/or renewable energy (biogas)<br><br>Reduced nitrate leaching<br><br>Less smell and improved sanitation<br><br>Less land needed for waste processing<br><br>Employment and income | Transport and energy use in compost collection, production and distribution (sources, location of composting sites and users, transport means used)<br><br>Idem for treatment and distribution of wastewater (treatment technology used, location of plants and users, etc.)<br><br>Degree of recuperation of methane at landfill |
| A-B | Promoting **reuse in UPAF of waste-water and "harvested" rainwater** | ++ | Less energy use and GHG emission due to reduced fabrication and use of chemical fertilisers and reduced secondary/tertiary wastewater treatment | ++ | Less vulnerable to drought<br><br>Reduced potable water use for irrigation and reduced competition for fresh water sources | Enables year-round intensive food production<br><br>Less pollution of open water sources<br><br>Possible hygiene effects<br><br>Potential health risks related to use of untreated wastewater in an improper way | Choice of wastewater treatment techniques<br><br>Costs of infrastructure to transport and store wastewater to urban producers, or local treatment, and safety measures |
| A-B-C | Promoting **climate- smart farming techniques & farm management** in UPAF1 | ++ | Higher carbon sequestration due to higher organic matter in soils | ++ | Higher water retention capacity due to higher organic matter in soils<br><br>More resilient farming systems<br><br>Positive effect on biodiversity<br><br>Use of alternative sources of water rather than potable water | Better-quality products (free of pesticides, etcetera) | Degree in which the various climate-smart management techniques are applied<br>Lower production per unit of land or energy? |

| City zone | UPAF type/ measure | 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 | Enabling **resource flows between urban agriculture and other urban sectors** (especially greenhouses) 2 | + | Less energy use and GHG emission due to reuse in UPAF of by-products, excess heat, (purified) $CO_2$ or cooling/waste water from industry or block heating of residential areas | + | Less vulnerability due to diversification of food and income sources<br><br>Enhanced resource-/ energy-use efficiency / more connectivity in the urban system | Enhanced food security and nutrition due to improved access to nutritious food close to consumer<br><br>Employment and income | Technical arrangement for reuse<br>Required external inputs (e.g., fertilisers)<br>Ecological vs. conventional production<br>Degree of use of organic wastes, rainwater harvesting and water saving production techniques<br><br>Needed external inputs/ materials<br>Use of drinking water? |
| A-B | **Improving the urban food-distribution system**[3] | + | Less energy use due to reduction of travel by car to buy food in super stores in city fringe | + | Enhanced food security especially for the urban poor | Avoidance of "food deserts"<br><br>Better accessibility to food by lower-income groups<br><br>Less fine dust, air pollution and traffic jams due to reduced traffic | Type of consumer transport used<br><br>More traffic to bring food to the local retailers |
| A-B | **Changing dietary choices and food preparation /preservation habits of consumers; reduction of food wastes** | + | Reduced GHG emissions and energy use due to consumption of less meat and imported products and more fresh seasonal local produce, and due to less food waste | + | Less household expenditure on food and thus less effect of rising food prices or lower incomes | Positive effects on health: less obesity; better nutrition<br><br>More cash available for other household needs | |
| A-B | **Transformation of existing non-green spaces** (brownfields, underused car parks and squares) **into green, multi-use spaces** | | | | | Improved local environment,<br>More recreational and eco-educational opportunities<br>Enhanced food security and nutrition due to improved access to nutritious food close to consumer | |

*1 We refer here to measures including: transition to ecological production methods; application of water-saving techniques and rainwater harvesting; use of drought- or flood-resistant species; adapting the timing of cultural practices; improved management of livestock (e.g. manure and urine management, feed production from organic wastes).*

*2 We refer here to use of excess heat, cooling water, $CO_2$ and by-products from industry, offices and block heating of residential buildings in green houses, aquaculture, production of animal feed, etcetera.*

*3 We refer here to facilitating the functioning of local markets and shops close to the consumer rather than large super markets at urban fringe and forms of direct selling from local producers to consumers (farmers' markets, box schemes, home delivery schemes)*

**RUAF Foundation**
Email corresponding author: m.dubbeling@ruaf.org

# Monitoring the Climate Change Impacts of Urban Agriculture in Rosario, Argentina

Piacentini R.D., Bracalenti L., Salum G., Zimmerman E., Lattuca A., Terrile R., Bartolomé S., Vega M., Tosello L., Di Leo N., Feldman S., Coronel A.,

