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

RUAF Foundation

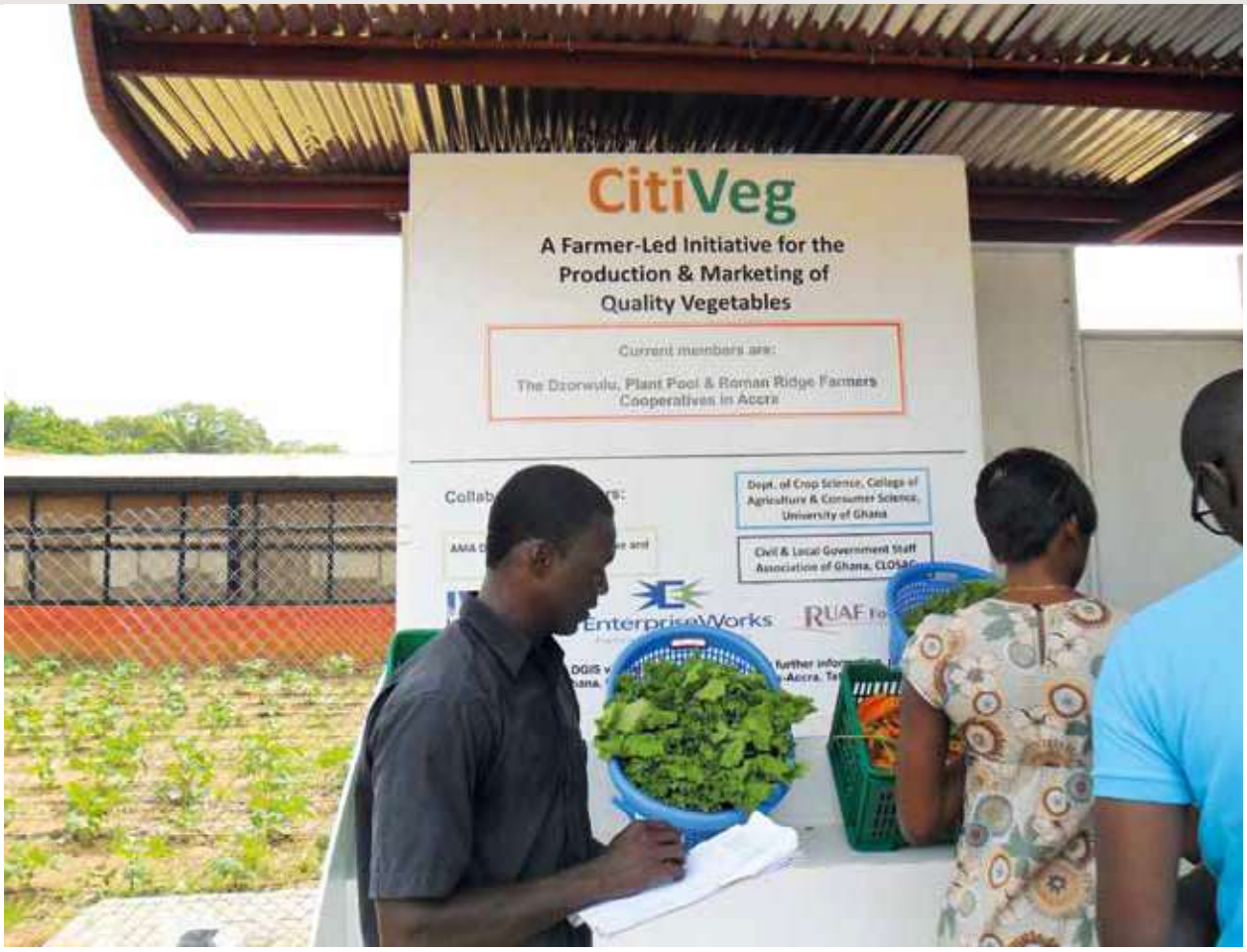
Impact categories of UPAF (urban and periurban agriculture and forestry) include climate mitigation, climate adaptation and co-developmental benefits (food production, income generation, sustainable resource management, etcetera).

