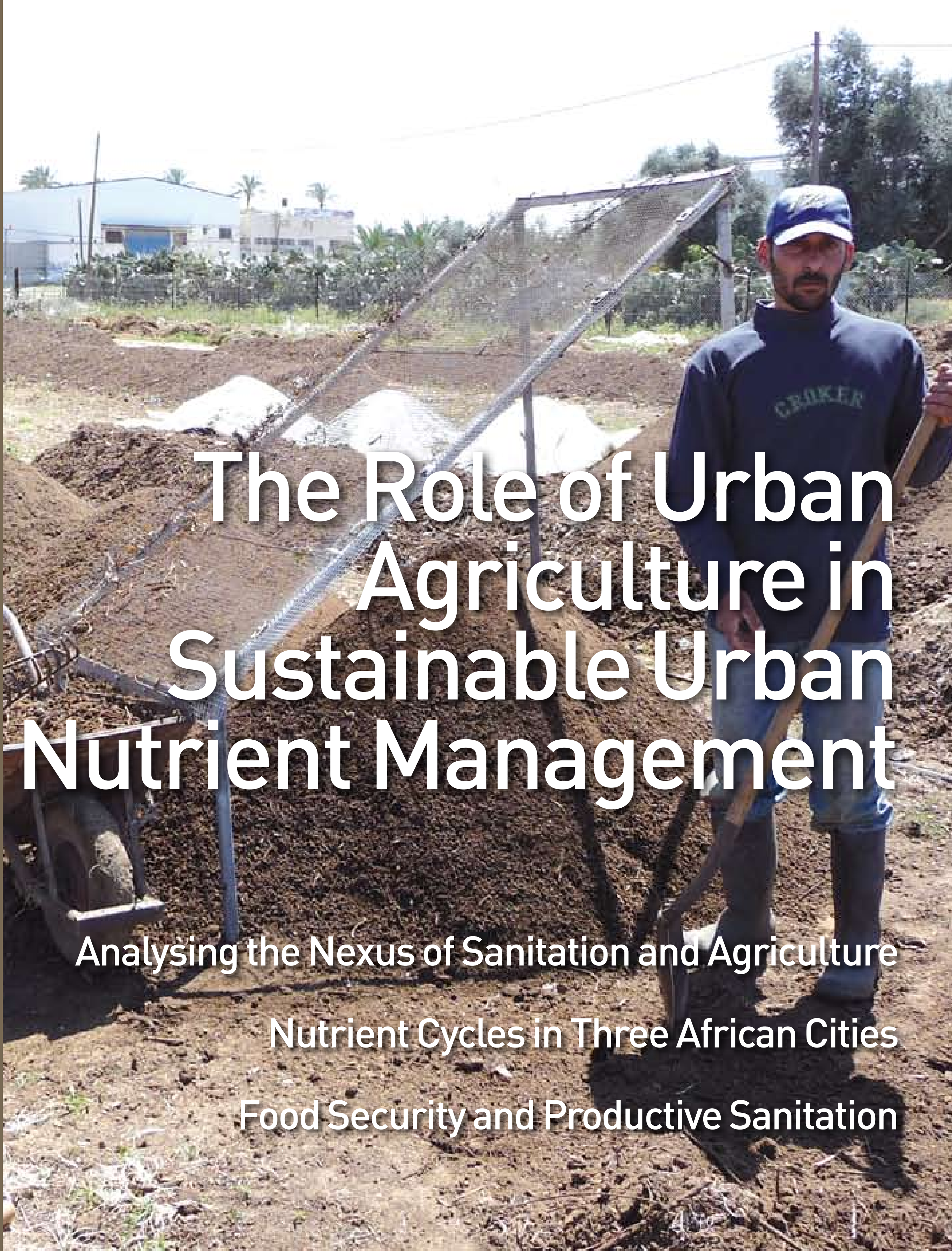
APRIL 2010

URBAN AGRICULTURE

UA MAGAZINE

23



The Role of Urban Agriculture in Sustainable Urban Nutrient Management

Analysing the Nexus of Sanitation and Agriculture

Nutrient Cycles in Three African Cities

Food Security and Productive Sanitation

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This issue will look at options for closing the loop through safe recycling of urban wastes, and argues that urban agriculture can play an important role in creating sustainable urban nutrient management. It is produced in collaboration with WASTE.

This issue of the UA Magazine is partly made possible by subsidy from the EU.

photo: Waste Recycling in Gaza, Palestine.
by: A. Adam-Bradford

Waste Management for Nutrient Recovery: Options and challenges for urban agriculture

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Urban agriculture is a response to the increase in demand for food and the market proximity in cities. This way of producing food is highly dependent on available space, nutrients and water. While access to space and water largely depends on local conditions, farmers commonly use different organic and inorganic nutrient sources.

The largest source is the residues from the food flows entering the city, comprising organic household and market waste but also human and animal excreta. Most of these resources end up in landfills or pollute the urban and periurban environment (urban nutrient sink).

This issue looks at options for closing the nutrient loop through safe recycling of urban wastes, and argues that urban agriculture can play an important role in creating sustainable urban nutrient management.

Rapid urbanisation in many cities is associated with an increase in urban poverty, growing food insecurity and malnutrition. The recent food and economic crisis has made city and national governments realise that *urban food security* is a major issue that requires policy intervention. Along with more efficient water use in agriculture, the productive safe use of recycled urban wastewater, rainwater and organic wastes has been identified as a sustainable way to produce food for the growing cities (SUSANA, 2009, see page 41). Management of urban wastes is a high-cost concern for many cities. Instead of flushing waste out of the city or bringing the waste to heaps in landfills, illegal dumps or transfer stations, there is growing understanding that composting and local reuse is an environmentally attractive way to manage parts of these otherwise wasted resources, especially in low- and middle-income countries.

Additional arguments are provided by the rapid increase in fertiliser prices and the dwindling phosphate market, making the need for alternative sources of fertilisers more and more important. Phosphorus shortage will be one of the most pressing problems of the coming years. According to experts, global reserves will be used up within the foreseeable future (Brown, 2003).

Many authorities seek to address these issues in the development of more resilient cities. Urban agriculture provides

Peak phosphorus and the need for recycling

Phosphorus shortage will be one of the most pressing problems of the coming years. The imminent shortage is a crucial problem for the world's food supplies. Phosphorus is an essential nutrient for all plants and animals. It is also one of the three key components (together with nitrogen and potassium) of fertilisers, and therefore crucial for the world's food supply system.
The demand for phosphate is increasing, while global fossil reserves are finite. The reserves in the US have been decreasing rapidly since 2006 and it is predicted that economic reserves will be depleted within 25 years. According to experts, global reserves will be used within approximately 100 years. The global supply of *recoverable* phosphorus is limited and concentrated in just a few countries.
The bulk of fossil phosphorus is found in just five countries: Morocco/Western Sahara, China, the US, South Africa and Jordan. Phosphate prices are set essentially by the current three producing countries, the US, China and Morocco. The problem is even more serious, as phosphate is a key component of fertilisers and there are no alternatives. Other known sources of phosphate rock are economically not viable to mine.
The need for alternative sources of phosphate is becoming more and more pressing. There are few solutions to the problem other than improving the efficiency of nutrient management in agriculture, and recovery of nutrients from waste (water) or manure/human excretions. Recycling of phosphates from human and animal manure contributes to closing the phosphate cycle. At present, approximately 11.4 million tons of phosphate is lost yearly due to erosion and precipitation. The phosphorus shortage will undoubtedly create new developments and opportunities in technology innovation and sustainable business development.
The Nutrient Flow Task Group (NFTG) is a Dutch initiative facilitated by the Development Policy Review Network (DPRN) that strives to accelerate the search for solutions for phosphorus depletion and its global impact.
http://phosphorus.global-connections.nl.

linkages to both the supply of (wastes) and the demand (food and income) for nutrients in and around settlements, while contributing to local economic development, poverty alleviation and social inclusion of the urban poor – and women in particular – as well as to reduced vulnerability of cities and their inhabitants. Nutrient loops can be closed, especially through safe recycling, and the environmental benefits of urban agriculture can be enhanced.

Nutrients

Agriculture is a key sector for understanding the cycling of macronutrients like phosphorus, carbon, nitrogen and sulphur (see the article on page 8). There are sixteen essential nutrients required for crop production, which are usually divided into macronutrients and micronutrients. Carbon (C), hydrogen (H) and oxygen (O) are macronutrients, abundantly available in the air. Macronutrients available in the soil and usually required in large amounts for production (taken up by the roots in ionic form) are: nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca) and magnesium (Mg). Throughout this issue attention is paid to the main three N, P, and K, of which crops need the largest amounts. Nitrogen is most important for plant growth, and often the first limiting nutrient. The main natural sources of plant-available N in the soil are degraded organic matter and N from the air that is fixed by microorganisms. The supply of plant-available P comes from soluble phosphates in the soil and from mineralised organic matter. Most articles in this issue concentrate on N and P.

Urine application tested on tomatoes
Photo: CREPA

Although micronutrients (including copper, iron, manganese, molybdenum, boron, chloride and zinc) are required in smaller amounts than the macronutrients, they are as essential for plant growth as macronutrients and for a balanced diet. The IAASTD (report 2009, www.agassessment.org) identified the lack of micronutrient-rich foods as a major problem in many developing countries and suggested that a more nutritious diet (including vegetables) containing micronutrients is needed. In many countries micronutrients are normally available in sufficient quantities in the soil and through the mineralisation of organic matter. In highly weathered soils, such as those in the tropics or in dry areas, the availability of micronutrients can however vary.

Under certain conditions, micronutrients can also occur in excess of plant needs and become toxic to plants. This concerns other trace elements too, such as lead, cadmium (both heavy metals), or chromium, none of which are nutrients. The health effects and the heavy metal threshold concentration under which it is possible to practise safe urban agriculture have been the subject of much discussion (Puschenreiter *et al.* 1999, Barker *et al.*, 2007) and the latter varies strongly between the various elements. Keeping safe distance from main sources of contamination (traffic, industrial smoke and wastewater) and appropriate crop choice can reduce risk to health of consumers (De Zeeuw and Lock 2001, Simmons *et al.*, 2010).

Integrated nutrient management

References on urban nutrient management often refer to the prevention of over-enrichment of fragile environments (such as urban green areas) with phosphate and nitrogen. Also, the Global Partnership on Nutrient Management (UNEP: www.gpa.unep.org) sees raising awareness on the causes and harmful impacts of this over-enrichment as a major part of nutrient management, while recently discussions have been initiated to include attention to improved sanitation and (decentralised) productive reuse – including urban agriculture – as possible solutions. And indeed, many articles in this issue regard productive use of nutrients (in wastes, wastewater and sanitation) as an interesting option in proper nutrient management (recycling and closing the loop).

The article on page 8 looks at rural-urban nutrient flows and options for recycling nutrients, which normally end up in drains or in landfills, polluting the urban environment (cities as nutrient sinks). The authors support the idea that food production, especially in and around cities can be enhanced if the nutrients and organic residues from urban consumption are recycled back into agriculture. But they also warn that this is not so easy in the face of significant logistical and financial challenges. The articles on page 8, 11, and 13, look at nutrient cycles and discuss methods to analyse these.

Nutrients are needed in small-scale agricultural production activities for household consumption and income generating purposes as well as in parks and gardens. One of the major constraints to agricultural productivity in and around cities is that farmers cannot choose their sites but have to use those that not being used or unsuitable for construction purposes. These sites are often on slopes, of poor fertility or too wet to support buildings. As farmland in cities is limited, farmers cannot let the sites lie fallow to regenerate. In contrast, urban production patterns are commonly very output intensive, with multiple harvests per year. These soils need a permanent nutrient supply and to be managed for increased nutrient retention capacity, improved soil structure and water-holding capacity.

Chemical fertilisers are often not available to or accessible for urban producers, but fertiliser use alone would not be enough to restore soil fertility. Building the organic matter base is important for improving poor soils, and organic materials come from manure, crop residues and compost. These hold plant nutrients in more complex forms, which are released for plant use after the organic material decomposes.

Against the background of soaring world chemical fertiliser prices, there is a need for agricultural authorities to support organic nutrient resources and to seek alternative solutions, such as mixtures of organic and inorganic fertiliser as an efficient alternative to using either one of them separately. An example of such a mixture is Comlizer (see Box).

Comlizer

Comlizer is a product derived from mixing composted municipal waste (organic waste, faecal sludge) and ammonium sulphate fertiliser. Developed in Ghana, it has been tested on maize and compared with split application of NPK (15-15-15) and ammonium sulphate, as usually practised by farmers. Maize yield from plots that received Comlizer at the rate of 91 kg N ha^{-1} compared well with yield from plots that received NPK (15-15-15) and ammonium sulphate at the rate of 150 kg N ha^{-1}. Nitrogen and phosphorus uptake in maize plants grown with Comlizer was 11 per cent higher than with NPK (15-15-15) + ammonium sulphate. Moreover, the organic matter content of soil treated with Comlizer was 22 percent and 64 percent higher than with fertiliser and on the soil alone. Crop water use efficiency was 12 per cent higher in Comlizer-treated crops than those treated with chemical fertiliser. There was no threat from heavy metals and pathogens. Compared to mineral fertiliser, Comlizer improved crop yield, nutrient uptake, soil organic matter content and crop water use efficiency. Moreover, Comlizer is relatively cheaper: it was found to cost about half the amount of ammonium sulphate fertiliser (Source: Adamtey *et al.*). *Similar experiences are described in this issue on pages 37 and 47 where human faeces are mixed with compost, resulting in increased plant growth.*

Integrated Soil Fertility Management combines the use of both organic and inorganic nutrient sources to increase crop yield, rebuild depleted soils and protect the natural resource base. It seeks to adapt local soil fertility management practices to optimise the effectiveness of organic and inorganic inputs in crop production. But nutrient management alone cannot assure the desired productivity in urban agricultural production systems. It has to be coupled with appropriate management of water and other agronomic practices. And organic and inorganic nutrient management need to be integrated in urban agricultural systems.