**As the world population in cities has surpassed that of rural areas, urban and periurban agriculture (UPA) can become an important strategy, not only to feed the people, but also to mitigate climate change. In the city of Rosario, Argentina, with the support of the RUAF Foundation and the Climate and Development Knowledge Network (CDKN), a detailed study is being conducted to monitor the urban heat island, reduction in the use of food transportation and preservation and in the impact of flooding by green infrastructure.**

## The city's urban agriculture programme

Municipal support to UPA in the city of Rosario, Argentina, largely increased after the national crisis of 2001, when unemployment hit a large number of working families. By 2013 there were 400 gardeners involved in the programme (280 of them producing food for the market and 120 for family consumption); 100 unemployed young people are receiving job training on UPA; 4 garden parks and other smaller public areas are devoted to vegetable production, covering a total area of 22 hectares; and 3 urban agro-industries are producing processed vegetables and cosmetics from medicinal plants. The total annual production is about 95 tons of vegetables and 5 tons of aromatic plants. The fresh and processed products are sold by the gardeners on five street markets in the city.

The Rosario Municipality has designated another 400 hectares in and at the outskirts of the city for expansion of UPA in the near future. Rosario's main aims of the UPA programme were to contribute to food security and income generation. In 2013 the city expressed interest in also exploring the potential contributions to climate change adaptation and mitigation. Supported by RUAF and CDKN and international research organisations such as WUR-PPO and the University of Florida, local researchers were trained in impact monitoring and scenario building. The preliminary results of the research are described below.

*Garden park in Rosario, Argentina* Photo: Marielle Dubbeling

*Pink trumpet vine (with flowers) placed at the central Montenegro square in Rosario* Photo: Rosario research team

*Landsat 8/NASA Multispectral Image. The blue band is the Paraná river and the pink/ reddish colours correspond to the islands of the Paraná delta. The periurban zone corresponds to the areas with green color (cultivated area) and brown color (non- cultivated areas).*

## The contribution of green areas to reducing the Urban Heat Island

Temperatures in cities are often higher than in the surrounding area (this is called the urban heat island effect). Consequently, cities are an interesting laboratory for testing different options to decrease the warming introduced by anthropogenic activities (building energy consumption, transportation, services, etc.). One of these options is to introduce green coverage, as this can significantly reduce the surface temperature of otherwise bare pavements and built-up spaces. The Rosario team monitored the temperature behaviour of the pavement of a central square in Rosario, with and without the incidence of direct solar radiation, in the latter case due to a compact Pink trumpet vine *(Podranea ricasoliana)*. The measurements were taken with a Minolta Land infrared thermometer. The mean difference of temperatures with and without direct solar radiation during the months of June–July 2013 (around the Southern Hemisphere winter solstice) was 9.6 (± 2) °C, with the temperature in the plant shadow being the lowest, as expected. This result demonstrates the large influence a plant with perennial leaves can have in reducing pavement (or building) surface temperature. Reducing such temperatures by applying green coverage may result in reduced energy use for cooling as well as it will contribute to reducing ambient temperatures and thus increasing human comfort levels. It must be pointed out that this is a result for a particular plant, while we will extend this study to other time periods and types of trees.

The team also installed temperature-humidity (HOBO) sensors and data captors in different parts of the city, in order to record the magnitude of the urban heat island in different areas and the effect of urban agriculture (gardens and urban trees) in mitigating temperature differences. These instruments, which store temperature information every 15 minutes, are located in tree garden parks (Molino Blanco, Hogar Español, Facultad de Odontología) and at fixed points in the city centre with or without tree cover (e.g. under a tree or exposed to direct sun radiation).

The information recorded during the months of September to October (Southern Hemisphere spring) show that average temperatures in the urban gardens are lower than in the central area, by 2.4 °C. This is particularly interesting for the garden located near the Facultad de Odontología, considering that it is located in a highly built-up area and is surrounded by buildings of about 10 stories high.

In addition to the data-loggers, satellite data was used to get a detailed description of the spatial distribution of a city and its surroundings. In Figure 2 we present a multispectral satellite image Landsat obtained on the 21st of June 2013.

