Integrating urban agriculture and forestry into climate change action plans:

Lessons from Western Province, Sri Lanka and Rosario, Argentina

By Marielle Dubbeling, RUAF Foundation

January 2015

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Residents receiving seedlings and garden kits from the government urban agriculture programme. Kesbewa, Sri Lanka.

Contents

Key messages

- Cities need to address the triple challenge of climate change mitigation and adaptation, as well as the provision of basic services, including food, to their vulnerable residents.
- Urban and peri-urban agriculture and forestry may be suitable strategies to address the triple challenge; they are potential strategies for adaptation and, to a lesser extent, mitigation, that can also bring important development benefits.
- Western Province, Sri Lanka is the first provincial government in the country to include urban and peri-urban agriculture and forestry in its climate change adaptation action plan.
- Western Province is promoting the rehabilitation of flood zones through their productive use as a strategy to improve storm water infiltration and mitigate flood risks.
- Rosario, Argentina and the Province of Santa Fé are supporting local agriculture to reduce dependency on imports, to lower greenhouse gas emissions and energy requirements for food production, transport and storage, and to improve the food security and livelihoods of their residents.
- Future upscaling of these interventions will need new urban design concepts and the development of local and provincial climate change action plans and other related policies at different levels that recognise urban agriculture as an accepted, permitted and encouraged land use.
- The involvement of the subnational (provincial) government is key to addressing agriculture and land-use planning at larger scale (outside municipal boundaries), promoting upscaling to neighbouring cities, facilitating access to financing, and developing the provincial policies that must accompany city-level strategies.

1. Cities as key actors on climate change and food security

For cities to be sustainable, they need to simultaneously address the vulnerability of people, places and sectors that may be affected by a changing climate; mitigate their greenhouse gas (GHG) emissions; and ensure adequate access to basic urban services such as water, food and energy to their growing populations.

Climate change adds to the existing challenges faced by cities. Cities – as net consumers rather than producers of food – are already highly vulnerable to the disruption of critical food and other supplies. Climate change may compound this problem as rural production and food imports are increasingly adversely affected by storms, floods, shifting seasonal patterns, droughts and water scarcity, resulting in (temporary) food shortages and rising food prices. In 2007, a World Bank publication[1] predicted that changing rainfall patterns will affect agricultural productivity, especially in African countries. Southern Africa would risk losing 30% of its coarse grain output by 2030, while Malawi, Mozambique and Zimbabwe 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. The latest assessment[2] from the Intergovernmental Panel on Climate Change confirmed these projections. As one article in *The Guardian* (March 2014) reported, "the report explored a range of scenarios involving a temperature rise of two degrees or more that saw dramatic declines in production in the coming decades. Declines in crop yields will register first in drier and warmer parts of the world but as temperatures rise two, three or four degrees, they will affect everyone. In the more extreme scenarios, heat and water stress could reduce yields by 25% between 2030 and 2049. … '*The main way that most people will experience climate change is through the impact on food: the food they eat, the price they pay for it, and the availability and choice that they have*,' said Tim Gore, head of food policy and climate change for Oxfam. … The rate of increase in crop yields is already slowing – especially in wheat – raising doubts as to whether food production will keep up with the demand of a growing population. Changes in temperature and rainfall patterns could lead to food price rises of between 3% and 84% by 2050".[3]

The urban poor, who are often located in the most vulnerable parts of cities and have few resources to adapt to climate-related impacts, will be hit hardest. Since they spend a large part of their cash income on food, they are directly affected by rising food prices. A recent nutrition study in low-income neighbourhoods of five large cities,[4] implemented by the International Network of Resource Centres on Urban Agriculture and Food Security (RUAF Foundation), showed that during the financial and food crises many urban poor households cut their number of daily meals and turned to cheaper and less nutritious food, which negatively affected the nutritional status of family members. The study also showed how the differential availability of household assets influences the capacity of households to ensure food security and cope with stresses and shocks. Households that have a high proportion of non-producing members (the young and/or the old) clearly have less opportunity for accessing multiple income opportunities and are stretching the demands on single income streams. The nutritional status of children under 5 years old (under-fives), as derived from assessments in the cities studied, shows a disturbing picture of high levels of stunting and wasting in several cities, in both the poorer and the better-off populations. Despite the extent to which consumption of animal source foods is reported, levels of malnutrition found in under-fives in some of the cities suggest that children must be receiving very small quantities of this type of food.[5] The results also clearly demonstrate the 'double burden of malnutrition' present among both under-fives and fertile women. As well as underweight populations, there is also a high incidence of obesity, especially among women, but also in some groups of children.[6]

2. Climate change adaptation requires an integrated approach

According to the World Bank,[7] urban climate-change and disaster risk management plans require an integrated approach that takes into account "mitigation (e.g. strategies to reduce GHG emissions), adaptation (e.g. reducing the vulnerability to climate change) and development (such as poverty alleviation, income generation and food security)". The United Nations Human Settlements Programme (UN-Habitat) also calls for sustainable urbanisation that addresses climate change while ensuring local food, water and energy security.[8] Both organisations recognise the important role that urban and peri-urban agriculture can play in making cities more resilient when faced with natural (e.g. climate change related) and human-induced disasters, such as economic or sociopolitical crises and conflicts. Resilient cities – as defined by the Rockefeller Foundation – are cities that have "the ability to withstand shocks while still maintaining [their] essential functions and to recover quickly and effectively. Simply put, resilience is what enables cities to survive, adapt, and thrive in the face of acute shocks and chronic stresses".[9]

For example, the increased risk of flooding induced by climate change adds pressure to existing serious deficiencies in storm drainage in many cities, where there are fewer open (green and productive) spaces in which excess storm water can be stored. Protection of such spaces for agricultural production is now promoted in Western Province, Sri Lanka, as described below.

At the same time, not only does a city's dependence on global food markets increase its vulnerability to climate change, the need to transport food from rural areas also contributes to greenhouse gas emissions – about one third of their total emissions.[10] Food transport, storage and preservation involve significant energy expenditure, which generally increases as distance, use of fossil fuels, storage time and degree of processing increase. Rosario, Argentina is one city that is trying to put into place a local food system in order to respond to these challenges.

3. The role of urban and peri-urban agriculture and (agro)forestry in adapting to climate change

An article by Dubbeling in the United National Centre for Regional Development publication 'Disaster risk reduction and resilience building in cities: focussing on the urban poor'[11] describes how urban and peri-urban agriculture and (agro)forestry help cities to become more resilient by the following means.

1. Reducing the vulnerability of the most vulnerable urban groups and 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.