Challenges of scaling up organic waste management

Most of the contributions to this issue describe experiences with the use of organic solid waste for compost production and its reuse (articles on pages 20-34). And indeed, in most cities sustainable management of solid waste has become a serious problem. The waste stream is not a homogenous mass. The organic waste fraction remains the largest proportion to be recovered, and composting offers a possibility to reduce the total waste volume by half. This can have significant consequences for the transport of waste (the largest cost factor of urban waste management), which could be an incentive for municipal authorities to consider resource recovery more seriously, given their insufficient financial, technical and institutional capacities to collect, transport and safely treat and dispose of municipal wastes (see the articles on page 8 and 20). The required approaches have to be decentralised, which would allow the use of organic waste without significant transport costs; hence priority given to backyard composting (household) followed by community approaches.

Photo: CREPA

An evaluation of composting projects in West Africa pointed out that, apart from being not financially viable, a common problem leading to project failure was lack of market analysis and poor institutional integration (Cofie, Bradford and Drechsel, 2006). Sound planning is required and should be based on a business model aiming at cost recovery that is sufficient to make the system sustainable while considering institutional linkages, sources of waste supply and sound quantification of compost demand.

In most cases, the supply of organic material is far greater than can be realistically absorbed in urban agriculture. This can limit the up-scaling potential. A demand assessment should look at all potential clients and their willingness and ability to pay. It is expected that a major demand for compost in rapidly expanding cities will come from landscape designers (horticulturists, parks and gardens) and real estate developers (see the article on Pune, India on page 27). As we have seen, most urban farmers are willing to use compost although not all have the necessary experience. Proper advice is required if farmers are to see the advantages of compost and not lose interest, for example if the release of nutrients is not as fast as they expected from mineral fertiliser or manure.

Various stakeholder institutions could play the role of regulator, manager, supporter of initiatives or beneficiary. The articles on page 31 on participatory design, and page 34 on master composter programmes, describe approaches in which all stakeholders participate in a thorough capacity building and planning process. The article on page 17 argues that linkages between sectors such as waste management, but also between crop and livestock, need to be enhanced.

Health implications are a major constraint to recycling organic waste in urban agriculture. Due to the close connection of organic waste recycling with the food chain, the issue of health is crucial, not just for farmers engaged in urban agriculture, but also for consumers of the products that are derived from recycled organic waste (see the article on page 37 and the box). Simple health and safety protection measures can be taken to mitigate many of these health hazards. Several articles show the added value of waste reuse. For instance, the nutrient value of the uncollected solid waste in Kumasi would be sufficient to pay the service costs of solid waste management for the whole city (US$180,000 per month). Moreover, about 80 per cent of this amount is spent on waste collection and transportation to disposal sites, which could be drastically reduced through composting for the additional benefit of the farming community. The challenge for the municipality is to use the saved money to subsidise compost stations. This is not easy, as other budget gaps such as hospital supply and teacher salaries have a high priority in municipalities.

Alternative finance mechanisms should be sought, such as carbon credits (Clean Development Mechanism). Diverting solid organic waste from landfills by composting is also one of the simplest ways to prevent emissions of methane (a greenhouse gas) and to reduce groundwater pollution due to leachates from the landfill. Recovering methane from landfills is still a technical challenge due to high losses through leakage.

Nutrient recovery from on-site sanitation systems

Werner (2004) argues that, at present, farmers worldwide use around 150 million tons of synthetically produced nutrients annually, while at the same time conventional sanitation systems dump more than 50 million tons of fertiliser equivalents with a market value of around $15 billion into water bodies. The author calls for a paradigm shift in sanitation towards a recycling-oriented closed loop approach. Ecological sanitation is such a shift, aiming to close local material flow-cycles. It is based on an overall view that material flows are part of an ecological system that can be tailored to the needs of the uses and local conditions of sanitation and agriculture. However, also here, there are a number of challenges, which are related to awareness and knowledge, regulation, the need for data on the existing gap between actual and potential reuse, and on organisational and infrastructural issues (see article on page 41).

Urine application in Ouagadougou
Photo: CREPA

Excreta are a rich source of organic matter and essential inorganic plant nutrients such as nitrogen, phosphorus and potassium. Each day, humans excrete in the order of 30 g of carbon, 10-12 g of nitrogen, 2 g of phosphorus and 3 g of potassium. Most of the organic matter is contained in the faeces, while most of the nitrogen (70-80 %) and potassium are contained in urine. The distribution of phosphorus between urine and faeces varies between 30-70 and 20-80 percent. The organic matter and nutrients contained in excreta can be recycled and reused as fertiliser-cum-soil conditioner, to fertilise crops and fish ponds.

The fertilising equivalent of excreta is, in theory at least, nearly sufficient for a person to grow his own food (see page 41). Although this model ignores losses in the system, it means that excreta from one person over the course of a year contain enough nutrients to grow about 250 kg of grain. However, the value of nutrients that can be recovered during recycling would be less than the value contained in the raw excreta. The type of storage/collection and treatment determines how much of these resources can be recovered and harnessed, and at the same time how safe the final product is for the end user. Some modest low-cost treatment options for excreta include constructed wetlands, drying beds, and stabilisation ponds. Decomposed excreta improve soil structure, increase water-holding capacity, reduce pests and diseases and neutralise soil toxins. However, farmers often prefer animal manures because of lack of knowledge, negative perception (of stakeholders) and the possible health risk associated with human excreta use.

Human urine is also a well-balanced (NPK) source of nutrients and contains easily accessible plant nutrients. The exact nutrient content depends on a person's food consumption. The urine collected would then be further processed and used as a local fertiliser in agricultural production, thus closing the nutrient cycle. Urine is rich in plant nutrients required for healthier crop growth and high crop yield (Esrey *et al*., 1998). Complete urine diversion has the potential to recover the majority of the nutrients from the wastewater stream, 80% of the nitrogen (N), 55% of the phosphorus (P), 60% of the potassium (K) as well as a substantial fraction of sulphur and magnesium. This is the equivalent of approximately 11g N, 1g P, 2.5 g K per person per day, depending on a person's diet.

Huge amounts of urine and other organic wastes are generated daily in urban centres. The urine can be collected in ordinary jerry cans, but for larger volumes tanks are required. Storing urine for at least a month can significantly reduce possible pathogenic organisms and make it an even safer fertiliser. Urine generally poses a much lower health risk than faecal material or any polluted water source. However, while farmers have generally accepted the use of manure, the discussion of urine usage continues, even though the elements we find in urine have already passed through the human body and might never again pass through the plant barrier and return to the human body through ingestion (see also articles on pages 37, 41 and 43).

ISSUE
Integrated Support for Sustainable Urban Environment (2007 – 2010)

The aim of ISSUE-2 is to scale up sanitation and solid waste infrastructure and activities, in order to effectively contribute to realising the MDGs (Millennium Development Goals). Fifteen districts (in 13 countries) are involved in the programme. Each district has set its own clear targets for these improvements and expansion. Overall this will benefit 75,000 households. The main beneficiaries will be the users of the systems and the entrepreneurs who provide the required services.

The ISSUE-2 programme includes the following innovative features:

- Genuinely **decentralised management**, done by a programme board at programme level, with district level field management.
- Using sanitation and solid waste management as the springboard to **supporting sustainable livelihoods**.
- A substantive focus on the **sustainable modernisation** of management of the urban environment: one that is based on a mix of approaches, rather than a single large technical system.
- A focus on the economic and environmental potentials to be derived from better understanding and managing

resource and nutrient cycles within, and between, districts.

- A commitment to exploring the synergies derived from **integrating the management of solid waste and excreta waste streams.**

The programme is nearing its end and several districts have conducted research on the material cycle and possibilities of reuse human excreta in agriculture. Costa Rica has done a study on the effects of reusing urine in the production of corn. The results can be found in a bio-assay that will be published soon. In 2009 similar research was done with sugar cane as the crop. India also has done research on reuse of urine, focusing on application with mineral fertiliser in different ratios. The aim of the research was to study the yield as well as the positive effects on the soil and plants. The study was carried out by the Tamil Nadu Agricultural University in 2008 – 2009. More information: www.waste.nl

From research to use

A considerable quantity of urban waste is biodegradable and hence of interest for recycling into a useful resource for urban agriculture and other uses. However, despite all the known and convincing benefits of reuse-oriented sustainable sanitation systems, a number of challenges and problems still need to be overcome. A key challenge is that locally appropriate solutions need to be supported by standards, which can also be implemented. Where for example only partial or no wastewater treatment is possible, health risks of productive reuse of wastewater can be reduced through complementary health risk reduction measures as explained in the new WHO guidelines for safe use of excreta and wastewater (WHO 2006, Drechsel *et al.* 2010).

But in most parts of the world, the new closed loop sanitation paradigm has not yet reached the legislation, and waste and wastewater use are not clearly incorporated into national or local policy in most countries. In fact, in many countries, the law is silent on the reuse of human waste, or is not encouraging. The fear of health impacts, cultural barriers and the larger focus on the supply of water than its return flow, might explain the lack of clear policies in support of safe reuse options.

Reversing current trends and patterns requires the adoption of holistic and integrated approaches. In many cases of urban planning, urban water and urban sanitation are managed separately, and certainly not in conjunction with urban farming. Multi-stakeholder consultation, joint planning and joint decision-making will be needed to adapt existing policies or develop new ones. In view of a reuse-oriented waste management, a key stakeholder will be small and micro-enterprises, as the sector lacks business models. More applied research is also needed to assess risks and risk management options in support of the local policy dialogue.

Many urban and periurban areas are vast nutrient sinks, as the recyclable nutrient potential from organic waste is seldom exploited and thus lost. Urban agriculture can significantly improve waste management through the productive (and safe) reuse of urban organic wastes (e.g. soil improvement, recycling of nutrients or animal feed) and urban wastewater (irrigation water and recycling of nutrients). As the articles in this issue show, the interests of urban waste recycling and use of sanitation products go well with the promotion of urban agriculture, since urban and periurban farmers are in need of organic matter as a soil conditioner, while cities and towns wish to conserve disposal space and reduce the costs of landfills as well as municipal solid waste management. In addition, this creates other opportunities such as involvement of informal waste collectors and the private sector.

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The urine circuit
Photo: CREPA

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Closing the Rural-Urban Food and Nutrient Loops in West Africa: A reality check

Pay Drechsel,
Olufunke Cofie and George Danso

Rapid urbanisation in developing countries intensifies the challenges of making sufficient food available for the increasing urban population, and managing the related waste flow. Unlike in rural communities, there is usually little or no return of food biomass and related nutrients into the food production process. Most waste ends up on landfills or pollutes the urban environment.
This is transforming cities into vast nutrient sinks, while the rural production areas are becoming increasingly nutrient deficient (Drechsel and Kunze, 2001).

In this study, we aimed at gaining a better understanding of the rural-urban nutrient flows, options for recycling and the role of urban agriculture compared to periurban and rural farming.
Four cities (Accra, Kumasi and Tamale in Ghana, and Ouagadougou in Burkina Faso) were selected along a South-North gradient across a variety of agro-ecological zones.

Location of the cities under study

In each city, we analysed, qualitatively and quantitatively, food flows related to all key markets as well as the consumption and fate of the related waste. This involved market, household and street food surveys over different seasons with interviews of more than 1700 traders, 4835 households and 922 street food consumers (Drechsel *et al.*, 2007). Twenty-two food items including fruits, vegetables and livestock products were considered. Presenting food flows in general could be based on various criteria, like the number of each food item, the diversity of food items, or their calorie or vitamin content. As we were interested in the nutrient cycle we looked at mass movements and nutrient content. In a more detailed study in Kumasi, all organic non-food items, such as timber and fodder, were also considered to assess the overall potential for organic waste composting (Belevi, 2002). The present study was accompanied by a demand and willingness-to-pay analysis for waste products in various farming systems, and a number of cost-benefit analysis scenarios for different demand-supply options, compost station sizes, transport capacities etc., using the financial software of GTZ-GFA (1999) for compost production.

Analysing the feasibility and viability of compost production

Organic waste materials can be recycled into carefully processed high-grade compost for agricultural use. Long-term success of commercial production, however, depends on a number of prerequisites. One key factor is economic viability. Before establishing a composting business, it is necessary to make sure that compost production and marketing will be an economically attractive and self-financing activity. In 1999, a GTZ project on municipal waste composting compiled a useful set of materials to assist planners and decision-makers in making feasibility assessments. The information package included a computer-based tool called the "Decision-makers' guide to compost production". The software offers users a quick and easy method to determine, right from the outset of the planning process, the costs that will have to be covered and gives a break-down of those costs (see book section).

In- and outflows

Based on their weight, the relatively heavy staple crops like yam, cassava and plantain form the major component of all food flows moving in and out of the cities, especially in the West African forest zone, which is Africa's tuber belt. This is reflected in about 600,000 tonnes of yam, cassava and plantain entering Kumasi every year, which is nearly two thirds of its total food inflow. The volume of the flow requires that a standard 7t-transporter enters the city every three minutes during daytime, a significant logistical challenge in view of common traffic jams. Further to the north, traditional cereals are an important part of the diet. Rice in particular is becoming increasingly fashionable as an urban fast food component, both in the north and in Accra to the south. About 30-50 per cent of the food entering the cities leaves them again from wholesale markets.