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 Reduction of waste volumes due to on-the-spot composting / reuse 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 Positive effects on urban biodiversity (especially niche species)	Enhanced food security and nutrition (especially for the urban poor and women) due to improved access to nutritious food close to consumer Positive effect on urban biodiversity and liveability Educational and recreational opportunities	Food import and consumer transport distances for buying food Degree of external inputs and materials used in UPAF and related energy costs/ GHG emissions (ecological vs. conventional production; degree of recycling and use of organic waste, use of rainwater harvesting and water-saving production techniques; crop choice: use of drought-resistant species)
A	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 Minor carbon storage and sequestration	+++	Minor: Less vulnerability due to enhanced local production and diversification of food (and income) sources Enhanced water retention capacity and reduced run-off Reduced urban heat island effect Positive effects on urban biodiversity (e.g., migratory stops)	Enhanced food security and nutrition due to improved access to nutritious food close to consumer Educational and recreational opportunities Multifunctional use Enhanced city liveability	Degree of external inputs and materials used in UPAF and related energy costs/ GHG emissions (degree of recycling and use of organic waste, use of rainwater harvesting and water saving production techniques; crop choice: use of drought-resistant species; choice of production technologies and inputs required, (energy-costs of setting up the system)

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 Carbon storage and sequestration	+++	Less vulnerability due to enhanced local production and diversification of food (and income) sources Enhanced water storage and retention capacity Reduced flooding incidences/ lower water peaks; lower impacts of floods due to prevention of housing in flood plains Positive effects on urban biodiversity	Food production (volumes) Enhanced food security and nutrition due to improved access to nutritious food close to consumer Employment Positive effect on urban biodiversity and liveability Multi-functional use	Seasonality of production Degree of external inputs and materials used in UPAF and related energy costs/ GHG emissions (ecological vs. conventional production; degree of recycling and use of organic waste, use of rainwater harvesting and water saving production techniques; crop choice: use of drought-resistant species)
B-C	Promoting **forestry and agro-forestry** (especially **on steep slopes** and other areas susceptible to erosion and landslides)	+++	Carbon storage and sequestration Less energy use for cooling/refrigeration/acclimatisation due to reduction of urban temperature (in warmer climates) Reduction of air pollution	+++	Less incidence of floods and landslides due to reduced run-off and enhanced water storage and retention capacity Positive effect on biodiversity conservation	Production of food (crops, fruit, nuts) /fuel / wood Liveability enhanced (shade, aesthetics, temperature, air quality) Less health problems due to less heat stress (heat stroke, skin diseases, and heart problems) and air pollution	% under high- / low-density production Degree of combination with food production Choice of tree species (growth rate; water needs, maintenance requirements; retaining leaves year-round or not, long- or short-living, etc.) Degree of maintenance and maintenance techniques applied and related energy costs and GHG emissions 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 Less cost in maintaining infrastructure for transport, storage and cooling Carbon storage and sequestration	+++	Improved health of biodiversity for appropriate habitats and species, especially in conjunction with organic, low-till agriculture Enhancing food resilience for city (especially during disasters and political/financial crisis periods); less vulnerability due to enhanced local production and diversification of food (and income) sources	Enhanced food security and nutrition due to improved access to nutritious food close to consumers Employment Positive effect on urban biodiversity and liveability	Seasonality / Lower production per unit of energy Degree of external inputs and materials used in UPAF and related energy costs/ GHG emissions (ecological vs. conventional production; degree of recycling and use of organic waste; use of rainwater harvesting and water saving production techniques; crop choice: use of drought resistant species)

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 Reduced methane emissions due to less organic materials in landfills and less uncontrolled burning of wastes Less energy use and GHG emission due to reduced fabrication and use of chemical fertilisers Delayed emissions and carbon sequestration due to higher organic matter in soils 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 Fertile agricultural land and/or renewable energy (biogas) Reduced nitrate leaching Less smell and improved sanitation Less land needed for waste processing Employment and income	Transport and energy use in compost collection, production and distribution (sources, location of composting sites and users, transport means used) Idem for treatment and distribution of wastewater (treatment technology used, location of plants and users, etc.) 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 Reduced potable water use for irrigation and reduced competition for fresh water sources	Enables year-round intensive food production Less pollution of open water sources Possible hygiene effects Potential health risks related to use of untreated wastewater in an improper way	Choice of wastewater treatment techniques 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 More resilient farming systems Positive effect on biodiversity 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 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 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 Employment and income	Technical arrangement for reuse Required external inputs (e.g., fertilisers) Ecological vs. conventional production Degree of use of organic wastes, rainwater harvesting and water saving production techniques Needed external inputs/ materials 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" Better accessibility to food by lower-income groups Less fine dust, air pollution and traffic jams due to reduced traffic	Type of consumer transport used 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 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, More recreational and eco-educational opportunities 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)

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