2. 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 (more cooling, less smog)
    - reduced impacts of high rainfall by storing excess water, increasing water interception and infiltration in green open spaces, and keeping flood zones free from construction, leading to a reduction of rapid storm water run-off, fewer floods downstream and better replenishment of groundwater
    - improved water quality through natural cleaning in low-lying agricultural areas (e.g. natural or constructed wetlands, aquaculture in maturation ponds)
    - CO_2 and dust capture
    - prevention of landslides by (agro)forestry on steep slopes, and preventing building on such sites
    - conservation of biodiversity, protecting a wider base of plant and animal genetic diversity.

3. Safely reusing waste water and composted organic waste:
    - adapting to drought by facilitating year-round production, safely using waste water flow and nutrients in water and organic waste[12]
    - reducing competition for freshwater among agriculture, domestic and industrial uses
    - lowering the depletion of certain minerals (e.g. phosphorus) by making productive use of the nutrients in waste water and organic wastes[13]
    - reducing landfill volumes and thus methane emissions.

4. Reducing their energy use and GHG emissions by producing fresh food close to the city:
    - using less energy in transport, cooling, storage, processing and packaging, and enabling synergic and cyclical processes between urban domestic and industrial sectors and agriculture (e.g. use of excess heat, cooling water or CO_2 from industry in greenhouses)
    - reducing the ecological footprint of the city by lowering the energy and water needed to produce and transport food.

However, urban agriculture, if not properly managed, may also have negative impacts on the urban environment and health. Soil erosion and pollution of groundwater may occur if chemical fertilisers and pesticides are used over an extended period. Health risks may occur if untreated waste water is applied for crop irrigation, while improper handling of agrochemicals may lead to health problems among urban farmers. Ecological farming practices are highly recommended in urban and peri-urban agriculture to prevent such negative effects, as promoted in both Western Province, Sri Lanka and Rosario. Similarly, promotion of urban agriculture without due attention to gender aspects may lead to a (further) increase in women's burden of work. In terms of urban governance, it is therefore important for vulnerable groups, particularly women, youth and migrant workers, to have a voice in a transparent decision-making and planning process.

4. Cities integrating urban agriculture in their climate change strategies

Kesbewa Urban Council and Western Province, Sri Lanka, along with Rosario and the Santa Fé Province in Argentina are two cities and subnational governments that have started to purposefully integrate urban and peri-urban agriculture and forestry in their climate change strategies and land-use policies. Both cities were partners in the CDKN-RUAF project on 'Monitoring impacts of urban and peri-urban agriculture and forestry on climate change mitigation and adaptation' (February 2013 to November 2014), which had three principal aims:

1. To field test a conceptual and methodological framework for the monitoring of the impacts of urban and peri-urban agriculture and forestry on climate change mitigation, adaptation and developmental co-benefits
2. To design – with multi-stakeholder involvement and taking into account the specific local climate change challenges, socioeconomic and geophysical contexts – different scenarios for each city for the development of urban and peri-urban agriculture and forestry, and calculate the expected impacts, as a basis for local decision-making and planning
3. To facilitate the integration of urban and peri-urban agriculture and forestry as a component of local and provincial city climate change strategies and other relevant policies and programmes.

This background paper will further briefly present both cities, the activities implemented and results achieved to date, and draw some lessons learned that may be relevant for other cities and provincial governments.

Western Province, Sri Lanka

Western Province, Sri Lanka is the most urbanised province in the country. With close to six million people, it is home to about 25% of the national population – yet it makes up only 5% of the country's land area. According to a climate vulnerability assessment by the Ministry of Environment,[14] 70% of the Sri Lankan population will live in cities by 2030. Rapid urban growth has posed a number of problems. Ever-increasing vehicle traffic and commercial industries have contributed to higher environmental and air pollution. Food transportation and storage and construction are major sources of GHG emissions.

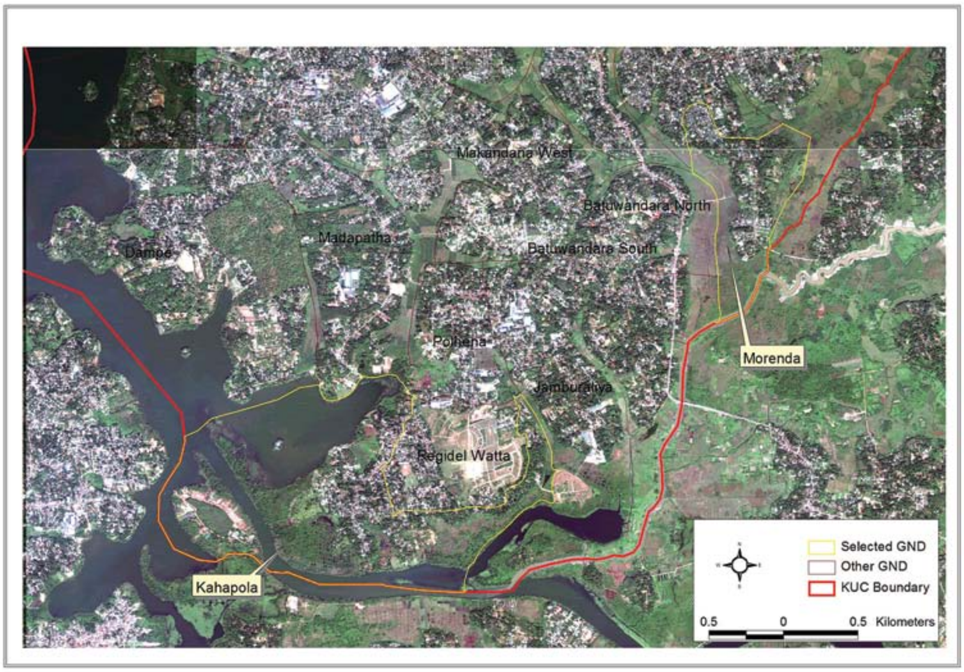
According to the same vulnerability assessment, the agricultural, urban and housing sectors will be increasingly affected by floods, sea level rise and increasing temperatures. Food production in the province is not sufficient, and importing food from other areas of the country is threatened by negative climate impacts on both agricultural production and transport.[15] At the same time, cultivable land, often located in low-lying areas, is being abandoned or converted to residential and commercial uses. Flood-related disasters are projected to increase, as will economic and social vulnerability to other effects of climate change.

Kesbewa Urban Council area is a fast-growing city in Western Province, located 21 km south of Sri Lanka's capital city Colombo. Historically, Kesbewa has been an agricultural area, endowed with the vast water resources of the bordering Bolgoda Lake. A relatively large area of paddy lands can still be found in its lower-lying zones. However, following the continuous growth of Colombo and the expansion of the urban boundaries of Colombo Metropolitan Region, Kesbewa Urban Council area became an attractive residential area for commuters, now hosting over 244,000 inhabitants (2012 census) on 49 km^2 of land. Much farmland was gradually converted to non-agricultural use, resulting in about 60% of the land now being used for residential purposes and related amenities (see Fig. 1).