Food sources

In the four cities, food flows originating from rural areas are the most important overall food sources. Depending on the city, rural farming contributes between 64 and 88 per cent of the total inflow to the urban area, with percentages again largely determined by the weight of tuber crops.

Especially interesting is the differentiation between commodities and seasons, which shows the niche and contribution of urban and periurban farming in terms of fresh leafy vegetables, like spring onion and lettuce. Urban farming provides up to 90 per cent of the cities' consumption. Also, most fresh milk found in Kumasi is produced in the urban area at the local university. In the periurban areas of Kumasi, large poultry farms produce 80 per cent of the eggs consumed in the city, while these farms suffer increasingly from cheap poultry meat imports, especially from Brazil.

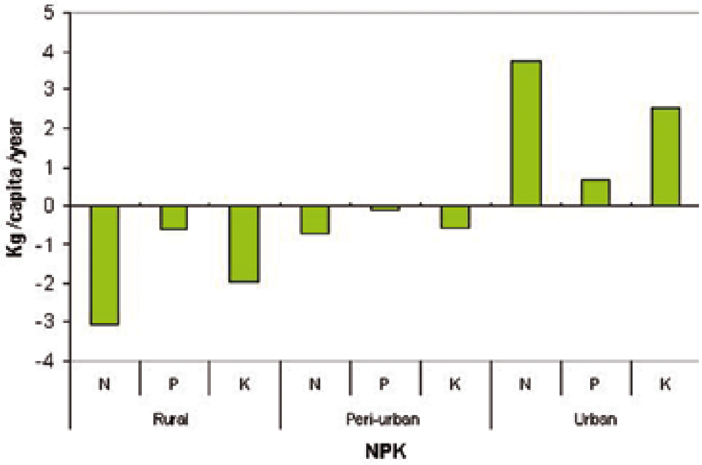
The situation is similar in the other three cities, where urban and periurban farming supplies only certain commodities, and thus does not contribute significantly to overall urban food security but to a diversified food supply. In particular, food rich in Vitamin A, such as carrots, local spinach, tomatoes, lettuce, beans, eggs and milk derive predominantly from urban and periurban farms. All these data refer to market-oriented production. They do not include backyard farming, which contributes to subsistence supply. In the cities studied, backyard farming involves not so much vegetables but staples (see UA-Magazine 22, p.6), and allows the households to save money otherwise spent on food. In terms of the food amount, however, urban agriculture only contributes around 5 per cent to the overall urban consumption in the cities, while periurban areas (40 km radius) can contribute between 10 and 36 per cent.

The urban nutrient sink

With the food, large amounts of nutrients flow into the cities. Some food-borne nutrients find their way back into crop production, e.g. through organic waste recycling in urban backyards. But the overall picture shows significant nutrient losses (depletion) in rural areas and huge nutrient accumulation and loss in urban areas. As the bulk of the waste ends in streets, drains or landfills, urban centres are indeed nutrient 'sinks' (see figure). This has significant implications for environmental pollution.

Closing the nutrient loop – not so easy!

To close the nutrient cycle it is necessary to bring the nutrients back into food production. This might be easy in rural areas where consumption and production are "neighbours", but along the rural-urban corridor this becomes a significant logistical and financial challenge. Nevertheless, it is important to note the fate of food and nutrients in the city "organism": A large share of the food brought into the cities leaves the city again through trade. The data from Kumasi, Ghana,



Balance of imported and exported nutrients per capita in the rural-urban continuum, based on the four cities studied

show that out of the consumed food and its waste products before and after consumption in households, about

- 15 per cent of the nitrogen is transferred to the atmosphere from the households
- 20 per cent of the nitrogen and phosphorus are collected with waste and then landfilled or processed in faecal sludge treatment plants
- 65-80 per cent of the nitrogen and phosphorus, respectively, are lost from septic tanks, via wastewater or uncollected solid waste to the environment.

Currently, about 18 per cent of the generated solid waste and 66 per cent of the faecal sludge remain uncollected in Kumasi's streets, pits and septic tanks. The nutrient value of the non-collected solid and liquid waste (sludge) would in theory be sufficient to pay the service costs of solid waste management for the whole city (USD 180,000 per month).

From a technical perspective, part of this environmental load could be reduced via waste composting or co-composting of solid waste with faecal sludge. In Kumasi, 230,000 – 250,000 tonnes of organic waste and in Accra 255,000 to 366,000 tonnes of organic waste are effectively available annually for composting, meaning that these amounts are already collected and have no other current use. The nutrient content of this waste in Accra alone is estimated at 3,500 to 5,300 tonnes per year of nitrogen, 1,700 to 2,600 tonnes per year of phosphorus and 760 – 1,100 tonnes per year of potassium. These amounts could easily cover the entire nutrient demand

Valuable resources not recovered
Photo: Pay Drechsel

of urban farming. In a scenario which only considers the amount of waste already collected and transported to a landfill, about 60 per cent of the produced compost could be used to replenish all urban farm soils in Kumasi. If all waste were collected, 30 per cent of the compost would be sufficient, while the rest could be sold outside the city. However, if the compost is sold at a price which covers its production costs, only a small fraction of about 1000 tonnes per year would be bought, while more than 100,000 tonnes would remain in the warehouses. And even if subsidised, transport costs would limit compost sale to a narrow radius around its distribution points.

Leafy vegetables like nitrogen
Photo: Pay Drechsel

These economic constraints favour community-based projects, with low production costs due to often cheap labour. However, the amounts produced and sold do not need or allow economies of scale, and thus cannot contribute significantly to overall urban waste management.

These limitations clearly show that the idea of "closing the rural-urban nutrient loop" is spatially constrained and not generally realistic. While it is feasible to transport high-value (food) products over long distances and through various middlemen into the city, it is hardly feasible to transport a waste product the same way back, unless there are favourable market conditions, such as a potent buyer, added value, no competition or strong subsidies:

- A win-win situation could for example be a private-public partnership linking public compost stations and real estate developers interested in large amounts of compost for gardening, as observed in Accra.
- In Kumasi, a mix of fertiliser and compost has been tested that increases the value of the waste product. This could create new demand.
- However, in the same city, and many others, compost sales suffer when cheap poultry manure is available. Poultry manure has a high nitrogen content, which is easily available, while compost is often poor in nitrogen and decomposes slowly. Despite its positive impact on soil water content etc., it is not attractive for exotic vegetables, like lettuce, which have a growing period of only 5-6 weeks. Thus market analysis should not only look at a specific product but also at competing products.
- Many city authorities have stressed that composting is most welcome as a means to reduce waste volume (i.e. transport costs). Thus compost production - even without any market - saves money, which could be used to finance the composting itself. Compost sales were considered a secondary issue or bonus. This favourable view of composting stems from the increasing problems faced by authorities in finding community-supported landfill sites in the vicinity of the cities, while local communities are less reluctant to accept a compost station. From this point of view, compost stations should be planned as close as possible to the points of waste generation; and from the sales perspective, as decentralised as possible. Knowing the daily production of organic waste, transport costs and station costs, it is possible to determine the optimal number of decentralised compost stations that would minimise costs. In the case of Accra, these would range from 6 (to cover the most optimistic agricultural and non-agricultural compost demand) to 33 stations (to reduce as much waste volume as possible).
- Arguments in support of subsidies could build on the reduction of environmental pollution in the city (up to 20 per cent in Kumasi), but would of course be more persuasive with improved collection capacity. This concerns in particular improved excreta management from septic tanks, since the most significant nitrogen and phosphorus fluxes to soil, surface waters and groundwater occur via faeces and urine.

Conclusions

While it is easy to demand closed loop concepts, the number of success stories usually decreases with increasing scale from household to community to city-wide initiatives. To look behind the common goals of closed loop concepts, this study put much emphasis on actual compost demand and economic feasibility. The analysis showed that closing the rural-urban loop is possible for manufactured high-value food products, which will return to their rural roots, but only under particular conditions for low-value waste products, like compost. Therefore, any initiative aiming at nutrient recovery should carefully analyse local demand and markets.

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Analysing the Nexus of Sanitation and Agriculture at Municipal Scale

Pay Drechsel
Marco Erni

To better understand the linkage between sanitation and agriculture at municipal scale, a study was carried out that addressed the following research questions:

- How does a larger investment in flush toilets affect water quality and urban farmers?

- How much of the nutrient demand of urban farmers could be covered through waste composting?

Modelling is required to answer these questions at municipal scale. A common approach is to quantify water and nutrient flows, for example, via material flow analysis (MFA) (see box). MFA has been used extensively to quantify the flows of food and other materials passing through cities, the related consumption and amounts of waste generated, as well as the fate of that waste. Once the pathways and quantities are known, the same flows can be broken down into streams of nutrients, biomass, energy, etc. This analysis allows researchers to identify points in the system at which interventions to reduce the environmental burden or increase resource efficiency would be most appropriate. The analysis becomes **decision support** when scenarios are calculated to see how the flows will be affected by population growth or certain investments in infrastructure or transport capacity.

The International Water Management Institute (IWMI) and SANDEC/EAWAG applied MFA twice in Kumasi, Ghana, first with emphasis on solid waste and options for co-composting for urban agriculture, later to understand nutrient flows in the household wastewater systems, focusing particularly on urban and periurban farmers exposed to highly polluted water.
Several scenarios were modelled to

- quantify the amounts of nutrients which could be recovered from the system before they are lost on landfills or the environment,
- quantify future urban water needs and wastewater generation and
- identify the impact of changing sanitation practices on water pollution and nutrient availability for farming.

The scenarios considered various types of investments that are planned in Kumasi as part of efforts to achieve the Millennium Development Goals (MDGs). The modelling showed interesting results (Leitzinger, 2000; Erni, 2007; Erni et al., 2010), some aspects of which are highlighted here to illustrate the application potential of MFA:

- The planned investments in urban water supply would largely be outpaced by population growth in the same period resulting in a much smaller improvement in per capita supply than officially aimed at. It also showed that if the expansion work was delayed (as often happens), per capita water availability in Kumasi would actually decrease. In all scenarios, the amount of water per capita would not surpass the minimum for conventional sewer operation.
- Even if the city does not aim at sewerage and opts for more flushing toilets connected to septic tanks, as is common now, more toilets in certain better-off districts would strongly compete with other household water needs and drastically affect water supply to the average household in Kumasi.
- From the nutrient perspective, the toilets would decrease the amount of nutrients directly entering surface water via gutters, but to a much larger extent increase the nutrients entering groundwater from the septic tanks, which are hardly ever emptied. This would result in a net increase of nutrients released to the environment.

The MFA showed that due to the continuing scarcity of drinking water, Kumasi, like many other African cities, can achieve the sanitation MDG better through investments in water-saving toilet systems. A higher fraction of dry sanitation systems would not only have a positive impact on water demand but also reduce the nutrients released into the water cycle (as has also been shown by Montangero and Belevi (2007) for Vietnam).

What happens to the nutrients released to the environment? The majority find their way into the streams passing through the city. Compared to the nutrient levels upstream of Kumasi, the nitrogen (N) and phosphorus (P) concentrations downstream of the city are approximately 14 and 6 times higher, respectively. In absolute figures, the amounts correspond approximately to half of the annually generated human excreta in Kumasi, and indeed the largest N and P input into water bodies derives from domestic sources, i.e. failing sanitation.

This nutrient load moves downstream passing hundreds of farmers who use the water to irrigate their vegetables. More than 50 per cent of the farmers in urban and periurban Kumasi are aware that their irrigation water contains nutrients, but only a small percentage showed a high level of awareness and indicated that they regularly consider this while managing crop nutrient needs. The reasons for this are two-fold:
a) Farmers use the water first of all to irrigate highly perish-

able crops; thus irrigation frequency depends on crop water needs and not nutrient needs.

b) Without options for water, soil or crop analysis, farmers' nutrient management depends on observations that they make of the crops and their own general experience. As water nutrient loads also vary, farmers prefer to stay on the safe side and apply e.g. poultry manure or chemical fertiliser according to their own experience.

Farmers do not tend to reduce their manure application rates over time. This results easily in over-fertilisation and nutrient imbalances, which was verified in this case using the NUTMON model (see box). This situation can strongly affect crop growth. Fortunately, in contrast to most cereals, leafy vegetables love excess nitrogen.

The MFA is only one of several methods needed to answer questions like those posed above. Looking only at already collected and transported solid waste and excreta, the Kumasi MFA showed that the amount of N and P that could be recycled through co-composting would be sufficient to cover the demand of all urban farmers and even some farmers in Kumasi's periurban fringe (see the previous article). However, even if all nutrients were available at one or more compost stations, a detailed analysis would be needed to determine how many farmers are actually interested in the product (or already have a cheaper fertiliser, like poultry manure), how many of those who are interested would be willing to pay for the product at a price that covers the cost of operating the compost station, and how much they are willing to pay in addition for the transport to reach the product. In the case of Kumasi, the answers to these questions showed that the final target group would be so small that composting only the urban market waste would already cover their demand. This again was an important message as it means that to reach the target group, there is no need to introduce waste sorting (organic – inorganic) at household level to have enough organic waste for composting. To reach a larger group of users, the above constraints will have to be removed.

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Analysing nutrient flows and balances

There are various ways to analyse nutrient flows and balances in urban or rural systems, on farms or for whole cities, these are two examples.