## Transportation and conservation of food

Food transport, storage and preservation involve significant energy expenditure, which generally increases with transport distance; use of fossil fuels, storage time and degree of processing increases. Next to $CO_2$ emissions, use of refrigeration equipment also contributes to emissions of hydrochlorofluorocarbons (HCFCs) and possibly chlorofluorocarbons (CFCs).

One possible indicator to measure such emissions is the delay time that each product requires for transportation, storage and conservation. This corresponds to the time interval between harvest of the product in the place of production and delivery to the consumer. Associated with this indicator is the amount of $CO_2$ equivalent (kg $CO_2$ and the other greenhouse gases) emitted by the whole process of storage and preservation, according to the needs of each product. Losses occurring during the process must be included by incorporating a loss factor.

The use of various means of transportation for the transport of foods from distant production centres to the city involves different levels of energy consumption and associated $CO_2$ emissions depending on the type of vehicle, condition, transport distance, type of fuel used and required logistics infrastructure. Transport systems that require cooling systems have additional energy consumption and emission of other highly polluting greenhouse gases (like HCFCs).

A suitable indicator to measure the impact of food transportation is the number of food kilometres (or food miles) travelled by each product to reach the city. In a more detailed analysis the amount of $CO_2$ equivalent emitted by the use and maintenance of roads, warehouses and related services, like traffic surveillance, should also be considered.

The distribution of food within Rosario can be separated into a traditional retail circuit and an urban garden retail circuit. This second distribution circuit ensures a very short time between harvest of food and its destination (the consumers), while maintaining a high level of quality and freshness without refrigeration and conservation.

For our research on the reduction of food miles we considered three products: the first two are squash (including pumpkin) and string beans, as they are currently produced in the urban gardens and their production can easily be increased. The third product is potato, the main vegetable consumed by the Rosario population. Even if potato is not produced in the intra-urban gardens, a significant reduction in $CO_2$ emissions can be achieved if the supply is sourced from the periurban region and areas near the city with high horticultural production.

A significant proportion of the potatoes consumed in Rosario city is currently produced in the Provinces of Mendoza and Buenos Aires, with a mean distance of about 1000 km from Rosario. They are moved by truck, usually with a capacity of 20 tons and around 10 % losses. Such transport represents a fuel consumption of 0.31 litres of fossil fuels per km and a $CO_2$ output of 3005 ton for each round trip. If this food were to be produced in the area around Rosario (in the Arroyo Seco region located at about 30 km), $CO_2$ emissions related to food transports would be reduced by 97 % per year. Similarly for the squash/pumpkin, which are imported from Ceres region about 200 km from Rosario and for the string beans, produced mainly in the horticultural area of Great Buenos Aires (about 300 km from Rosario), there would be a reduction of 92.5 % per year for squash/pumpkin and 95 % $CO_2$ per year for string beans.

A similar analysis carried out for the other vegetables consumed in Rosario and other cities in the country would yield a significant contribution of UPA to reduce food miles and GHG emissions. Of course, the potential of food growing in and around cities has to be analysed and production methods and yield per area should also be included in such an analysis.

*Food transports in Rosario* Photo: Marielle Dubbeling

### Effects of UPA on run-off and infiltration of storm water

There are positive effects produced by the increase of green areas in urban spaces, such as agriculture, forestry and green roofs on rainfall infiltration and storage capacity. This contributes to reducing storm water run-off and can offer an alternative to substantial hardware improvements in urban drainage systems and infrastructure that are generally difficult and expensive.

The team introduced a simple method to estimate run-off, based on a rational equation. The indicator used is the variation of the run-off coefficient as function of the increase in green areas. The method we propose is based on the calculation of the change of the run-off coefficient, relative to the increase or decrease in UPA surfaces. Different future land use scenarios were developed, considering the current policies and land use ordinances, the building patterns in the city, the area of non-built up land available, etc.

A food flow analysis carried out for vegetables consumed in Rosario demonstrates that UPA can significantly contribute to reduce food miles and related GHG emissions

The run-off coefficient is a ratio that indicates the amount of run-off generated by a watershed, given an average intensity of storm precipitation. The run-off coefficient varies with slope, surface condition, vegetation cover and hydrological soil type. Surfaces that are relatively impervious, like streets and parking lots, have run-off coefficients approaching one. Surfaces with vegetation that intercept surface run-off and those that allow infiltration of rainfall have lower run-off coefficients (near to 0). All other factors being equal, an area with a greater slope will have more storm water run-off and thus a higher run-off coefficient than an area with a lower slope. Soils that have a high clay content do not allow much infiltration and thus have relatively high run-off coefficients, while soils with high sand content have higher infiltration rates and low run-off coefficients.