Increasing flood occurrences and projected temperature increases

In the traditional land-use system in Sri Lanka, low-lying lands are kept free from construction for drainage of rainwater and/or used for paddy cultivation. Since the year 2000, however, paddy lands have been converted into residential housing and this trend is expected to increase. A study implemented in 2012 by the national NGO Janathakshan, in the context of a UN-Habitat- and RUAF-supported programme, shows that between 2000 and 2010, some 14% of agricultural (including paddy) lands were converted to residential areas.[16]

Figure 1. Low-lying agricultural areas in Kesbewa Urban Council area are facing rapid urbanisation.



Source: Kesbewa Urban Council (2012).

The rapid filling and conversion of the paddy lands (that were all privately owned) to residential and commercial areas has significantly altered natural water flows and drainage. Coupled with an increase in average rainfall and heavy rainfall events, this has resulted in recurrent flooding and related damage to infrastructure, utility supply and the urban economy in some parts of Kesbewa area.[17]

Although Kesbewa still had over 600 ha of paddy lands in 2011,[18] some 32% of these were left fallow, mainly because paddy cultivation in this part of the country is less profitable than it is in the northern part of the country, where labour costs are lower. The opening up of other urban livelihood opportunities is an additional driver of abandoning paddy, coupled with an increasing problem with saltwater ingress in the fields, resulting in lower crop yields and incomes.

The Ministry of Agriculture, Western Province realised that well-maintained and well-drained paddy areas function as buffer zones in which water is stored and drainage regulated, thus reducing flood risk in nearby areas. It also realised that, as a result of the land-use changes, Kesbewa has increasingly needed 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, and increased refrigeration and air conditioning, all leading to higher GHG emissions. Finally, as a result of decreased vegetation, climate change projections foresee a significant increase in extreme heat days in the area, with projected severe impacts on energy demand for cooling and heat-related illnesses.[19]

> "Exposure to floods, strong winds and extreme temperature events will increase in the future. Vulnerability of the Kesbewa Urban Council area will increase by more than 200% (from 25% to 82%) within the next 20 years. This emphasises the need for reinforcing the adaptive capacity of the city in order to cope with expected climate change scenarios."
>
> – Prof. P.K.S. Mahanama, University of Moratuwa[20]

Until recently, the climate change literature has almost exclusively called for increasing the density of cities to make transport and services systems more efficient. However, a different approach is being taken Sri Lanka's Western Province. Its urban plans now include ecosystem design principles and low-cost climate-change adaptation strategies, such as rehabilitating and reconnecting productive green spaces throughout the city. By reducing surface flows and enhancing infiltration, this strategy aids in storm water management, reduces flood risks and increases urban food production.

Potential adaptation and mitigation benefits are being monitored at the provincial level, along with other positive social and economic impacts, to support policy lobbying and formulation. Pilot projects and practices are also being put into place that promote awareness and networking, policy dialogue, capacity development, new partnerships and pilot financing schemes.

Pilot projects adapt existing development initiatives for climate compatibility

Since 2005, home gardening and urban agriculture have been promoted in Western Province as part of the country's policy aimed at achieving food sovereignty and promoting domestic food production. However, this was not done from a climate change perspective. In partnership with the international network of RUAF, the International Water Management Institute, UN-Habitat, Wageningen University–Plant Research International, the School of Forestry of the University of Florida, and local project partners, a CDKN-funded assessment of the potential impacts of urban and peri-urban agriculture and forestry on climate change adaptation, mitigation and developmental benefits was undertaken.

On the basis of this assessment, and with support of the UN Habitat Cities and Climate Change Initiative Janathakshan conducted a further diagnostic study to identify appropriate urban and peri-urban agriculture models that fit well within the present and future land-use patterns in Kesbewa, and to identify the wider context within which these urban and peri-urban agriculture models could be replicated and guided by relevant policies and interventions. The diagnosis and assessment included five interrelated studies to identify the most feasible urban and peri-urban agriculture models.

- **Vulnerability mapping** – to identify which areas in the city are most vulnerable to flooding and could benefit from rehabilitation of paddy areas and low-lying zones for agricultural production
- **Land-use mapping** – to identify where urban and peri-urban agriculture and forestry is currently taking place and how such areas could potentially be connected in an 'urban green mosaic'

- **Food-flow mapping** – to map sources and transport distances for different food items, and to identify which imported foods could best be produced locally (i.e. those having the largest potential impact on emission reductions)
- **A policy scan** – to identify current policies dealing with urban and peri-urban agriculture and forestry that could be expanded upon, as well as to identify gaps or potential areas in agricultural, land-use and climate change policies and city development plans where urban and peri-urban agriculture and forestry could be included
- **A feasibility scan** – to analyse the feasibility of proposed pilot projects and prioritise the best ones.

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.[21] The food flow mapping identified five vegetables (gourd, cucumber, aubergine, okra, chilli and capsicum) and two fruit species (banana and papaya) that can be locally grown in Kesbewa, but are at present imported from distant locations.[22]

Based on these studies, two promising urban agriculture models and pilot projects were selected to showcase the potential impacts that urban and peri-urban agriculture may have on climate change adaptation and mitigation: i) the productive rehabilitation of abandoned paddy lands with more salt-resistant and local varieties of paddy (which are high in demand and fetch good market prices), alongside the cultivation of the selected vegetables in raised bunds that generate additional income; and ii) intensification of home gardening, coupled with promotion of rainwater harvesting and organic waste composting.

Pilot project 1: Rehabilitation of abandoned paddy lands

The first project (January 2013 to March 2014) involved 47 farmers in four locations in Kesbewa. Altogether 43 acres (17.4 ha) of paddy fields have been put into cultivation, including 13 acres (5.2 ha) of abandoned fields, all located in medium- to high-risk flood zones that have been abandoned for more than 20 years.

‘Cultivation meetings’ of farmer groups were used by staff from Janathakshan, as well as agricultural officers from the Provincial Ministry of Agriculture, to discuss with the farmers involved the problems they are currently facing, the proposed project and its potential positive impact on the socioeconomic conditions of the farmer families and the environment. It was agreed that the project should start with cleaning the drainage channels to facilitate water flow and reduce waterlogging in the paddy fields. In all project areas, the channels were cleaned by farmer organisations with financial and technical assistance from the Provincial Ministry of Agriculture.