NUTMON is an integrated model which allows farmers and researchers to jointly analyse nutrient flows and balances at the farm or plot level to improve soil fertility management. NUTMON software is easy to use and a free global public good. It can be used to analyse nutrient balances at village, regional, national, and supra-national levels and to better understand the effects of current and alternative land use options on productivity, farm finances and sustainability. NUTMON looks primarily at in- and outflows, rather than internal processes, to determine whether there will be a nutrient deficiency or a surplus. In addition to major nutrient inflows and outflows (erosion, leaching, harvest, fertilisation, atmospheric deposition, etc.), the NUTMON Toolbox considers interactions with livestock and human activities such as household waste recycling. It can also link the nutrient flows with financial assessments.
More information: http://www.nutmon.org
Examples of the use of NUTMON in periurban vegetable farming: www.vegsys.nl

Material flow analysis or flux analysis (MFA) goes beyond NUTMON and allows researchers to capture all flows in and out of the black box as well as between different components or transfer points in the box. It describes the fluxes of resources used and transformed as they flow through a city or region, using a defined space and time frame. In industrialised countries, MFA proved to be a suitable instrument for early recognition of environmental problems and development of solutions to these problems. The scientific basis is more complex than that of NUTMON and based on the law of conservation of matter and energy.
One commonly used MFA programme is SIMBOX, which was developed at the Swiss Federal Institute for Environmental Science and Technology (EAWAG), Zürich, Switzerland. Licenses for its use can be obtained from EAWAG
More information and application examples:
www.eawag.ch
www.eawag.ch/organisation/abteilungen/sandec/publikationen/publications_sesp/downloads_sesp/MFA_lecture_notes_05.pdf
www.eawag.ch/organisation/abteilungen/sandec/schwerpunkte/sesp/mfa/index_EN.

Closing the Phosphorus Loop in Hanoi, Vietnam

Agnès Montangero

In Hanoi, Vietnam, water bodies are polluted by high levels of nutrients, which are discharged in wastewater. At the same time, farmers in and around the city use artificial fertilisers. A nutrient accounting tool indicates where to set priorities to enhance nutrient recovery, and in this way reduce water pollution and the mining of limited phosphorus reserves. The analysis in this article focuses on phosphorus.

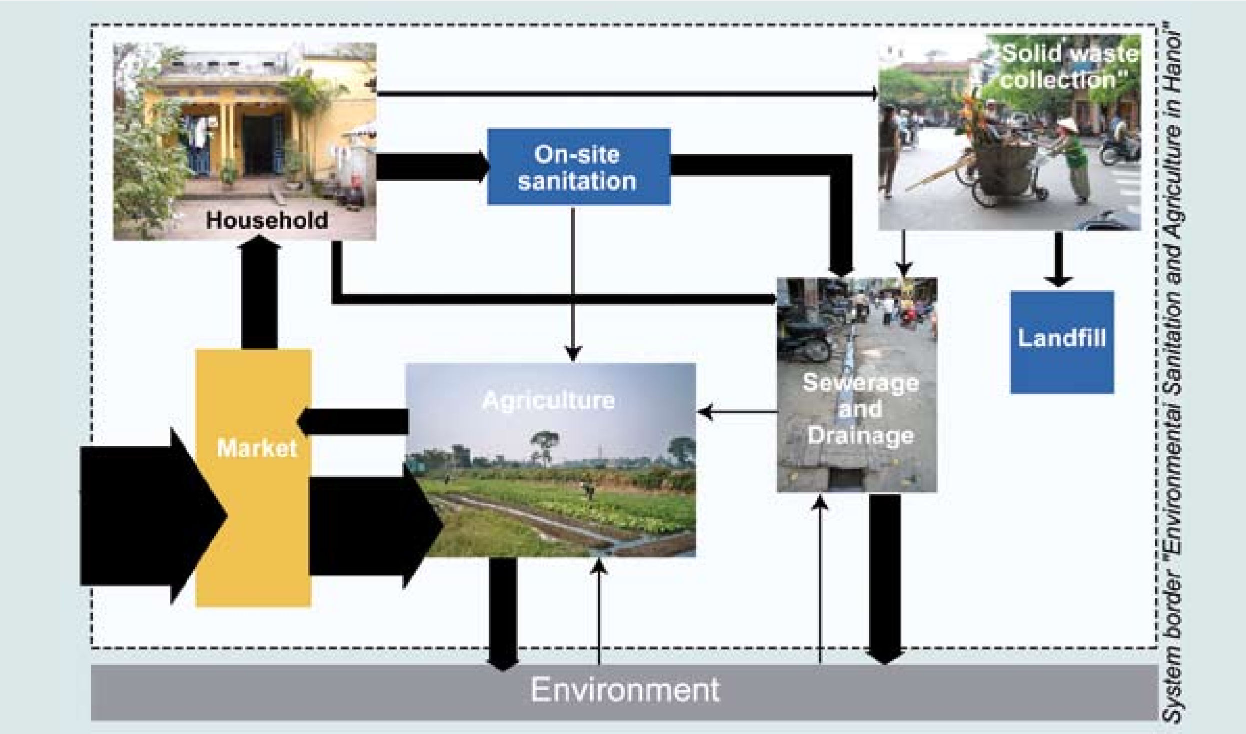
Wastewater irrigation in periurban Hanoi
Photo: Montangero

Phosphate rock - the main source of phosphorus used in fertilisers - is a finite resource, and global production of high-quality phosphate rock is estimated to peak by 2033 (Cordell et al., 2009), after which demand for fertilisers will exceed supply (also see the box in the editorial).

Material flow analysis

EAWAG/SANDEC and its partners in Vietnam have developed a tool to estimate and visualise water and nutrient flows in a region. The tool links urban organic waste/wastewater management and urban agriculture. Concretely, it consists of a computer model made up of a series of Excel-based nutrient accounting sheets. The user enters various parameters, such as the number of inhabitants, type of sanitation system, area under cultivation and livestock population. The model subsequently estimates, for instance, phosphorus inputs into surface waters and phosphorus recovery for agricultural use. The model is designed to support local actors in analysing the impact of different measures on fertiliser need and nutrient discharge in the environment.

The tool is based on material flow analysis (MFA). This method studies the fluxes of resources used and transformed as they flow in a specified region. In industrialised countries, MFA proved to be a suitable instrument for the early recognition



Simplified representation of the environmental sanitation and urban agriculture system of Hanoi Province of environmental problems and development of countermeasures (Baccini and Brunner, 1991). It can also be applied in rapidly developing cities in the South to evaluate the impact of changes in consumption patterns, solid waste and wastewater treatment infrastructure, periurban agricultural production, and waste and wastewater reuse practices on resource consumption and environmental pollution.

Phosphorus supply and demand in Hanoi

In Hanoi, like in many other cities in developing countries, high population growth, industrialisation and economic development have led to increased resource consumption and environmental degradation. Periurban agriculture is of key importance in the supply of food and provision of income, especially to the poorest section of the population. However, rapid urbanisation also creates pressure on the land. Farmers tend to use more fertilisers in an attempt to enhance yield and maximise benefit from their decreasing land area. A better balance between nutrient supply in urban waste products and nutrient demand in periurban food production could be the key to reducing resource consumption and environmental pollution (Montangero *et al.*, 2007).

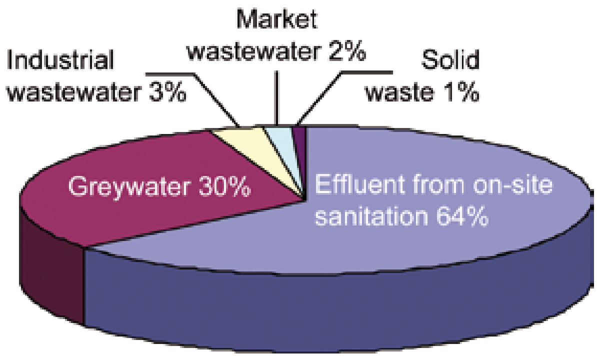
The MFA tool was applied to demonstrate the effects of selected extreme scenarios on phosphorus inputs into the river and on phosphorus recovery for agricultural use. For this purpose, the effects of various parameters, such as the type of sanitation system, area under cultivation and livestock population were simulated.

The impact of urine diversion toilets

To illustrate the model, this article looks at the impact that the type of sanitation system has on phosphorus recovery (more information and different scenarios can be found in Montangero *et al.*, 2007 and Montangero and Belevi, 2008).

In Hanoi, most buildings are connected to septic tanks, which collect wastewater from toilets. Most of the phosphorus contained in toilet wastewater leaves the septic tank in the pre-treated effluent (septic tanks do not retain phosphorus efficiently). Effluent from septic tanks and greywater (laundry, kitchen and bath wastewater) reach surface waters via roadside drainage channels. Together, they account for 94 per cent of the total phosphorus load in Hanoi's water bodies. Only a small proportion of this phosphorus load is recovered for use in food production.

Urine diversion toilets offer crucial advantages over septic tanks with regard to phosphorus recovery, since these toilets have two compartments, keeping urine and faeces separate. Urine leaves the toilet through a pipe / tube. Faeces are stored directly beneath the toilet. After defecation, dry soil, ash or sawdust is spread over the faeces, controlling odour and absorbing moisture. There are generally two chambers for faeces used alternatively. When one of the chambers is full, the other is used and the faeces/ash mixture is stored in the first compartment for about a year. During this period, pathogenic microorganisms die off, substantially reducing the health risks associated with reuse of the mixture as a fertiliser in agriculture. The urine, meanwhile, possibly



Relative contributions of various sources to the total phosphorus load in Hanoi's surface waters

diluted, can be used for irrigation. This system makes it possible to retain all the nutrients contained in human excreta – apart from a small amount of nitrogen volatilising during urine storage. These nutrients could subsequently take the place of some of the artificial fertilisers used in agriculture. It is interesting to note that this kind of system was formerly widespread in North Vietnam.

The extent to which phosphorus recovery could potentially be increased was quantified. Assuming, for example, that all septic tanks in Hanoi were replaced by urine diversion toilets, the amount of artificial phosphorus fertiliser required could be reduced from 2800 to 1200 tonnes per year – a 57 per cent decrease! This is one step towards closing the phosphorus loop.

Need for an integrated planning approach

To further develop scenarios such as that involving urine diversion for Hanoi (or other cities), more information is needed on users' perceptions of new sanitary facilities, the costs and whether these are acceptable to users, longer term market analysis, etc. MFA could be used as a tool in integrated planning that involves all stakeholders.

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Assessing Patterns of Nitrogen Management in Periurban Agriculture of Hanoi, Vietnam

Dionys Forster, Harald Menzi, Roland Schertenleib, Bernd Lennartz

To identify the potential for organic waste reuse for agricultural production in and around a city, in so-called "spatially explicit scenarios of re-use", it is necessary to analyse existing patterns of nutrient management. These management patterns are mainly influenced by the type of crops cultivated, the distance between the field and the farmer's homestead and the perceived soil fertility.

Urban food demand will strongly increase in the coming decades, especially in Africa and Asia. Cities constitute a sort of "nutrient sink" (Belevi, 2000; Drechsel et al. on page 8 of this issue), since some components of the imported agricultural products end up in waterways or on landfills. Better use of organic residues in urban and periurban agriculture could help overcome the waste problem and save limited resources while contributing to sustained food security (Drechsel and Kunze, 2001; Schertenleib *et al.*, 2004).

Knowledge of existing and potential patterns in crop and nutrient management, is a pre-requisite for any waste reuse scenario. Therefore, the nutrient use in urban and periurban agricultural systems needs to be analysed, in order to avoid surplus application of fertiliser. This article highlights experiences from a study undertaken in Hanoi and published earlier as "Exploring spatially explicit crop rotation models for periurban agricultural production systems" (Forster *et al.*, 2009a) and "Linking nutrient flows to spatially explicit crop rotations" (Forster *et al.*, 2009b).

Interviewing farmers on their farming system
Photo: D. Forster

Bac Hong, Hanoi

The commune Bac Hong, in north Hanoi, was selected because of its diverse periurban production system. The commune covers 7.2 km^2 of flat land, of which 5.1 km^2 is allocated to mixed farming, including crop and livestock production. Staple crops such as paddy rice (*Oryza s.* L.), sweet potato (*Ipomoea batatas* L) and cash crops like maize (*Zea maize* L.) are the main crops for the warm and humid tropical first and second seasons (mid-February to mid-June and mid-June to mid-October), while maize and other cash crops such as vegetables are grown on a reduced area of land during the cooler third season (October to February).

The study

Thirty-four farmers were selected from all parts of the commune. The selected farms had 5 to 7 fields each that ranged from small (79 m^2) to large (862 m^2). Semi-structured interviews and a differential GPS system were used for data collection. Similar to NUTMON (see page 11), the crop, soil conditions (e.g. farmer's perceived soil fertility) and the management practice of each field was discussed and recorded on a farm map during field visits in two consecutive years (2005/2006). Three different yearly crop rotations were evaluated: 1) *staple crop based*, with two staple crop seasons and one fallow season; 2) *cash crop accentuated,* with two staple crop and one cash crop season; and 3) *cash crop based*, with three cash crop seasons.

Factors that possibly influenced the choice of crop rotations were: distance from the homestead to the field, field size, perceived soil fertility, water availability, topography and livestock. The importance of these factors was analysed to explain why a specific rotation was used. Since the environment and land use strongly influence the combination of crops in rotation, rather fixed patterns in requirements of production sources could be expected. Thus, in a second step, nutrient flows associated with crop rotations were analysed. Organic, inorganic and total (inorganic + organic) nitrogen fertiliser inputs were used as indicators for nutrient flows. The nutrient inputs were farmyard manure, compost or inorganic sources such as chemical fertilisers.