Negative values for the variation in run-off (between a hypothetical scenario and the actual situation) at any time period will indicate a net decrease in run-off (which corresponds to the reduction of risk of floods) and an increase in infiltration/storage of the storm water within a given surface area. It can be demonstrated that small increases of green areas in urban systems reduce significantly the risk of flooding. For example, from historical rainfall data for the city of Rosario, a 5 % reduction in the run-off coefficient would cause a probability reduction of 30 % for urban flood risks.

### Policy review

Based on these first results a policy proposal on UPA inclusion in watershed management was presented to the Municipality of Rosario for review. Such policy calls for increasing the area of green roofs on new and existing buildings; integrating UPA in public squares, walks, sides of motorways and railways; and reducing the risk of flooding and waterlogging caused by paving and building in flooded areas through UPA strategies, by means of land use ordinances.

More detailed results of the present project will be published once they become available (later in 2014).

**Piacentini R.D.**
IFIR, CONICET-National University of Rosario UNR
**Bracalenti L. and Salum G.**
FAU, UNR
**Zimmerman E.**
FCEIA, UNR
**Lattuca A., Terrile R., Bartolomé S., Vega M., Tosello L.**
Municipality of Rosario
**Di Leo N., Feldman S., Coronel A.**
FCA, UNR
Email corresponding author: ruben.piacentini@gmail.com

**References**
Brown, M E y Funk C C, Food Security Under Climate Change Vol 319, 580-581, 2008 (available at http://digitalcommons.unl.edu/nasapub/131).
IPCC (Intergovernmental Panel on Climate Change)/SRRES (Special report on Renewable sources). Renewable energy sources and Climate change mitigation (http://srren.ipcc-wg3.de/report).
IPCC (Intergovernmental Panel on Climate Change). Working Group 1: The physical science basis, 2007 (available at: www.ipcc.ch).
IPCC (Intergovernmental Panel on Climate Change). Working Group 1: The physical science basis, 2013 (available at: www.ipcc.ch).
NEF (National Energy Foundation), UK (http://www.nef.org.uk/).

# Surface Temperature Variations in the Kesbewa Urban Council Area, Sri Lanka

L. Manawadu, Y.M. Wickramasinghe
Sudeera Ranwala, M.T.M Mahees
M.M. Ranagalage, E.N.C. Perera

**Recent climatological studies by scholars from different disciplines and different parts of the world have proven that the surface temperature of urban areas is generally higher than those of neighbouring vegetated areas.**

The present study attempts to examine the spatial pattern of surface temperature using remotely sensed data and discusses the factors influencing temperature increases in the Kesbewa Urban Council (KUC) area in Sri Lanka. For the last five years, KUC area has shown an increasing trend in air temperature , related to increasing urbanisation and population growth and conversion of agricultural lands to urban activities.

## Study area and methodology

Kesbewa Urban Council is located in the Colombo district of the Western Province of Sri Lanka. KUC lies on Colombo-Horana main road about 20 km away from the capital Colombo. Satellite imagery (Landsat 7TM) was utilised to examine the urban heat distribution of the KUC area on 01 January, 2007. Results of the analysis provide information on (a) the spatial pattern of surface temperature in the KUC area, and (b) the relationship between demographic factors and surface temperature.

## Spatial pattern of surface temperature in the KUC area

The distribution of the extracted surface temperature values vary from 26.59 °C (lowest) to 39.90° C (highest), with the recorded average surface temperature in the city being 33.24° C. We found a significant spatial variation of surface temperatures in the KUC area representing different morphological characteristics of the city. On paved areas the extracted surface temperature is relatively high, whilst green areas and water bodies represent relatively low surface temperatures.

Based on the different land use categories and their morphological characteristics, extracted surface temperature values can be classified into five groups: (1) built- up area in the city centre, (2) roads, (3) lower-density residential area, (4) paddy lands and (5) water bodies. There are very clear-cut differences of temperature values among these categories (Table 1).