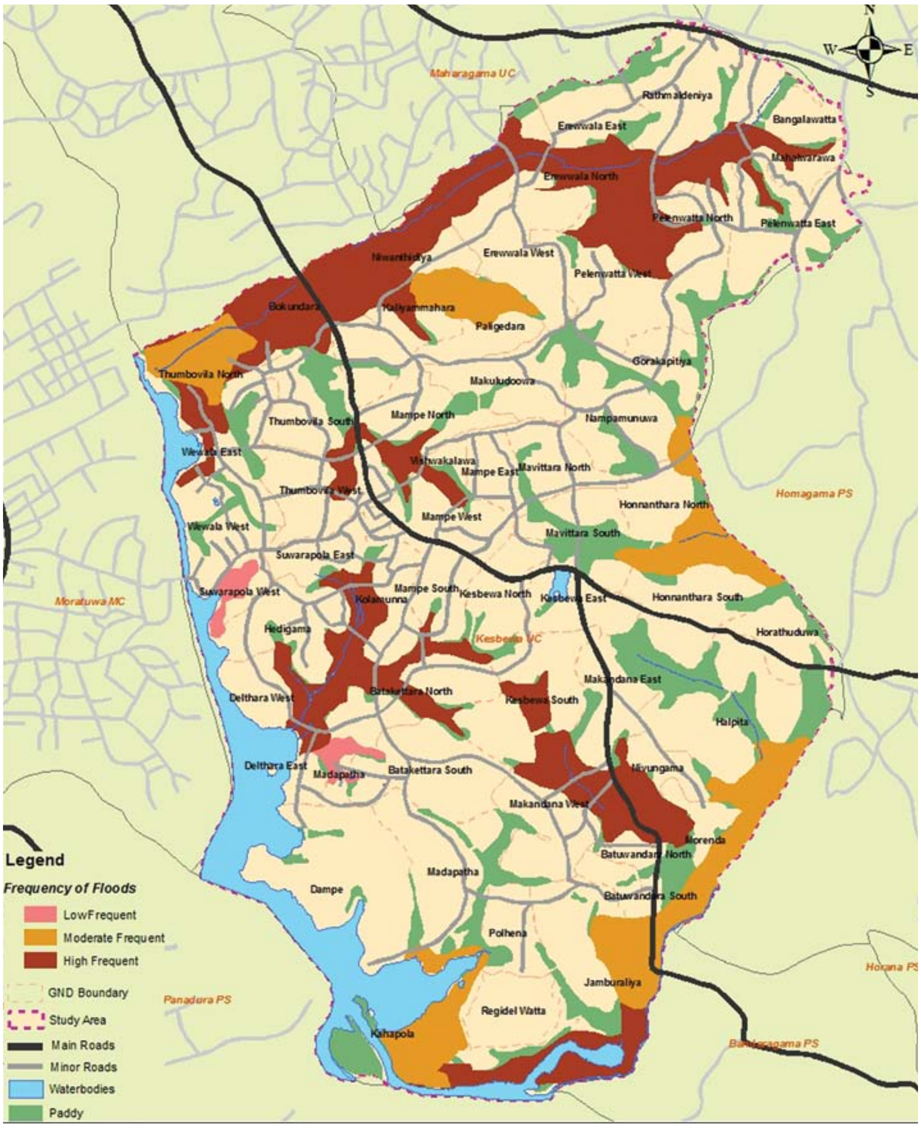
Another problem encountered was that several of the fields had been abandoned for more than 20 years and large trees had grown, thus making land clearance costs relatively high. Several farmers were only convinced to invest in land clearance after they saw positive results from fellow farmers in Kesbewa and other areas of the country.

The Ministry of Agriculture, Western Province also assisted the farmers technically and provided traditional paddy seeds. Agriculture Instructors attached to the Kesbewa Agrarian Development Centre were trained as trainers of trainers. The project took the paddy farmers and the agrarian officials to the southern part of Sri Lanka to show them rehabilitated and re-cultivated abandoned paddy fields.

Co-funding for project implementation was assigned from various programmes and departments, such as the ‘Divina Naguma’ home garden programme and the Department of Agrarian Services. The Ministry of Agriculture, Western Province has also made available and funded the staff time of their agricultural officers and extension staff, who will play a key role in future upscaling the activities in the province (the ‘paddy model’ has already been transferred to an area in Colombo city).

The income of the farmers involved was increased considerably when compared to paddy farmers not involved in the project. One kilogram of conventional paddy is generally bought at 28 Sri Lankan Rupees (Rs), earning the farmer around Rs 28,000 per acre (close to Rs 70,000 per hectare) per season (with average production of 1,000 kg of paddy per acre). After incorporating vegetable production and the traditional salt-resistant varieties of paddy, the farmers involved in the project got an average price of Rs 40.00–50.00 per kilogram of paddy depending on the quality, thus earning between Rs 40,000 and 50,000 per acre per season (Rs 99–124 per hectare). In addition, the farmers received an average income of Rs 12,500–15,000 through the sale of vegetables produced in the paddy fields.

Figure 2. Flood exposure in Colombo, Sri Lanka.



Source: Faculty of Architecture, University of Moratuwa (2012). Based on data from the Ministry of Disaster Management, Government of Sri Lanka, Colombo.

Where paddy lands are abandoned, nearby houses are regularly flooded. Photo: Janathakshan

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

Monitoring of impacts on reduced flooding are ongoing and need to be carried out over several (rainy) seasons in order to establish reliable trends and differences from non-rehabilitated areas.

Pilot project 2: Intensification of home gardening, coupled with promotion of rainwater harvesting and organic waste composting

In 2011, a total 410 ha were used for home gardens in Kesbewa (next to the 600 ha of paddy land there), while another 285 ha remained available for cultivation.[23] The Kesbewa urban population is not wealthy: 84% falls in the low- to middle-income category.[24] A sample of households involved in home gardening and a control group living in the same area studied by the University of Colombo indicated that major sources of jobs were government jobs, jobs in private business or self-employed (each around 20%), with 25% being retired or not employed and 15% earning their main income from farming.[25]

Home gardening is practised by around 30% of the population for both home consumption and income. Home gardening helps lower household vulnerability by enhancing access to more diverse and nutritious food and by diversifying income sources. Thus, people with home gardens are less vulnerable to disturbances in food supply from rural areas or imports and to increases in food prices – both of which may be aggravated by climate change. In the light of continuing urban development and increasing competition over land, home gardens should be designed with future space restrictions in mind.

The second project thus looked at the intensification of home gardening units, coupled with the promotion of rainwater harvesting and organic waste composting. The vegetables and fruits promoted in home gardens were selected on the basis of their potential to replace food imports as identified by the food-flow analysis mentioned above.

Home gardening beneficiaries were selected through a participatory process with the support of Agriculture Research and Production Assistants (APRAs)[26] and management assistants of the Divisional Secretariat of Kesbewa. The process included initial awareness raising of the pilot project, selection of interested participants by the management assistants of the Divisional Secretariat, verification of participants by APRAs, technical training and assistance, preparation of business models, and linking home gardeners to plant nurseries.