Crop allocation

The distance from the homestead to the field proved to be an important influencing factor. Farmers whose fields were located farther from their homesteads were more likely to choose crop rotations based on staple food crops, while the closer the field was to the homestead, the more likely a crop rotation with cash crops such as vegetables would be used.

In addition to distance, perceived soil fertility played a role: the likelihood of finding cash crops in rotation was higher on plots with perceived high soil fertility. With increasing distance and decreasing perceived soil fertility, the number of cash crops in rotation decreased while the number of staple crops increased.

Nutrient management

Total, inorganic and organic nitrogen fertiliser inputs (260, 210, 50 kg ha^{-1}, respectively) were significantly lower for the staple crop based rotation. Furthermore, mean total nitrogen fertiliser input was found to be significantly higher for cash crop based rotation (540 kg ha^{-1}) than for the cash crop accentuated rotation (480 kg ha^{-1}). In addition, variation of organic fertiliser inputs was considerably high among all rotations. In general, the average nitrogen input contributed by organic fertiliser was far higher for the cash crop accentuated (110 kg ha^{-1}) and cash crop based (120 kg ha^{-1}) rotations than for the staple crop based (50 kg ha^{-1}) rotation. The latter can be partially explained by the fact that the cash crops usually respond well to the application of organic manures. Longer distance and limited availability of organic manures further pronounced the pattern. As a first priority, farmers applied manure on close fields with a high proportion of cash crops. Only if manure was left over it was then applied on more distant fields dominated by staple crop based rotations. Likewise, when farmers were asked to allocate organic and inorganic fertiliser on different fields of an exemplary farm, the majority of organic fertiliser was applied on fields close to the homestead. Farmers argued that organic fertiliser should be used on all fields, but in practice, they often would try to economise fertiliser management. Though farmers knew that crops benefit from organic matter application, they primarily applied the bulky manure on cash crops, close to their homesteads. Conversely, inorganic fertiliser could easily be transported by bicycle to staple crop rotations on remote fields.

Data collection in Bac Hong
Photo: D. Forster

In the periurban commune of Bac Hong, Hanoi, organic manure is still highly appreciated by farmers. In general, total nitrogen fertiliser supplies are sufficient to meet the crops' nutrient requirement. Since organic fertilisers cover only a small fraction of the crops' total nitrogen requirement (20 – 30 per cent), reuse of organic waste still has an important development potential. Surplus application of organic fertilisers has not been observed; however, surplus application of inorganic fertilisers may, in some cases, give cause for concern. Additional organic waste reuse in the commune could contribute to reducing application of mineral fertilisers. Possible obstacles include costs associated with transport of the waste, its quality (e.g. pathogens, heavy metals, etc.), and the lack of incentive among farmers to use the rather bulky organic waste instead of easily manageable mineral fertilisers.

Conclusion

Crop rotations can be spatially explicit: the crop rotation may change depending on where the field is located and how soil fertility is perceived. As different crops have different nutrient requirements, fertiliser input is likely to change as well, depending on the crop rotation. However, crop rotations are temporal and allow the summing up of nutrient inputs over the entire rotation (e.g. spanning one year). Variations in nutrient supply, which are often difficult to explain at larger scales, can thus be consolidated and presented in one figure. For instance, when different crops were grouped into rotations, the coefficient of variation of total nitrogen input was almost 10 per cent less than for single crops. Therefore, if the commune or village area can be mapped according to crop rotations, it is possible to estimate nitrogen inputs for the classified area. In addition, the area with high or low organic fertiliser use can be identified. Besides nitrogen inputs, data on crop outputs could also be assessed and used for nutrient balance estimates. Furthermore, instead of only assessing nitrogen, phosphorous or potassium could also be included to provide a more comprehensive picture of nutrient flows for the respective commune or village.

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Cash crops are cultivated closer to the homesteads
Photo: D. Forster

Nutrient Cycles in Three African Cities

Diana Lee-Smith
Nancy Karanja
Mary Njenga
Thomas Dongmo
Gordon Prain

When Urban Harvest began its sub-Saharan programme in 2002, scientists in the Consultative Group on International Agricultural Research (CGIAR) knew that crop-livestock interactions intensify with human population densities[1]. However, little was known about the nature of these interactions at the higher densities in and around cities, such as Nairobi where the population density was on average almost ten times higher than in the rural areas at that time.

Urban Harvest developed its programme and supported research as described in the forthcoming book *Urban Harvest: Agriculture in the Cities of East and Central Africa*. The three cities featured in this article all wanted to study nutrient cycles in urban agriculture as one of the topics of the CGIAR research. As co-authors of these studies, we summarise and discuss the findings here.

Nairobi, Kenya

Seventy per cent of the Kenyan capital's solid waste is biodegradable and could potentially be used for livestock feed or compost making. Every year nutrients worth about USD 2 million could be generated from the city's estimated 635,000 tonnes of waste. However, our preliminary mapping of organic waste flows in 2003-2004 found that they are managed by a few large and small-scale actors in an uncoordinated way, mostly outside the market. Since on-farm measurements were not taken, we mapped but could not model Nairobi's total nutrient inflow and outflow.

We found that the materials and market flows of compost and manure are entirely disconnected from each other. Both, however, are characterised by lack of market information and *ad hoc* arrangements between producers and consumers. This applied to both large commercial farms and landscapers, and small farmers needing items like livestock fodder or trying to get rid of livestock wastes. At the final workshop, where the research results were discussed, farmers identified their lack of security and safety in informal settlements as the main constraint to nutrient cycling.

At the time of the study, only 0.6 per cent of the city's total annual organic waste (2500 t) was being processed as compost by community-based organisations (CBOs). However, these organisations are not the main actors involved in managing Nairobi's nutrient flows; they are out-numbered by urban households engaged in mixed crop-livestock farming. These farmers recycle nutrients either on their own farms

Day-old chicks delivery to a poultry enterprise in Yaounde
Photo: Urban Harvest

A pig farmer and his wife in Yaounde
Photo: Urban Harvest

or through non-market exchanges. Based on data from a 1985 sample survey in Nairobi, we estimated that 54,500 households in 2003 (35 per cent of all Nairobi farmers) used compost. Most of these households (91 per cent) produce the compost themselves. Twenty-nine per cent of all Nairobi farmers (estimated at 37,700 households in 2003) used livestock manure to fertilise their crops, 44 per cent producing it on their own mixed farms. Only 3.6 per cent of those who used compost purchased it and only 2 per cent purchased manure. Schools and institutions engaged in farming, such as prisons and orphanages, also produce compost, but the amounts have not been measured. Thus, although the amount marketed is very limited, it is clear that the scale of these activities is much larger than that undertaken by CBOs.

In the case of manure, rural Maasai herders are linked to urban and rural crop production enterprises via an organised market in Nairobi. But, due to lack of information, manure produced by livestock keepers within the city is disconnected from this market and is mostly dumped or burned.

We found that Nairobi's urban and periurban composts were of lower quality than cattle manure and way below optimum levels, especially for N and P (which are important for Kenyan soils); and the compost samples also had a low C:N ratio mainly due to the farmers' lack of knowledge. To improve their product, and the management of their associations, the farmers need capacity building. The absence of an enabling legal framework was also found to limit quality as well as demand for compost: the groups did not operate in formally-recognised spaces and farmers were reluctant to fertilise land that did not belong to them.

Further, with over 60 per cent of Nairobi's population living in informal settlements, which cover only about 5 per cent of the total land area, wastes produced there have little chance of being recycled through local crop-livestock farms, which mostly belong to better-off people with backyards. However, while not much of the city's waste is processed by CBOs in these conditions and even less is well utilised, compost-

Poorly managed nutrient cycling in Nairobi
Photo: Urban Harvest

making does contribute to neighbourhood cleanliness where local authority services are lacking.

A task force to develop an urban agriculture policy in Kenya was formed in 2007, led by the Ministry of Agriculture's Provincial Agriculture Board and the Kenya Agricultural Research Institute (KARI). The group began drafting a policy in early 2009 and thanks to stakeholder engagement nutrient recycling is expected to become part of the policy. Public awareness campaigns, media articles and official statements could follow, promoting compost production as a strategy for cleaning up the city, which would improve the demand for compost and its business potential. An urban agriculture policy also needs to be localised through urban by-laws for enhanced regulation and control, as is already underway in Nakuru. Some of the considerations for legalising urban agriculture and organic waste management have also been incorporated in a draft Land Bill for Kenya.

Nakuru, Kenya

Following the Nairobi study, Urban Harvest wanted to get a more in-depth picture of sources and types of organic waste generated and used by urban farmers. According to Foeken (2006), Kenya's fourth largest town, Nakuru, has both large- and small-scale farming within its boundaries, together supplying 22 per cent of the food intake of farming households, and 8 per cent of the town's overall food needs. Thirty-five per cent of Nakuru's population engaged in urban farming in 1998, 27 per cent of all households growing crops and 20 per cent keeping livestock. These are very similar to figures from a study of six Kenyan towns conducted by Lee-Smith and others in the 1980s.

Common crops in Nakuru are maize, kale (*sukuma wiki*), beans, onions, spinach, tomatoes and potatoes, while chicken, cattle, goats, ducks and sheep are common livestock. Foeken (2006) found that the poor were proportionally less represented among urban farmers than the better-off Nakuru residents, mostly due to land access. Our 2005 study also confirmed that livestock keepers were more likely than crop growers to be farming for income purposes. These data can be found in the forthcoming book.

Farmers purchased 70 per cent of food items they consumed, but more than 50 per cent of kale and spinach consumed was sourced from their own farms, showing how urban agriculture acts as a source of food as well as a means to save income. Most cattle keepers were mixed farmers and kept a range of livestock, similar to what is observed in other urban centres in the region.

Farmers in our study recycled nearly all their domestic organic waste, mostly as livestock fodder, which benefits the town in terms of waste management and efficient food production.

We projected that about 283,000 t of wet manure is produced annually in the livestock and mixed farms of Nakuru, just over half of it not being re-used in farming, resulting in dumping and environmental contamination. With an average of 20 t of wet manure produced by an urban farmer in Nakuru, those living in a middle-income area with backyard mixed farms achieved a very high re-use rate of 88 per cent, mostly applied to their own crops, while those in a low-income area with a higher population density and less space only achieved 17 per cent re-use. Most of the recycled manure (61 per cent) was used directly on the same urban farms, while 6 per cent went to rural farms and the rest was sold or used elsewhere in town. Women tended to be more involved than men in managing the nutrient cycling of domestic organic waste such as livestock fodder. Some intensive vegetable producers in the low-income areas were making good use of this manure on under-utilised plots and the practice could be expanded with municipal support.

The urban farming system would work better if lower-income livestock farmers were encouraged to farm more efficiently using land set aside for the purpose. Alternatively, or in addition, collection and re-use of livestock wastes from low-income farms in high-density areas would increase both the efficiency of food production and waste management. This could be done through organised collection and distribution points and guidance to crop farmers through extension services. The dumped manure could also be co-composted with household and market organic waste and packaged as a bio-fertiliser.

Currently, these findings are being taken up by the Municipal Council of Nakuru (MCN) through its Department of Environment. They have already influenced ongoing efforts to develop urban agriculture bye-laws, following resolutions of a workshop for Nakuru councillors in May 2005.

Yaoundé, Cameroon

About half of Cameroon's population lives in urban areas. The population of the capital, Yaoundé, is estimated to be increasing at about 10 per cent per annum and is expected to reach 4 million by 2020. Unemployment in Yaoundé is about 25 per cent and many households feed themselves and provide some income through urban agriculture. We conducted two studies in Yaoundé, one on those selling traditional leafy vegetables, mostly produced by women from about 32,000 households, and another on integrated crop and livestock production on small mixed farms. Both are important urban farming systems in Yaoundé.

A pig farmer in Yaounde
Photo: Urban Harvest

In 2003 we collected primary data from 150 chicken and pig producers, 75 in each category, based on a stratified random sample taken along seven major axes crossing

Waste co-composting with manure in Kahawa Soweto in Nairobi
Photo: Urban Harvest

Yaoundé, in an attempt to assess the potential of this vibrant sub-sector of Cameroon's agriculture. We found that rearing small livestock in city backyards contributes to urban dwellers' incomes, health and nutrition, as well as being an integral part of their culture (animals are given as gifts or used for religious purposes).

Following cultural norms, more women were said to be involved in keeping chickens (65 per cent) and more men in keeping pigs (76 per cent). Households kept livestock mainly as a source of revenue, and both types of enterprise generated a good income. Many sold animals to generate liquidity (55 per cent) and a significant proportion of all sales (30 per cent) were specifically used to pay children's school fees. A high proportion of sales were said to result from demand during festivals such as Christmas and Aid-el-Kebir (77 per cent). Manure was a crucial part of the urban farming system for the production of garden crops. Some farmers used manure alone, while some applied a mixture of manure and fertiliser.

Poultry production in urban and periurban Yaoundé represents 70 per cent of the total for the Central Province, about 0.91 million birds, mostly broilers (710,000) and some layers (200,000).
At the time of this study Cameroon had about one million pigs with approximately 50,000 located in the urban and periurban area. By combining the figures from our surveys of livestock farmers and vegetable growers with official statistics we were able to calculate the total volumes of manure produced and utilised. Yaoundé produces over 20,000 t of this organic fertiliser per annum, of which about 69 per cent is utilised in farming and the rest, about 6,350 t, is discarded. Our study also showed that this production system supports a market for itself outside the city, notably in a provincial urban capital, Bamenda, where the product fetches a higher price. Ten per cent of the capital city's manure production is sold this way, although official agricultural planning is not aware of this fact!