*Table 1:* **Surface temperature in different land use categories**

| Land use | Area (Ha) | Minimum T | Maximum T | Average T |
|---|---|---|---|---|
| Water | 3.7320 | 28.1370 | 31.6783 | 29.3472 |
| Paddy | 10.2600 | 26.5885 | 34.1501 | 30.4532 |
| Residential | 32.7900 | 26.5885 | 35.9036 | 31.6997 |
| Road | 1.4240 | 29.1588 | 37.0572 | 32.1686 |
| Buildup area | 0.2100 | 30.6764 | 36.0951 | 33.6029 |

The table illustrates that the central built-up area of the city (characterised by high population concentration, high housing density, traffic congestion and relatively low vegetation cover) reports the highest surface temperature values whilst the lowest surface temperature values were reported in the fringe area, which comprises mostly water bodies and paddy lands.

Another important finding is that the lowest temperature value in the built-up area (30.7 °C) is higher than the average surface temperature of either the paddy or water bodies category (30.4 °C and 29.3 °C respectively). In between these two extremes we find the lower density residential areas where most of the houses have (home) gardens. These areas cover more than 32 per cent of the city.

## Demographic factors and surface temperature

Surface temperature is determined by various factors such as urban morphology, environmental factors, demographic factors, social and economic characteristics. As indicated earlier, population and housing density are relatively high in the central part of the city, while density in the residential areas is lower. Scattered plot analysis shows significant positive correlations between surface temperature and population and housing density. Figure 2 very clearly demonstrates the decreasing pattern of surface temperature from the city centre to the periphery.


*6b and 6c: lower density residential areas; 8b and 8c: higher density inner city area* Source: University of Colombo

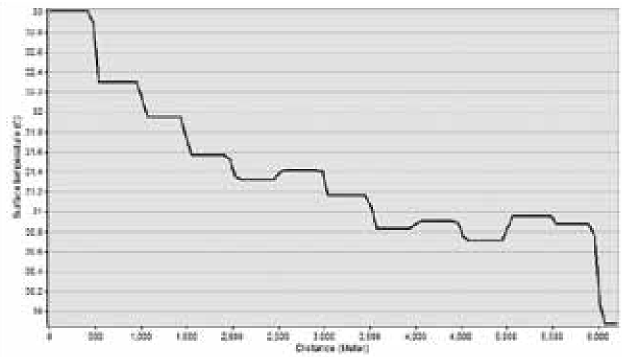


*Figure 2: Profile of surface temperature from city centre to periphery*

## Conclusions

This study argues that the surface temperature of the KUC area has increased substantially due to human activities. The surface temperature of the KUC area shows a very clear regional distribution. It can be divided into four main regions:

1. Highest temperature in built-up city area;
2. High temperatures in the lower density residential areas;
3. Normal temperature in urban and periurban agriculture and forestry (including paddy) areas; and
4. Lowest temperature in water areas.

The city area of Kesbewa is increasingly exposed to the heat island phenomenon. Population density, housing density, land use and land cover are the major factors affecting the surface temperature of the city. The study is mostly based on satellite data (LANDSAT) and will still implement ground verification to better analyse the data.

The thermal remote sensing technique which has been applied was very useful in understanding the spatial distribution of surface temperature in a particular urban setting, rather than depending on data provided by the meteorological department that only covers very few locations.

L.Manawadu
Sudeera Ranwala
M.T.M Mahees
E.N.C.Perera
University of Colombo
Y.M.Wickramasinghe
M.M.Ranagalage
Rajarata University of Sri Lanka
Email corresponding author: lasangeo@gmail.com

**References**

Manawadu L, and Liyanage N., Identifying Surface Temperature Pattern of the City of Colombo, ENGINEER - Vol. XXXXI, No. 05, pp. 133-140, The Institution of Engineers, Sri Lanka (2008).

Ranasinghe A.W.L.H., and Halwatura R.U., User comfort on urban roads, University of Moratuwa, Department of Civil Engineering, (208).

Warusavitharana E.J., Analysis of Relationship between urban thermal distribution and morphological aspects in Colombo city using thermal remote sensing, Department of Town & Country Planning,University of Moratuwa, (2009).