A total of 150 home gardeners from 10 divisions actively participated in this second project that ran from January 2013 to March 2014, with high participation among the elderly (57%), who often have more time and interest in growing and a more natural lifestyle. Techniques like bio-intensive farming, vertical structures and certain irrigation methods like solar drip irrigation and micro-irrigation methods have been introduced to make optimal use of available space and reduce labour requirements for production. The gardeners have also been provided with technical training on space-intensive farming and business planning (for those farmers more interested in commercial production), 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 members of the public, government officers, politicians and schoolchildren. A series of six television programmes

Box 1. Applying key lessons from other home garden programmes

The past lessons of many other organisations that have implemented home garden programmes and projects suggests that market linkages and (business) support services are crucial factors to ensure the viability of small-scale semi-commercial urban home gardens. The project therefore paid attention to identifying simple business models that link home gardeners to support and marketing services. Awareness creation, forming of business groups, preparation of business plans and support to establishing linkages to markets and business support services were among the activities carried out. The business plans for 150 home gardens were developed with the help of the APRAs, a business-planning consultant and the households involved. The idea of market-oriented home gardening worked well for about 40% of the households, though not for the other 60%, which principally comprised elderly farmers or those lacking motivation. It was mainly younger and experienced farmers who found working with a business orientation very attractive, as they were willing to sell their produce within the division, while many of the elderly participants practise gardening mainly for psychological relaxation, social network building and to grow produce for their own consumption or to share with relatives and neighbours.

Intensive use of home gardening Photo: Janathakshan

A square foot vegetable garden
Photo: Janathakshan

on this demonstration plot was broadcast on a national channel. More demonstration plots are now being established to further enhance awareness and uptake of the practice.

An evaluation carried out by the project in March 2014 showed that 26.1 ha of home gardens are now cultivated with space-intensive and small-scale production aimed at commercial markets as well as home consumption. Among the households practising space-intensive home gardening, food production increased. They were also able to sell 50% more than at the start of the project.

Over the project period, 60,200 kg of urban organic compost was produced using organic household and garden waste, and was used in the gardens. This resulted also in a reduction of 60,200 kg municipal solid waste that would have been transported to landfill. The households involved were able to reduce the use of external fertilisers by 56.3% by using homemade compost, saving all households together approximately Rs 175,560 over the project period.

At the end of the project, more than 67% of the households were applying simple micro-irrigation methods, resulting in less water needed for gardening thereby saving on households' use of drinking water.

At the end of the project, 150 households had access to improved service and market suppliers and outlets. Six plant nurseries were set up that provided over 6,000 seedlings to the project beneficiaries and other farmers. The nursery producers earned on average Rs 16,250 from their business in the period January-March 2014

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

Impact monitoring

Impact monitoring by the universities of Moratuwa and Colombo shows that households involved in the production and sale of urban food (paddy and vegetables) can increase their income and reduce their food expenditure, improving both food security and dietary diversification. Flooding incidence and impacts are also estimated to be lower when paddy lands are preserved and well managed, though future and continued monitoring should confirm this. Reducing the transport of vegetables over longer distances by increasing local production of the selected vegetables (gourd, cucumber, aubergine, okra, chilli and capsicum) in home gardens, while at the same time improving organic waste reuse, can reduce GHG emissions by 74.89 tonnes/year.[27] Emissions of GHGs could be further reduced if home gardens were used more intensively, yields increased and nutrient management improved (as only small quantities of compost are used), requiring extension and technical support.[28]

Policy implications

> "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 physically vulnerable sites and viable response to climate change effects such as excess storm water."
>
> – S.T. Kodikara, Former Secretary, Ministry of Agriculture and Environment, Western Province, Sri Lanka[29]

In parallel with project implementation and monitoring, researchers conducted a policy review to determine where intervention would be needed to scale up these models, at three levels.

- **Local level** – promoting the integration of urban agriculture into urban development plans and in municipal programmes and budgets. Starting with Kesbewa Urban Council, a call was made for: i) the identification and zoning of urban agriculture areas; ii) the design of such areas, building on the results of the pilot projects and including direct support for interventions (e.g. financial incentives for rainwater harvesting in home gardens); or iii) for rehabilitation of drainage canals in paddy areas.
- **Provincial level** – developing, with the contribution of all stakeholders, a provincial climate-change adaptation action plan that will help Western Province better cope with climate change impacts. The plan should identify concrete actions for implementation over the short, medium and long term. It should also seek to integrate urban agriculture and forestry in each of the five sectors to be covered: food security, biodiversity, health, water and human settlements.
- **National level** – revising the Paddy Act, which previously allowed for paddy cultivation only in assigned areas. The Act should promote and support new production models for mixed cultivation of rice and vegetables that can increase income, promote and revalorise agro-ecological forms of production and traditional saltwater-resistant rice varieties, and maintain the natural drainage functions of paddies.

At the time of publication of this paper, policy revision and development are ongoing and supported by awareness raising, impact monitoring and broad stakeholder participation. Revision of the Kesbewa Urban Development Plan is being done in consultation with Kesbewa Urban Council, the Divisional Secretariat and the Urban Development Authority. The Plan already proposes to develop agriculture in the environmental protection zone around Bolgoda Lake and low-lying areas, bringing economic benefits while facilitating ecotourism and botanical research. Promotion of home gardening is also mentioned. However, clear choices on production systems and land-use design still need to be included, as do tangible proposals and incentives for urban agricultural production and marketing.

Triggered by the interest in climate change risks and adaptation strategies generated by the project, the Ministry of Agriculture and Environment of Western Province drafted a proposal to prepare a provincial climate-change adaptation action plan. However, the design and planning of stakeholder inventory and consultation, and preparation of sectoral action plans and implementation strategies has been delayed by the loss of institutional memory after a change of staff in the Ministry of Agriculture.

Box 2. Steps towards a provincial climate change adaptation action plan

The proposal to prepare a provincial climate change action plan outlines the steps and timeline for the drafting of such a plan. The provincial climate change adaptation action plan will be prepared in collaboration with the Climate Change Secretariat of the Ministry of Environment, with funding from the Ministry of Agriculture and Environment of Western Province. It will be streamlined with the National Climate Change Policy (2012) and the National Climate Change Adaptation Strategy (2010) of Sri Lanka to the extent possible. It will also build on inputs from all levels of society in order to identify key concerns faced by the population and build on practical solutions for adaptation.

A fact sheet on the specific contributions of urban and peri-urban agriculture to the five sectors is currently being prepared by RUAF, including the results of the impact monitoring of the Kesbewa pilot projects. The publication will also include other international examples and results of the contribution of urban and peri-urban agriculture to climate change adaptation.