We found that 10 – 20,000 persons, including producers, retailers, processors, animal input and feed traders, are employed in the urban livestock industry. Because pigs and chickens both grow rapidly, they provide a high level of protein and a quick return on investment. Urban livestock production supplements the diet of low-income households with an important local source of protein and minerals. The wasted manure corresponds to a discharge of 400 t of nitrogen, 229 t of phosphorous and 114 t of potassium as waste, which also constitutes serious environmental pollution. Although pig and poultry production near residential areas in towns creates problems related to smell, noise and pollution, including contamination of the water table by nitrates, these need to be weighed against their benefits and dealt with through improved planning and management. Proper support is required for this vibrant sector of agriculture.

Conclusion

Together, these studies indicate the scale of nutrient production and its uneven recycling through farming in African cities. They also suggest some of the main parameters for improving the efficiency of such recycling. The role played by small urban mixed crop-livestock farms is clearly important, while the potential for exporting nutrients to rural farms and even other cities is demonstrated in both Yaoundé and Nakuru.

Dairy farmer in Kahawa Soweto in Nairobi
Photo: Urban Harvest

However, lower income farmers are at a disadvantage because they lack the same access to backyard land for mixed farming, especially when they are crammed into extremely dense informal settlements in a place like Nairobi. The better livelihoods, improved waste management and food production that could potentially be gained by supporting these low-income farmers through strategic means is clearly enormous. Some solutions are emerging in Nakuru, based on the practices of farmers themselves and as agricultural extension and city authorities start to take an interest in managing and regulating urban farming.

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Note

1) starting at 150-160/km² and becoming optimal with respect to recycling efficiency around 375/km2 (Staal, 2002)

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Decentralised Composting of Market Waste and Use in Urban Agriculture; Conakry, Guinea

Roland Linzner

Manual turnover in a compost station in Conakry
Photo: Roland Linzner

It is estimated that two out of three people will live in urban centres in West Africa within the next 20 years. According to UNOWA (2007) more than ninety per cent of the urban population lives under substandard conditions. An important issue is the management of urban solid organic waste. Currently, these wastes contribute to urban pollution, while large amounts of nutrients are lost.

Composting is a promising approach to solving these problems. The portion of biodegradable organic waste is higher in low-income countries (sometimes up to 90 per cent of the total waste stream). Organic wastes and residues are usually locally available, unlike the imported mineral fertilisers, which many people cannot afford to buy. In addition to improved soils and yields, compost production and application may have indirect benefits, such as increased food security and income generation, reduced landfills of organic waste and the related prevention of pollution.

Due to the lower macro-nutrient content of compost compared to that of mineral fertiliser, it is a challenging task to market this product and also to convince potential users of the additional positive effects of compost, such as its support of soil functions and the prevention of soil erosion. One common approach is to blend compost with other materials, like nitrogen-rich chicken manure.

Technologies for the aerobic treatment of organic waste range from open windrow composting to closed systems. The complexity and scale of these systems vary considerably. The easiest way to compost organic waste is to make static piles, while more effort is required for bin / barrel composting or open windrow composting, in which the waste is mechanically rotated to improve aeration. Systems with forced aeration or enclosed systems are even more complex.

Several efforts to promote composting technologies in Africa have been unsuccessful for different reasons (Linzner and Wassermann, 2006). Composting projects in the past decades focussed on large-scale composting plants, but the majority of these composting plants failed owing to waste characteristics (like impurities, hazardous substances or material properties that hindered the degradation process), seasonal variations (problem of continuous supply of input material), lack of technical education and training, lack of (funds for) maintenance, variations in water and power supply and the status of waste management in politics and administration (Dulac, 2001). A major problem for large-scale composting plants is the funding of construction costs and investment costs for machinery and equipment. Large-scale facilities have a higher turnover of organic waste, which requires a continuous supply of input materials. Seasonal variations and feasibility of transport have to be considered in this context. Furthermore, it is necessary to have an adequate compost demand in order to generate sufficient revenues.

Since the 1990s new approaches have been introduced through small-scale composting projects initiated by NGOs or neighbourhood communities. Decentralised composting involves small groups of people and relatively low costs. Local governments or other institutions can support such a project by educating the public, providing land for the facility (little space is required), assisting with start-up costs, transporting and disposing of rejects to local landfills, and using the final compost in public parks or in collaboration with Ministries of Agriculture. These small-scale operations depend mainly on human labour (e.g. pre-sorting processes, turnover and irrigation of the windrows). The start-up costs for these facilities involve low capital input as (almost) no machinery is used. The running costs are also low, because human labour is comparably cheap in low-income countries.

Due to high fuel prices in low-income countries, it is important to minimise transport costs. The location of the composting facility should therefore preferably be close to both the point of origin of the input material and the place of compost application.

Both for larger scale and more decentralised composting, proper assessment of input supply, compost quality and existing and potential markets for compost is required. A proper market assessment provides information on the potential compost users and the existing fields of application, e.g. city farmers (urban agriculture), application in parks, horticulture, silviculture etc. and on the estimated value of the product for the user (willingness to pay, ability to pay, price of competing products). A comprehensive guide for the marketing of compost in low and middle-income countries is freely available on the internet (Rouse et al., 2008). Transport and seasonal variations affect both the quantity and the composition of the input material. Collection schemes for certain waste types may already exist. The purity of the input material has a major influence on the quality of the produced compost: source separated organic material improves the quality of the compost.

Conakry, Guinea

A research project "Recirculation of local organic waste in urban and rural agriculture - the impact on soil functions in Guinea" (West Africa) was carried out at the Institute of Waste Management and the Service National des Sols (Guinea), and was funded by the Austrian Academy of Sciences (more information available at: http://www.wau.boku.ac.at/abf.html: Linzner et al., 2007). The study focussed on a small-scale facility in the periurban area of Conakry and included a cost analysis and field trials.

The facility has a main rotting area of approximately 80 m^2 with a roof and a concrete slab inclined 5 per cent. Market waste serves as the input material; the bulk of which is elephant grass as oil palm stems are not suitable due to their fibrousnesses. About 40 members of a women's cooperative have been trained to operate the composting facility. They are at the same time users of the produced compost because they carry out periurban agriculture activities at the composting site. The cooperative is associated with the Ministry of Agriculture and uses fields that are owned by the Ministry. The land for the composting station was provided by the Ministry at no cost. In the first year of operation approximately 4 t of compost were produced, even though the facility did not operate in the rainy season (June to September).

The economic viability of composting is crucial for the sustainability of such a project. The overall expenses for construction and operation (material and labour) of the small-scale (decentralised) plant in Conakry for one year amounted to approx. 5,700 EUR (for the production of 4 t of compost). Construction costs accounted for about 70 per cent of this amount. This illustrates the impossibility of covering start-up costs (construction costs) by means of revenues (compost selling), and confirms previous experiences regarding the difficulty of establishing economic viability (Drechsel and Kunze, 2001). There is thus a need to reduce the costs to a minimum, e.g. through Community Based Composting Schemes in which land, input material, collection and labour can be obtained free or at marginal cost. With respect to location, it is important to determine whether the facility should be close to the input materials or close to the end users of compost (if a location close to both is not possible).

Based on the records kept, a small cost analysis was carried out. The Austrian Funding Organisation funded all costs at the beginning (construction and running costs). Therefore the compost price was calculated based on the idea of covering the running costs of the compost station (1,660 EUR) with an annual output of 4 t of compost. The production cost of 1 t of compost is approximately 415 EUR and 1 kg of compost should therefore be sold for at least 0.41 EUR on the local market. Unfortunately it is difficult to charge this price, because of the availability of cheap competing products, such as cow dung (0.05 EUR / kg) or chicken manure (0.075 to 0.1 EUR / kg). By contrast imported mineral fertiliser is sold at a cost of approximately 0.5 to 0.6 EUR / kg, which is encouraging for composting. A detailed compilation of the costs (currency conversion rates from the years 2005 and 2006) is provided in the project report (Linzner et al., 2007).

The project was also confronted with cost issues that were not anticipated in advance, e.g. municipal charges and the costs of hiring truck drivers for market waste. The costs for bulky material, mixed market waste and transport accounted for 390 EUR for the output of 4 t of compost.

The results of the field trials showed that compost application in Conakry increased the maize grain yield in the first year by approx. 400 kg/ha. This surplus yield contributed to the food security of the involved female farmers. A considerable amount of money could be saved because they did not have to purchase as much food. Furthermore, selling the harvest generated an income of approx. 200 EUR per hectare and per vegetation period that could subsequently be used to meet other basic needs, e.g. schooling for children. In comparison: the monthly wage of a non-skilled worker in Guinea ranges from 12.5 to 25 EUR, with wages of scientific personnel ranging from approx. 50 to 75 EUR. It was reported that income and wages in urban agriculture are often higher than those of mid-level civil servants. In the last few years salaries in Guinea have stayed more or less the same while the prices of rice (the staple food) and fuel have increased steadily. Living conditions have therefore worsened. This means that compost application in urban agriculture could generate an income that is indispensable for survival.

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Using urban waste as mulch,
Photo: Ivana C. Lovo

The Productive Garden: An experience in the city of Belo Horizonte, Brazil

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As part of the RUAF's Cities Farming for the Future programme (1), a project called the Jardim Produtivo (Productive Garden) was initiated to transform a vacant plot(2) of 3,500 m² into a multifunctional urban space.

The process started in January 2008, with awareness-raising and organisation and training of the gardeners. The garden's development over a nine-month period was continuously monitored, with a specific focus on production, food and nutrition, socio-economic factors and gender. Currently, seven households are farming at the *Jardim Produtivo.*

Recycling organic materials

At the start of the project, each participating family received a bucket with the capacity to hold 5 kg of household waste (including leftover prepared foods, peels and inedible parts of fruits and vegetables). Each household consists of two or three members. Throughout the project period, five of these families were able to collect a bucketful of household waste every eight to ten days. In the period March 25 to September 25, the total organic household waste collected for the community garden was 84 buckets, or 420 kg. The organic material was used for the collective production of compost, which was distributed to all members of the *Jardim* (which is shared by seven households).

In addition, the gardeners obtained organic material through a number of other channels. An interesting partnership was formed between the farmers and two small poultry production enterprises, located in the surrounding area. Poultry manure (3) is the primary source of nitrogen used in the manufacturing of compost. On average, the two partner enterprises produce 400 kg of chicken litter every two weeks. The gardeners also used pruning material from parks and gardens, like residual cut grass. This is very useful for the production of compost and for protecting the soil and planting beds, since it controls the waste of water and protects crops planted directly in the beds. Three truckloads of this type of organic waste were delivered to the production area during the project period (the exact amount was not quantified). It was provided by the Parks and Gardens office of the municipality only on request (it is not routinely provided). Cattle and horse manure was donated by rural farmers or collected from roaming animals near the *Jardim*. Leaves of plants growing in and around the garden were also collected. In addition to the above, the households purchased cattle manure from local suppliers (bag of 50x80cm of dry cattle manure is sold for R$5.00 = USD2.8). The estimated demand for the cattle manure for the current production levels in the garden is 12m³/year, or approximately six tonnes.

It was not possible to obtain more information from the authorities on the costs of litter collection and maintenance of public areas, plazas and gardens comparable in size to the *Jardim Produtivo*. This information would be needed to estimate the savings that could be gained with this type of organic garden through reduced expenditure on maintenance of public areas and disposal of the mentioned volume of organic wastes.

Inorganic material

In addition to the recycling of organic material and nutrients, over 2,700 PET bottles were collected and used in the garden to create two irrigation circles and 20 horseshoe-shaped and rectangular planting beds, covering an area of approximately 980 m². The gardeners and neighbouring residents separated and collected these bottles. Burlap sacks (40x80 cm) were also used together with Tetrapac milk containers to build a shed to store the tools used in the garden. The burlap sacks were used to increase the adherence of the cement mass to the iron structures of the walls of the shed and the milk containers were used to waterproof its roof. These materials were also collected by the beneficiary families themselves and donated by local merchants and neighbours.

The table summarises the recycled materials used during the monitoring period.

Table

Recycled material	Use	
PET bottles/ containers	2,789 units	Containment of planting beds
Household waste	420 kg (monitored from 25 March to 29 Sept. 2008)	Composting
Pruning material from gardens and parks	Volume was not measured	Composting and protection of soil and plantlets in the beds
Poultry manure	400 kg every 2 weeks	Composting
Cattle and horse manure	Volume was not measured	Preparation of natural fertilisers and defenses
Plant leaves	Volume was not measured	Preparation of natural fertilisers and defenses
Burlap sacks (used to transport potatoes)	25 sacks measuring 40x80 cm	Construction of tool shed (to enhance adherence of cement to walls)
Tetrapac containers	60 long-life milk containers	Construction of tool shed (to waterproof the roof)

The area in Belo Horizonte, before the work started
Photo: Marcos Jota

Preparation of biofertiliser
Photo: Marcos Jota

Water recycling

In 2009, together with the SWITCH Project in Belo Horizonte, two cisterns (ASA model[4]) were installed to capture rainwater. The cisterns have a capacity of 18 l each and are set up to catch water on the grounds of the church property located next to the production area (See photo). With the cisterns and an appropriate irrigation system in place it will be possible to supply 80 per cent of the water needed for the gardens, thereby reducing monthly expenditures (the average cost of water during the seven months of monitoring was R$566 (USD 321)/month).

