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

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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).

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