The Paddy Act is regulated by the Department of Agrarian Services in the Ministry of Agriculture. Current agrarian policy deals with the revitalisation of abandoned paddy lands. Based on the pilot project results, a recent circular published by the Department supports the promotion of short-term vegetable crops in rotation with paddy. However, uptake of this new practice is lagging. A clear implementation plan is needed as is further awareness raising and information for interested farmers, plus financial support to rehabilitate drainage systems.

Similarly to Kesbewa and Western Province in Sri Lanka who approach the link between urban and peri-urban agriculture and forestry and climate change from the point of view of flood risk reduction, livelihood improvement and reduction of food imports; Rosario and Santa Fé Province in Argentina also embarked on a research study to assess the impacts of urban and peri-urban agriculture and forestry on run-off, urban temperatures and food transport and related emission reductions. Their story is told below.

Rosario, Argentina

Rosario (1.3 million inhabitants) is situated in the strategic central region of Argentina (Santa Fé Province), on the banks of the River Paraná, 300 km north of Buenos Aires. Its location and its important activity as a port have made it the chief town of a busy region. Rosario used to produce a large part of its food in the fertile agricultural green belt surrounding the city. Urbanisation and conversion of agricultural land to soya production have, however, greatly reduced local production, with the city now having to import its food from other provinces or countries. In an attempt to reduce food transport and as part of its climate agenda, Rosario – with support of the Santa Fé Province – now aims to protect and preserve its peri-urban production area; while at the same expanding on its existing intra-urban (inner city and surrounding areas) agriculture programme to increase its benefits as a food-security and income-generating strategy for the urban poor, as well as enlarging its potential benefits for storm water drainage and reducing the urban heat island.

Municipal support to urban and peri-urban agriculture in the city increased greatly 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 receiving job training in urban agriculture, 4 “garden parks” and other smaller public areas devoted to vegetable production (covering a total area of 22 ha), and 3 urban agro-industries are producing processed vegetables and cosmetics from medicinal plants. The total production is about 95 tonnes of vegetables per year and 5 tonnes of aromatic plants per year. The fresh and processed products are sold by the gardeners at five street markets in the city.

The Rosario Municipality has designated another 400 ha in and around the city for expansion of urban agriculture in the near future.

> “We see the importance of preserving and expanding areas for local food production. The municipality has included a new land use category in our urban development plan: ‘land used for primary production’. We have currently doubled the peri-urban agricultural protection zone from 400 to 800 ha”
> – Mónica Fein, Mayor, Rosario (August 2014)

From its start in 2001, the main aims of Rosario’s urban agriculture programme were to contribute to food security and income generation for vulnerable households living in the various marginal settlements of the city (involving about 12% of the city’s population). In 2013, the city expressed interest in also exploring the potential contributions of urban and peri-urban agriculture to climate change adaptation and mitigation, in order to monitor and promote its contributions to the city’s climate change action plan. Supported by RUAF, CDKN and international research organisations Wageningen University–Plant Research International and the University of Florida, local researchers from the National Institute of Physics, the National University of Rosario, as well as municipal staff from the urban agriculture programme, were trained on impact monitoring and scenario building. The preliminary results of the research on monitoring the contribution of green areas to the reduction of the urban heat island and run-off, and the effects of local food production on reduction of food transport are described here.

The contribution of green areas to reducing the urban heat island

As in most densely built-up cities, Rosario is experiencing higher temperatures in city areas than in surrounding areas. The period December 2013 to January 2014 (the summer period in the southern hemisphere) was a period with extremely hot climatic conditions in Rosario and the northern part of Argentina, with air temperatures

Remaining horticulture production in Rosario's greenbelt. Credit: Raul Terrile

over 35–40°C and relative humidity of over 50%.[30] With these – for Rosario – extremely high temperatures and heat indices, the use of air conditioning was so high that the electricity supply was interrupted for several hours and even days in some parts of the city. Extreme temperatures also have potential negative influences on human health and mortality rates. For these reasons, Rosario is looking for different options to reduce temperatures, with one of the options being the introduction of urban green (forest and vegetative) coverage, as this can significantly reduce the surface temperature of otherwise bare pavements and built-up spaces.

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

A first set of measurements was made during the months of September 2013 to January 2014, and a typical representation of temperature behaviour for the different hours of the day for December 2013 is given in Fig. 3. This was the hottest month of the southern hemisphere spring–summer, and an extreme mean value of 36.8°C was registered close to the government building located in the city centre. Temperatures recorded show that average temperatures in the urban garden parks or in streets/squares with a large tree vegetation are lower than in the central area by around 5°C (see Fig. 3). This result 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. Highest maximum temperatures were also found in areas without urban agriculture and forestry in other months.

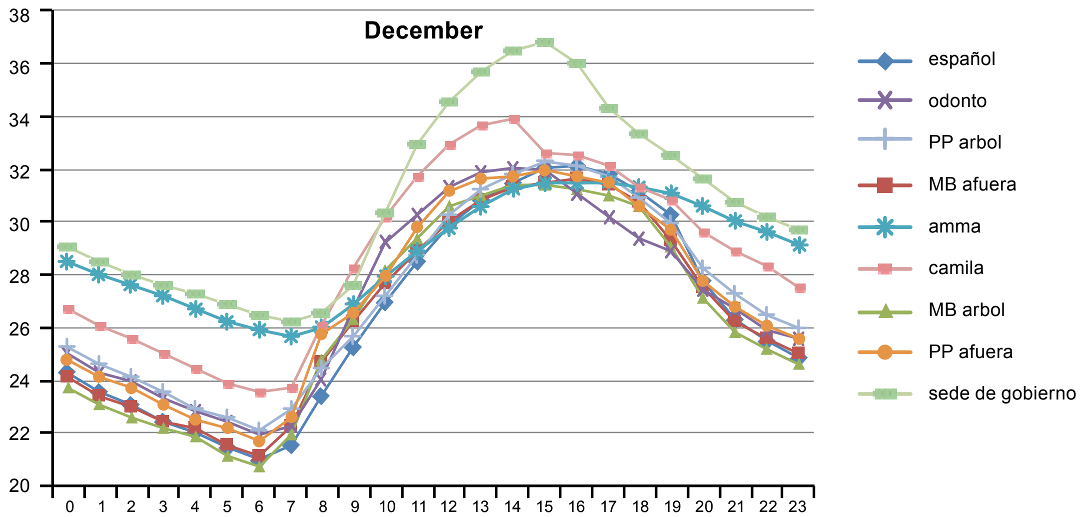
Transportation and conservation of food

Due to the loss of its traditional horticultural green belt, Rosario now has to import a large part of its food and vegetables from areas located 200–1,000 km away. The research team decided to do a scenario study and calculate the amount of food kilometres (or food miles) travelled by each product to reach the city.[31]

The distribution of food within Rosario can be separated into a traditional retail circuit (food is imported and distributed and sold through retail stores and on city markets) 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.