Improved nutrition

Nutrition indicators were collected before the implementation of the *Jardim Produtivo* (in April 2008) and after 5 months (in September 2008), using a food frequency survey and a 24-hour food log. The results showed an increase in the average number of vegetable portions[5] consumed (0.5 portions/day vs. 1.8 portions/day, respectively). The frequency of consumption of each type of vegetable also increased between April and September. Initially participants consumed lettuce an average of 2 times per week and this increased to 5 times per week. Tomato consumption increased from approximately 3 times per week to 7 times per week. Consumption of other leafy vegetables (cabbage, *almeirão* and *acelga*) also rose from 4 to 6 times per week. It appeared that the availability of vegetables, and the assurance of safe production – free of contamination from agrotoxins and chemical fertilisers – and the strong involvement of local consumers in all the stages of production, favoured this increase in consumption.

and after: the Productive Garden
Photo: Ivana C. Lovo

Integration and upscaling

The local government played an important role by making resources available free of charge, such as cut grass and water, and by contributing to the construction of the garden.

A community garden like the *Jardim* can be an important factor in municipal solid waste management, allowing decentralised collection and recycling, eliminating costs and reducing transport. Decentralised recycling and composting integrated with food production thus reduces waste management costs, protects the environmental and promotes health and a better quality of life. However, there is still a long way to go in scaling up these experiences and incorporating such productive areas in municipal solid waste management systems. To increase the scale to the territorial and environmental management of Belo Horizonte as a whole, regional policies and regulations need to be altered. This requires the involvement and commitment of other actors.

A productive garden can be a space that integrates citizens and nature. It further promotes the health of the local community through the use of medicinal plants; maintains traditional ecological knowledge passed down from generation to generation; creates opportunities for recreation activities; and (re)affirms the cultural identity of rural emigrants living in cities. Urban agriculture furthermore transforms vacant lots – considered to be focal points for the propagation of disease vectors – into productive green areas, increasing their visual impact on the urban landscape. It improves the permeability of the soil, thus increasing the city's capacity to recharge the water table and reducing flooding. It also strengthens social relationships between neighbours and communities.

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Compost management
Photo: Marcos Jota

Notes

1) For more information on CCF in BH see: http://www.ipes.org/index.php?option=com_content&view=article&id=101&Itemid=112
2) Term used by the Urban Planning Office for unused urban areas and for which no plans exist.
3) "Chama de galinha", or chicken litter, a mixture of sawdust and chicken manure.
4) ASA is a Social Training and Mobilisation Programme to Familiarise with a Semi-Arid Climate, under which one million rural cisterns have been installed.
5) The concept of portion is that provided by the Ministry of Health of Brazil (2005). A portion of vegetables is the quantity capable of providing 15 calories, and a portion of fruit is that which provides 70 calories.

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Improving Food Security through Environmental Management in Ibadan: The case of the Ayeye community

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Solid waste disposal is a nagging problem faced by various communities in Ibadan in southwest Nigeria and other state capitals. Ibadan, the capital of Oyo State, is the most densely populated city in the state with over three million inhabitants. It is said that in Ibadan every street is a market. Many backyards are used for growing local vegetables and medicinal herbs.

The community provides compost also to other local government areas.
Photo: Photo: M.K.C. Sridhar

The Sustainable Ibadan Project (SIP) was established in 1994 (together with 11 similar projects across the world) by UNCHS (HABITAT) as part of the Sustainable Cities Programme. Participants at a City Consultative Forum in 1995 concluded that waste management and conversion to organic fertiliser were top priorities for Ibadan and jointly identified aerobic composting technology using windrows as a viable method to collect and recycle waste, generate income, and use compost for urban agriculture.

One of the pioneer community-based projects is the "Ayeye Waste Sorting Centre". In collaboration with Urban Basic Services (sponsored by UNICEF), the authors trained community members in waste assessment and source separation of biodegradable and non-biodegradable wastes. The project has been able to generate economic returns and employment for the local community (Sridhar and Adeoye, 2003).

Ayeye community

Ayeye is a densely populated, low-income community located in the core area of the city, with a population of 13,720 located in the core area of Ibadan city. It occupies an area of 14.13 ha, with 42 compounds and 460 houses (as observed in 2009). The population per housing unit is estimated to be about 30. Women and children regularly sell and load goods along roads in the area. The Ayeye community has very low access to sanitation and other basic services. The per capita generation rate of solid wastes is about 0.43 kg per day, 60 to 80 per cent of which is organic in nature.

The many open drains in the neighbourhood pollute the Gege stream. At the start of the project in 1994, there was no waste disposal facility and people littered everywhere, especially along the Gege stream. At that time, the community had only one toilet. In 2002, the Ayeye Community built two "Pay and Use" toilets, which initially were emptied into the nearby drains and then into the stream. In 2009 however, the Sustainable Ibadan Project established a system in which the pits are emptied by so-called "faecal waste contractors". The community charges five Naira (0.25 Euro cents) to each user of the toilet. This has improved the physical condition of the area.

Concept and methodology

The initiative was set up to develop practicable solutions to the solid waste problems by converting wastes to fertiliser. By improving environmental health and employment and generating income as well as food security, it also aimed to benefit the community (particularly women and children, who are the most involved in waste collection and disposal and thus the most vulnerable to its hazards). Improving sanitation and training community members on food security, health care and waste management issues were also part of the project.

The community members collected solid wastes from their homes, and food waste from the Ayeye-Agbeni food market. Household wastes were sorted into major components (plastics, metal and glass) and then transferred to a sorting centre (where separate cubicles were provided for the segregated waste) at a location designated by the community.

Using compost on maize produced yields comparable to when fertilisers were used
Photo: M.K.C. Sridhar

Biodegradable wastes were converted into organic fertiliser. UNDP and UNICEF provided major funding, while the Oyo State Government and other stakeholders (like university) provided other support through materials and human resources. A 5-t per day capacity plant was commissioned in November 2002. It was to produce 45-50 bags of 50 kg organic fertiliser per day to be sold to farmers within and outside the community.

The project was executed in three phases (in 2001-2002), a quick appraisal survey; construction, mobilisation and training; and community participation in the composting process, and field trials of compost utilisation on identified farms. At the end the project was handed over to the community.

Results and lessons

Details of the waste generated in the community (in 2002) are given in table 1. The total compostable waste generated per capita / day was 0.16 kg. Other major components include plastics (high and low density film), metal, and ash arising from the cooking activities.

Table 1. **Wastes generated in Ayeye community (kg)** (Total population: 13,720, or 30 per housing unit).

	Per week per house	Per week in 460 houses	Per day in 460 houses	Per capita per day
Compostable waste	21.55	9913	1416.14	0.103
Animal waste	11.385	5237.1	784.16	0.057
Recyclables	15.15	6982.0	997.43	0.073
Total	48,085	22,132	3198	0.233

The project has been sustained since 2002. It is required that the waste collection is efficient, electricity supply is regular, production is steady, and buyers are readily available. In the project period, the supply of electricity to the composting plant was not regular, which affected production capacity. Other constraints identified were lack of land area for expansion, and lack of an organised marketing framework.

At least four people worked regularly at the sorting centre producing about 10 bags of fertiliser per week (each bag weighing 50 kg). In addition, they also produced Grade A compost by fortifying it with additional nitrogen (3.0 to 3.5 per cent) and phosphate (1.8 to 2.0 per cent), which was in greater demand by farmers who grew maize and other crops requiring high N.

Maize and other vegetable crops were also grown on demonstration plots. The finished compost and the compost amended with additional N and P produced yields comparable to when chemical fertilisers were used (see table 2). The farmers appreciated the benefits of organic fertiliser application, as they saw increased yields, a second crop with no additional inputs and its usefulness in controlling soil erosion and degradation (Adeoye *et al.* 2008). Farmers and horticulturists are eager to have the compost produced in larger quantities to satisfy their needs.

Table 2. **Effect of organic fertiliser produced by Ayeye community on maize yield and comparison with the effect of chemical fertiliser**

Fertiliser treatment	Plant height, cm	Grain yield, t/ha	Number of seeds per cob
No fertiliser, n=12	177.97	2.02	197
NPK fertiliser (15:15:15);n=10	237.67	5.40	463
Organo-mineral fertiliser, 1.5 t/ha, n=14	212.5	6.06	435
Organo-mineral fertiliser, 3 t/ha, n=12	238.93	6.52	546

The community project provides compost to horticulturists and Oyo State Farmers Association, whose members are spread across 33 Local Government Areas (LGAs). But the members are continually looking for markets where they can sell their compost and their farm produce. The compost is also sold to other urban and periurban farmers: chairmen of the 11 LGAs in Ibadan buy and distribute the compost to their farmers. Ayeye represents one of the traditional core communities in Ibadan. The other 11 LGAs have expressed interest in replicating the project in their communities. This project also serves as a model in Nigeria and seven of these small to medium level composting plants have been established in different parts of the country.

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Municipal Solid Waste Management as an Incentive for City Farming in Pune, India

Sohal Behmanesh

The disposal of waste presents an increasing challenge to the administrative bodies of megacities. The Municipal Corporation of the Indian city Pune has introduced source separation systems and on-site organic waste composting. The citizens concerned are looking for practical ways to treat their organic wastes and they have found city farming to be a viable solution.

Pune, situated in Western Maharashtra, India, is a rapidly growing city of about 5 million inhabitants (Kraas & Kroll 2008). The city produces around 900-1100 tonnes of solid waste per day, all of which enters the Corporation's premises. Organic waste amounts to 630 tonnes, corresponding to 65 per cent of the solid waste produced. It is estimated that the largest part of total solid waste (40 per cent) is derived from private households, while the rest comes from hotels and restaurants, shops and markets (see Kroll 2007). Private separation and processing could thus contribute considerably to relieving the centralised disposal infrastructure.

Waste management did not reach the municipal agenda of Indian cities until the second half of the 20th century. The management systems in Pune today are based on the idea of on-site separation. Waste pickers or municipal litter services collect the waste at the households or at central collection points. Some recyclable materials are extracted and the remaining waste is transported to a landfill site outside the city, where, however, only a small part of the biodegradable matter is composted properly (Kroll 2007).

Municipal waste regulations

In the early 1980s several small civil movements began raising awareness about the rising amount of waste in the city. Their ecological concerns occasioned the promotion of organic waste recycling at household level. Adoption of the practice progressed slowly, partly due to the negative connotations of dealing with wastes within the Indian middle class households (Behmanesh 2009). A change was induced by the introduction of the Municipal Solid Wastes (Management and Handling) Rules 2000 (MSW 2000). They included local amendments in Pune that made the disposal of organic waste on residential premises mandatory for housing societies built after 2002 (Kroll 2007). The inhabitants of those societies now seek acceptable solutions for decomposing their organic waste.

Organic waste recycling and city farming

The Pune Municipal Corporation (PMC) collaborates with the non-governmental organisation "Wealth-from-organic-waste", which emerged from an early ecological civil movement and promotes a viable organic waste recycling technique. The organisation's members have been advertising natural bio-catalysts, or "biosanitisers", developed by the Bhawalkar Ecological Research Institute (BERI) for many years. City residents, mostly housewives, are motivated to use organic waste and the biosanitisers to cultivate organic fruits and vegetables on their rooftops and terraces. The components are simply added to the cultivation beds. The practice is viable for cities because of the micro-scale farming techniques involved, low cost, and lack of unpleasant smells during the decomposition of organic wastes.

The new regulatory framework provided an improved context in which to promote this practice. Citizens in Pune have started to implement city farming at different scales: from herbal kitchen gardens to cultivated terraces of more than 100 m^2. Local ward officers now cooperate with builders and inhabitants in providing infrastructure for the compost sites on the societies' courtyards and in disseminating know-how on the use of compost in city farming, an orphanage recycles its diaper waste and uses terrace gardens to educate children about nature; prisoners recycle the prison's kitchen waste and grow fruits and vegetables; organic waste is

Cultivation in plastic bags with soil and organic waste
Photos: Sohal Behmanesh

composted in a maternity hospital; and disabled army veterans plant medicinal plants in their residence.

Efficient disposal of garbage seems to be the most significant motivation for users. The access to healthy and fresh food and the ecological benefits seem to be of lesser importance. But, the potential for creating closed nutrition cycles within the city and reducing its ecological footprint by producing fresh organic products on site is underestimated. Lack of awareness is partly to blame, but also the fact that projects involve mainly middle class inhabitants of housing societies.

Rooftop garden in Pune
Photo: Sohal Behmanesh

RoTrees on thin layers of soil in a backyard
Photo: Sohal Behmanesh

Another city farming project, initiated by the PMC with the international NGO International Institute for Energy Conservation (IIEC) envisages the involvement of local environmental NGOs and product suppliers for a broad implementation of rooftop gardens on private, public and commercial buildings.

Bottlenecks and potentials

Pune's municipality has a good basic understanding of different kinds of city farming. The MSW 2000 amendments provided an important incentive for the emergence of city farming using composted organic household wastes. However, the potential for poverty alleviation and chances for broader collaboration in implementing waste-recycling techniques have been neglected. Lower-income households and organic waste recycling are not considered in current city farming project proposals of the Garden Department. The lack of interest in addressing social matters may stem from the Department's limited mandate. The disposal of wastes falls under the mandate of the Health Department, which has no vision regarding developing an eco-city.