## No. 28: Innovations in urban agriculture (JULY 2014)

**Deadline for contributions: 30 APRIL, 2014**

This issue will highlight innovations in urban agriculture, from small-scale and low-tech innovations to larger-scale and higher tech innovations such as vertical farming. Urban farming systems need to be adapted to specific urban conditions such as confined space, closeness to consumers, and take into account safety concerns. Innovation is continuously taking place, exploring the multiple functions of urban agriculture, including food security, income generation and environmental management.

Innovations can be of a technical nature, referring to strongly improved or new products or services and improvements in production process and practices. Or they can relate to social, institutional or political aspects, such as improvements in marketing strategies, relations between various actors or organisation of a group of farmers. We also welcome contributions that discuss sustainability criteria for stimulating, assessing and monitoring innovations and business ideas, including social inclusion and empowerment.

The Magazine will include contributions on innovations encountered in a number of past and ongoing projects RUAF is involved in, like the OXFAM NOVIB funded GROW the City project and the SDC funded initiative in Gaza with Oxfam Italy. It will also report on the 2014 Global Forum for Innovations in Agriculture. In addition, your contributions that are not related to these projects and events are needed and welcomed.

Please share the following aspects of your experience (as applicable) in your article:

- a short narrative on your experience (main goal, where, who implements, target group, activities)
- the methods applied (how, why this method, why does it work well, with whom – links with NGOs, farmer organisations, municipalities, etc.)
- the impacts achieved (in which areas, extent, unexpected impacts? Who benefits?)
- problems/challenges faced and solutions found
- major lessons learned
- the way forward (future plans, new partners, support required from whom, etc.).

Articles should consist of maximum 2000 words (three pages), 1300 words (two pages), or 600 words (one page), preferably accompanied by an abstract, a maximum of 5 references, figures and digital images or photographs of good quality (more than 300 dpi or in jpg format more than 500 kb). The articles should be written in a manner that is readily understood by a wide variety of stakeholders all over the world.

If you have ideas and suggestions for an interesting contribution, inform us and e-mail them right away to info@ruaf.org.

## Other information on the subject

*We also invite you to submit information on recent publications, journals, videos, photographs, cartoons, letters, technology descriptions and assessments, workshops, training courses, conferences, networks, web-links, etc, especially those relating to the theme of the upcoming UAM.*

## FEEDBACK

We appreciate your input, support and views on the UA Magazine.
You can send us your feedback at any time by email to info@ruaf.org


27

# Urban Agriculture Magazine

**Promoting urban agriculture as a climate change adaptation and disaster risk reduction strategy**

ISSN 1571-6244
No. 27, March 2014

**UA Magazine**
The *Urban Agriculture Magazine (UA Magazine)* is produced by the RUAF Foundation (the International Network of Resource Centres on Urban Agriculture and Food Security), in close collaboration with strategic partners on particular topics addressed in each magazine.

*UA Magazine* is published twice a year on the RUAF website (www.ruaf.org).

*UA Magazine* facilitates the sharing of information on the impacts of urban agriculture, promotes analysis and debate on critical issues for development of the sector, and publishes "good practices" in urban agriculture.

*UA Magazine* welcomes contributions on new initiatives at individual, neighbourhood, city and national levels. Attention is given to technical, socioeconomic, institutional and policy aspects of sustainable urban food production, marketing, processing and distribution systems. Although articles on any related issue are welcome and considered for publication, each UA Magazine focuses on a selected theme (for previous issues, visit: www.ruaf.org).

*Editors, No. 27*
This issue was compiled by Marielle Dubbeling.
*Language Editor* Diane Schaap
*Design and Layout* Interface Communicatie B.V., Ede
*Printing* Koninklijke BDU
*Subscriptions* The editor: info@ruaf.org

*Address*
Urban Agriculture Magazine
Kastanjelaan 5
3833 AN Leusden
The Netherlands
Tel: +31.33.4343003
e-mail: info@ruaf.org
website: www.ruaf.org

**The RUAF Foundation Partners**
- IWMI-Ghana, International Water Management Institute, Accra, Ghana
- IGSNRR, Institute of Geographical Sciences and Natural Resource Research of the Chinese Academy of Sciences
- IWMI-India, International Water Management Institute, Hyderabad, India
- ETC Foundation, Leusden, The Netherlands
- MDPESA: Municipal Development Partnership, Harare, Zimbabwe
- IPES, Promoción del Desarrollo Sostenible, Lima, Peru
- IAGU, Institut Africain de Gestion Urbaine, Dakar, Senegal