To monitor the impact of the reduction of food miles, three products are considered: the first two are squash (including pumpkin) and runner beans, as they are currently produced in the urban gardens and their production

Figure 3. Evolution of mean air temperature during the 24 hours of the day for the month of December 2013



Note: The places with urban agriculture and forestry (tree cover) are: garden park Hogar Español (español), garden park Facultad de Odontología (odonto), garden park Molino Blanco (MB), Parque Independencia with tree cover (PP arbol) and amma (street with trees). Places without vegetative cover are: Parque Independencia without tree cover (PP afuera), a typical urban square (camila) and the government building located in the city centre (sede de gobierno).

Box 3. The emissions reductions potential of urban agriculture

Potatoes are mainly imported from a region located about 630 km from Rosario. They are moved by truck, usually with a capacity of 20 tonnes. During transport around 10% of food is wasted. To supply all the potatoes needed to feed the Rosario inhabitants, such transport represents a CO_2 output of 3,350 tonnes per year. Assuming that emissions from production would be equal in both distant and peri-urban locations, then if potatoes were produced close to Rosario, CO_2 output related to food transport would only be 160 tonnes per year.

Similarly, if squash/pumpkin, which is imported from the Ceres region about 200 km from Rosario, was produced locally, there would be a reduction of 92.5% in CO_2 emissions per year; for runner beans, which are produced mainly in the horticultural area of Great Buenos Aires (about 300 km from Rosario), the CO_2 emissions reduction related to food transport would be about 95% per year.

Further research demonstrates that a total of 6151 ha of land would be needed to produce sufficient potato, tomato, lettuce, carrots, onions and pumpkin (the six most consumed vegetables) to satisfy local consumer demand in the greater Rosario region. Land use analysis illustrates that this entire 6151 ha of land can be found in the urban and peri-urban zone of Rosario. Local production potential will, however, also be determined by current and future land use, land prices and speculation.

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 could be achieved if the supply was sourced from the peri-urban region and areas near the city with high horticultural production. If these potatoes were to be produced in the area around Rosario (in the Arroyo Seco region located at about 30 km from the city centre), CO_2 emissions related to food transports would be reduced by 97%.

If a similar analysis were to be carried out for the other consumed vegetables in Rosario and other cities in the country, it would yield a significant contribution of urban and peri-urban agriculture to reduce food miles and GHG emissions. Of course, this would be dependent on the actual potential to grow food in and around cities, while production methods and yield per area should also be included in further analysis.

It should be noted that the study did not look into the net effect of shifting production from rural to urban areas on rural communities and other people who are currently producing and supplying food products (truckers, restaurants on highways, labourers used for loading and unloading, etc.) to cities such as Rosario or Kesbewa. This would merit further research. Also, price impacts for the consumer of producing local food versus importing food should be looked into further.

Effects of urban agriculture on run-off and infiltration of storm water

As is the case for Kesbewa, certain areas in Rosario along the borders of its two streams are regularly flooded, negatively affecting the mainly poor households located there. The Rosario researchers identified one urban and two peri-urban watersheds and developed three land-use scenarios: one being the current situation; one with an increase in urban and peri-urban agriculture area (urban garden, trees, productive floodplains, green roofs); and one in which the watersheds would be totally built up and urbanised. They introduced a simple method to estimate run-off, based on a rational equation. The indicator used was the variation of the run-off coefficient as a function of the increase in urban agriculture areas. The run-off coefficient varies with slope, surface condition, vegetation cover and hydrological soil type. Surfaces that are relatively impervious, like streets and car parks, have run-off coefficients approaching 1. Surfaces with vegetation that intercepts 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 a reduction of the risk of floods) and an increase in infiltration/storage of the storm water within a given surface area.

The research team calculated that with the actual land use (scenario 1) the average run-off coefficient is 0.64 for the urban watershed. Envisioning a future land use with an increase in green area in the total area (that would be possible given current land uses and characteristics), the run-off coefficient would reach a value of 0.49, which implies an approximately 20% decrease compared to its present value. This reduction in run-off would cause a similar reduction in the risk of urban flooding, which would significantly improve the situation of the population.

On the other hand, a future land use considering further increase in built-up area (scenario 3), gives a run-off coefficient of 0.74, which implies an increase of approximately 15% of the current value. These values would require upgrading and consequent increase in the costs of urban drainage infrastructure to maintain a similar (or lower) level of flooding to the current situation.

Policy review

Technical staff and decision-makers from the Municipal Urban Agriculture Programme, the Parks and Gardens Department, and the Provincial Department for Production have from the start of the project been involved in the research design and discussion of its (preliminary) results. Findings from the study on urban temperatures will be used by the Department of Parks and Gardens to further promote city green belts and urban forestation, particularly in those areas in the city with the highest temperatures and also in newly urbanised areas.

Sharing and discussing the results of the urban food miles study led to increased awareness among policy-makers at city and provincial levels of the need to protect and preserve the horticultural green belt (peri-urban agriculture) around Rosario, as well as to promote more ecological production technologies. Consequently, the Province of Santa Fé Secretariat of Production has agreed to finance a project that aims to: i) strengthen knowledge and capacities of farmers in this area in ecological production methods; and ii) ensure a local market for healthy produce. The project has already started with a group of interested farmers and connected them to restaurants interested in buying and serving local food. In the longer term, the project aims to contribute to increasing local horticultural production, while raising farmer income, thereby helping to preserve farming in the area. The project will also work on further regulations to protect the horticultural green belt. Collaboration between the city and the Province is crucial as the main horticultural green belt lies outside the municipal boundaries of Rosario city.

Resulting from discussions on the first measurements on the role that urban agriculture and green areas can play in reducing run-off and flood risks, a policy proposal on inclusion of urban agriculture in watershed management was developed by the project team and presented to the Urban Agriculture Programme and Housing Secretariat of the Municipality of Rosario for their review. The proposal calls for an increase in the area of green roofs on new and existing buildings through ordinances that define where they should be built and which specify their technical characteristics. It also calls for integration of urban agriculture and forestry in public parks, squares, walks, beside motorways, railways, institutional green spaces and public woodland, and for reducing the risk of flooding and waterlogging caused by paving and building in flooded areas, through urban agriculture land-use strategies by means of land-use ordinances.

Policy discussions are under way to see how best these proposals can build on existing policies and plans, and to agree on the need for new proposals and plans and for their institutional uptake and funding.

5. Drawing lessons learned from the two cases

In both cities, project results to date have been facilitated by integrally linking project implementation, research, monitoring and policy-making, and by the building of local partnerships between policy-makers and researchers and between local and subnational (provincial) governments. However, challenges remain with regard to further improving research to policy outreach, and further areas of research have been identified.

Pilot activities and impact monitoring to guide parallel policy-making

In both cases, the ongoing policy revision and design of new programmes (such as the horticulture green belt project in Rosario) are guided by pilot and demonstration activities (Sri Lanka) and/or research and impact monitoring (both cities). Project results and available monitoring data are used directly in policy-making. From the start of the project, the participation of policy-makers (from local and provincial government) was facilitated in research and project design, and through sharing and discussion of projects and monitoring results. Such direct involvement allows for a direct flow of information. At the same time, policy-makers can guide researchers on the type of data needed and in this way influence research design and scenario formulation.

Finding a common language

Although direct partnerships between researchers and policy-makers are beneficial and enhance policy-making, finding a common language among researchers and policy-makers proved difficult at times – but crucial for the uptake of results. For example, presenting research data on reductions in GHG emissions in terms of tonnes of CO_2 may have no meaning to policy-makers unless it is compared to impacts of other interventions or presented in other forms like 'the emission or energy equivalent of X urban households'. Individual householders in turn, simply want to know how much money they can to save by reducing emissions or energy costs. Similarly, data on local food production should be presented in terms of percentages of urban consumption (for specific crops) and linked to land availability and land-use potential (i.e. how much food can realistically be locally produced and how much land would it require) if they are to be used as a basis for urban planning.

Partnerships between local and provincial governments

The two cities show that metropolitan, municipal and other local government institutions can play a proactive and coordinating role in enhancing urban food security and their cities' resilience by:

- integrating urban food security and urban and peri-urban agriculture and forestry into climate change adaptation and disaster management strategies
- maintaining and managing agriculture projects as part of the urban and peri-urban green infrastructure
- identifying open urban spaces that are prone to floods and landslides, and protecting or developing these as permanent urban and peri-urban agriculture or multifunctional areas
- integrating urban and peri-urban agriculture into comprehensive city water(shed) management plans
- including urban and peri-urban agriculture in social housing and slum upgrade programmes
- developing a municipal urban agriculture and food security policy and programme.

It should, however, be acknowledged that city governments are not always officially mandated with working on agriculture, land-use or watershed development and in such cases would need to engage and liaise with the relevant departments at higher levels of government in order to implement urban agriculture activities. This will also be the case if (peri-urban) land-use planning needs to be tackled at a larger scale outside the direct city boundaries (as illustrated by Rosario). This can be greatly facilitated through the involvement of provincial governments. Provincial governments can also play an important role in mobilising additional financing (as done by the Ministry of Agriculture, Western Province and the Province of Santa Fé); in facilitating upscaling to other cities in the region (as happened in Western Province), as well as in developing subnational plans that need to accompany city-level strategies (like the provincial climate change policy in Sri Lanka).

Further areas of research

Throughout the course of the current research project several research questions have been identified that would merit further attention and analysis:

1. To what extent will urban and peri-urban agriculture be affected by climate change? What is its capacity to adapt to climate change through new production and storage practices or, for example, selection of more drought- or salt-resistant crops?

2. Which production systems (e.g. home gardens, green roofs, productive flood zones) are working best where (e.g. in what areas in or around the city), and what are the related barriers and enablers (e.g. regulations, incentives and zoning)?
3. What would be the implications of urban agriculture on agriculture in rural or other 'competing' areas?

The potential for application of various replicable urban agriculture models in city climate change programmes should also be better assessed and packaged. Meanwhile (technical, socio-organisational and financial) information on selected 'good practices' requires wider dissemination. Interested cities, provincial governments and other local actors can get inspiration from the cases described in this paper that showcase replicable urban agriculture models and policies.

6. Conclusions

There is growing recognition of urban and peri-urban agriculture and forestry as an important strategy for climate change adaptation and disaster risk reduction. Experiences in Sri Lanka and Argentina have shown that urban agriculture can help reduce the vulnerability of the urban poor *and* address climate change at the same time.

The experiences in Sri Lanka and Argentina provide a first set of monitoring data and have informed the development of an appropriate and applicable monitoring framework. Local application of this methodology elsewhere could be effectively used to: i) develop GHG emission reduction plans, taking into account urban agriculture alongside other interventions; ii) develop local food system strategies; iii) integrate agriculture in urban planning as an appropriate use for vulnerable sites and a viable response to climate change effects; iv) enhance awareness among citizens, the private sector and policy-makers on urban agriculture and climate change; and v) obtain national and international support and funding for adaptation measures involving urban and peri-urban agriculture.

Development of urban and peri-urban agriculture and (agro)forestry as a climate change and livelihood strategy should, however, go hand-in-hand with the development of a clear urban development and zoning plan, and promoting urban densification in certain zones (which may partly take place in the current green zones), while protecting other zones (where home gardens, garden parks, horticulture areas and paddy lands are or could be located) to arrive at a clear and sustainable urban structure. Without becoming more dense to some degree, cities will lose the rural character of their peripheries as increasing population and industry seek accommodation in the often historically agricultural areas. Therefore, the design of a 'green mosaic' plan is proposed, in which urban agriculture and forestry and residential areas are designed in a complementary way.

These views match well with concepts in urban development that stress the need for increased rural–urban linkages and "city–regional development".[31] According to Rafael Tuts of UN-Habitat: "*Integration of food systems in city–region planning – including regulated urban agriculture in flood plains, incorporation of roof top gardening into building codes, or inclusion of home gardens in 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*". This also includes the planning of urban catchments and watersheds for urban agriculture and forestry land use, as is currently being discussed in Rosario.

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About this background paper

The authors have produced this paper as part of a learning programme managed by the Climate and Development Knowledge Network (CDKN) and ICLEI-Local Governments for Sustainability. The programme captures lessons learned, and seeks to enrich understanding of what makes low-carbon and climate-resilient development efforts work well at the subnational level. For more papers in the series, visit www.cdkn.org/resources

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The RUAF Foundation promotes (intra- and peri-) urban agriculture and city region food systems for more sustainable and resilient cities. Since 1999, RUAF has supported local and national governments, urban producer organisations, NGOs, CBOs, research centres and other stakeholders with training, technical assistance, action-research and policy advice in the field of urban agriculture and urban food strategies. In addition, RUAF supports local, national and international advocacy and learning activities. RUAF is a not-for-profit organisation registered in the Netherlands. For more information visit www.ruaf.org

Editing, design and layout: Green Ink (www.greenink.co.uk)

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