Some attempts have been made to implement city farming on informal holdings in Pune, however, the insecurity of land holdings and the densely built infrastructure in slums, where light and space are limiting factors for cultivation, are important obstacles. A project initiated by a local NGO, in which slum dwellers produced and sold manure from organic waste, ended due to a forced eviction from the area (Behmanesh 2009).

So far, no effort has been made to bring together different stakeholders, such as the municipality, NGOs, building societies, slum inhabitants and urban farmers. The Health and Garden departments of the municipality have also not exchanged information regarding their city farming projects. Important synergy effects could be achieved if the different departments of the municipality integrated their existing city farming approaches. Awareness raising about the potential of a sustainable valorisation of organic wastes in slum communities with insufficient municipal infrastructural facilities is needed. If the vision of transforming Pune into a pilot city of "green roofs" in India (see Behmanesh 2009) progresses, the first step of bringing together environmental and construction stakeholders could be expanded to include a social component. The PMC, as a representative of all of Pune's inhabitants, should then facilitate a more inclusive and holistic approach to city farming.

The future

The Pune Municipal Corporation is slowly adopting the idea of organic waste recycling and city farming and supporting its promotion. One important incentive for urbanites to apply these practices at household level was provided by the MSW 2000 rule amendments. If implementation can be expanded (to other houses and slums), the metropolis will benefit from this closing of nutrient loops, but also from augmented urban biodiversity, decreased water run-off as well as an improved microclimate. Allotment gardening and eco-housing projects using rooftops as garden areas are starting to emerge. An information exchange on innovations of waste-recycling techniques together with these new initiatives could benefit all types of city farming activities and broaden the effects of a decentralised disposal of organic wastes.

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Commercial Substrates for Urban Agriculture in Bogotá

Blanca Arce
Andrés Peña

There is a need for low-cost, locally produced substrates for urban agricultural production in Bogotá, Colombia. The Colombian Agricultural Research Corporation (CORPOICA) coordinates participatory research on substrate mixtures using a wide variety of low-cost organic materials.

Fresh vegetables produced on substrate
Photo: Blanca Arce, Urban Agriculture Project-Corpoica, Colombia

Urban agriculture is increasingly common in Bogotá, the capital of Colombia. Especially due to rural-to-urban migration, the percentage of Colombians living in cities rose from 40 per cent in 1951 to 75 per cent in 2005 (DANE, 2009). The poverty rate in many of the country's cities is increasing and a growing proportion of urban residents encounter difficulties in securing access to food. In addition, there is an increase in demand for organically produced food and many inhabitants are prepared to pay more for the quality and safety that these products offer. Urban farmers are well positioned to take advantage of this lucrative market.

There are an estimated 4000 agricultural producers in Bogotá. In the periurban areas there are more than 300 hectares of highly productive vegetable gardens both in open fields and in greenhouses. In the city itself, though, mostly containers are used in open or closed spaces (backyards). These containers need substrate capable of maintaining continuous harvests, especially if they are used for the production of vegetables.

Peat is one of the most frequently used substrates in Bogotá, particularly for growing tomatoes and other vegetables. It is a natural product, containing 80 per cent organic matter that has many positive qualities including good water retention. It is free of pathogens and thus need not be disinfected. However, peat is imported from Canada and is very expensive (approximately USD 2/kg). It is more affordable for commercial producers who have extensive areas of production (10-30 ha) than for small producers who cultivate only small areas (0.5-2 ha). Small producers are more interested in cheaper, local substrates of high quality such as lime, compost, raw husk, scum (residue of burnt charcoal), burnt husk, charcoal-sand, solid humus, sawdust and urban waste compost.

Due to the high price of available substrates, mainly peat, there is a need for cheaper, locally produced, substrates (of the same high quality). In addition, recycling of locally available material reduces pollution and the cost of (urban) waste management. For instance, in warmer regions where sugar production dominates (Cachaza and Vinaza), the contamination of rivers and soils has been diminished by almost 60 per cent through the composting of industrial waste. This waste is utilised as substrate in vegetable production. And in Cajica City, under the organic waste recycling programme initiated in 2008, organic waste from all 11,000 households (50,000 citizens) is collected and converted into organic fertiliser for agricultural use. Local high school students teach households how to make the compost at home. Materials are provided by Cajica City, and the collected waste compost is used for organic fertiliser and animal feed.

A study was undertaken in 2009 to evaluate these locally available substrates, using mixtures from a wide variety of low-cost organic materials that could be used in urban agriculture.

The project

The urban agriculture project CORPOICA worked with three schools and households in three municipalities of the Department of Cundinamarca West Savannah of Bogotá: Funza, Facatativa and El Rosal. This involved 60 teachers, 90 students (from elementary school to high school) and 21 households. The project aimed at strengthening technological innovation and skills, by involving researchers, teachers, students and households in participatory planning and research (Photo 1).

The project involved the following steps.

- Working groups were organized comprising of researchers, teachers, students and farmers.
- A programme of technical-pedagogical training (with theory and practice) was created, based on agro-ecological guidelines and good agricultural practices.
- Urban and periurban horticultural spaces were designed in a participatory way (separately for each group in its own

environment) and in accordance with local, educational and socio-economic conditions.
- Vegetables were identified and agricultural techniques were discussed, adjusted and validated.
- Participants monitored the technological innovations.
- Didactic support material for technology transference was created, and urban agriculture was included in the curriculum of the elementary and the high school.
- Outreach activities were undertaken in ten cities around Bogotá, to disseminate the results achieved.

Six locally available substrates were evaluated (in PVC guttering): treated soil (lime, compost, raw husk), scum (residue of burnt charcoal), burnt husk, charcoal (together with sand at a ratio of 2:1), and solid humus (mixture of soil, solid humus and raw husk at a ratio of 2:1:1). The system of PVC gutters is ideal for use with crops that have a long growing cycle, as they provide a good accommodation for the roots, are low cost and save water and electricity.

The project looked at the performance of lettuce plants in different containers. Similar tests were done in the research centre, in three urban school gardens and in six urban home kitchen gardens. The substrates made up of two or more materials mixed together demonstrated better properties than those that only contained one element. Different techniques were also applied: rainwater harvesting, the use of various substrates including solid and liquid (only water and with nutrient solutions). It is important to have the right substrate mixture, and specific mixtures are needed for different vegetables. The nutrient solutions were composed of minor and major elements (chloride, sodium, sulphur, magnesium, calcium, potassium, iron, copper, bromine, zinc). These nutrient solutions when used in substrates are specially formulated to nurture the development of the plants, which have different needs depending on their stage of growth. They are easy to obtain and handle and they are cheaper than imported alternatives.

Main results

Through this project vegetable production in vessels and containers and in conventional organic gardens has improved in Bogotá. Various systems of production have been developed and recommended for growing urban crops in containers. For both containers and organic gardens, a training module has also been developed. The module for conventional organic gardens emphasises the efficient use of natural resources (soil, water) and environmental conservation (Photo 2). The module for vessels or containers includes a variety of different materials, such as PVC guttering, prefabricated roof material, fibre cement boards, black plastic bags, recycled soft drink bottles, wood; and in different set up: pyramidal, stepped and netted structures (see González Rojas, 2007: UAM no 19).

The substrates of raw husk and burnt husk were the least efficient because of their low moisture retention capacity and the difficulty of achieving homogeneous humidity. Rice husk is a sub-product of the milling industry, which is not available locally, so the main cost is transport.

The mixtures using solid humus (combined with soil and raw husk) and compost (combined with lime and raw husk) had better characteristics in terms of germination rate of lettuce; moisture retention capacity; infiltration and drainage; contamination; colour of the crop; environmental conservation; cost and availability at local level; and quality. With these mixtures, the urban farmers obtained lettuce with a greater number of leaves and a higher fresh weight, thus leading to better earnings. The other types of substrate produced lettuce with nutritional deficiencies and thus led to lower quality and output. For more information see Tibaitatá-Corpoica research center (2009).

Substrates were tested in different technologies at the Tibaitatá research centre
Photo: Blanca Arce, Urban Agriculture Project-Corpoica, Colombia

The production of lettuce using these mixtures achieved results similar to those obtained with the use of commercial substrate. The disadvantage of the latter is that it is more expensive and comes in larger (25 kg) bags. These need to be stored, which is not good for the quality of the substrate. A mixture of compost with local products seems to be a good alternative in terms of price, performance and accessibility (it is easy to produce or buy in shops in the city).

Future

Teachers, students and households are replicating and adapting their vegetable production systems in built-up areas, including the design of their urban garden schools and household productive units. By using different containers, they can take better advantage of the scarce amount of space available, and plant a wider variety of species for their own consumption and for sale. In this way they have been able to improve their family's diet, diversify their food patterns, and generate complementary income. Recommendations are being developed on the use of substrates containing compost and local sub-products. A growing use of compost will reduce the amount of waste in the city. The results are encouraging, but more research is needed on issues like transport, type of containers and vegetable varieties.

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Using Participatory Urban Design to "Close the Nutrient Loop": A Case study from the Philippines

Jeannette M.E. Tramhel

A shift towards resilient cities will require more than rethinking the built form; it will require the redesign of systems to facilitate more sustainable urban living practices. "Closing the nutrient loop" is an important principle in sustainable urban design, but challenging to implement. Engaging the community in the design of such systems is therefore critical to their successful implementation.

Vegetable landing area at Agora Market
Photo: Jeanette Tramhel

The allotment garden concept was introduced in 2003 by the PeriUrban Vegetable Project ("PUVeP") in Cagayan de Oro City in the Southern Philippines (see UA-Magazine no. 18 and no. 20). Thanks to the support of community groups, Xavier University and local government, today there are ten allotment gardens in operation for the benefit of the urban poor. As PUVeP has also introduced composting and vermicomposting, the gardening communities are thus familiar with the benefits of using organic waste as fertiliser for food production (PUVeP, 2008).

Reuse of organic waste

Planning for the reuse of organic waste requires examination of the solid waste stream in the following stages: segregation (in some systems); collection; transportation; processing; and disposal or reuse. Each of these steps has to be viewed in relation to the different sources of the waste. Organic solid waste is generated roughly in two ways: it is either in bulk and segregated (such as waste from wholesale produce markets) or dispersed and unsegregated (such as waste generated by households and small-scale commercial operations). These categories require different approaches in collection and processing.

Under the conventional approach in most cities, unsegregated solid waste is collected and transported to a single centralised location. An alternative is a decentralised approach in which each district takes responsibility for its own solid waste management, from collection to processing and reuse. This is essentially the principle behind national legislation that has been introduced in the Philippines, the Ecological Solid Waste Management Act (RA 9003) and, in Cagayan de Oro City, a supporting municipal ordinance (No. 8975-2003). This legislation requires segregation, recycling and composting, and represents a shift away from the conventional practice of operating a single centralised dumpsite towards a decentralised approach with several smaller sites, referred to as Materials Recovery Facilities (MRFs). Effective implementation of this legislation requires that solid waste be segregated at its source and that several practical issues be addressed.

Participatory urban design

A participatory process was undertaken to explore these issues with selected communities in Cagayan de Oro (Barangays Lapasan, Kauswagan and Macasandig). These three "barangays" (districts) were already familiar with allotment gardens and had expressed interest in the project. The process had the support of their councils and the city administration.

Participatory urban design is based on the principle that "the environment works better if the people affected by its changes are actively involved in its creation and management instead of being treated as passive consumers" (Sanoff, 2000). Moreover, urban design is inherently an asset-based approach, given that the designer is generally encouraged "to begin with what is already there." Therefore, the approach known as Asset Based Community Development ("ABCD") was explored for its suitability as a participatory urban design tool. It was incorporated into the traditional "design charrette", which was restructured as a two-stage process that began with community consultations in each barangay, followed by a training course for a core group of selected participants.

1) Community consultations
Participants were encouraged to share their "success stories" – these could be any accomplishments, large or small, initiated by members of the community, either together or individually, related to organic waste management or urban agriculture and the community assets (i.e. skills, people, physical resources) that had been involved to achieve them. These accomplishments (or "assets") were indicated on a base map. Major sources of organic waste were identified with blue dots and existing or potential sites for urban agriculture were shown by green dots. The exercise encouraged a shift in mindset among participants towards viewing organic "waste" as a community "asset". Participants were then invited to develop a vision statement for the integration of organic solid waste management with urban agriculture in their community.

"After five years, Barangay Macasandig will be one of the cleanest and greenest barangays in the city with healthy people, who are orderly, peaceful, self-reliant and self-sufficient in vegetable production and root crops as a result of composting and recycling of organic waste."
Vision Statement, July 10, 2008

In a second consultation, participants were asked to consider and post any possible projects for the integration of organic solid waste management and urban agriculture that would help the community move towards its vision statement. The group prioritised and selected one idea as the basis for a pilot project.

2) Training of Community EcoAids
The purpose of the training course was two-fold; it served simultaneously as a design studio and as a capacity-building exercise to foster community-based environmental leadership. In each barangay, out of those who had participated in the consultations, 7-8 persons were selected who were interested in the topic and had already demonstrated leadership potential.

During the 5-day course, trainees developed a site plan for the pilot project that their own communities had chosen. This required that trainees be provided with a basic understanding of the principles behind waste segregation, the advantages of "closing the nutrient loop," the basics of composting and its use in agriculture, and the socio-economic dimensions of waste management. A session on city planning and urban design explained planning tools such as land use zoning, as well as the principles of "designing with nature" (McHarg, 1967) and creating "continuous productive urban landscapes" (Viljoen, 2005). Another session considered how the commercial sector could be engaged. These lectures were supplemented with "hands-on" exercises and field trips. All of the information gained was used in the development of the pilot projects.

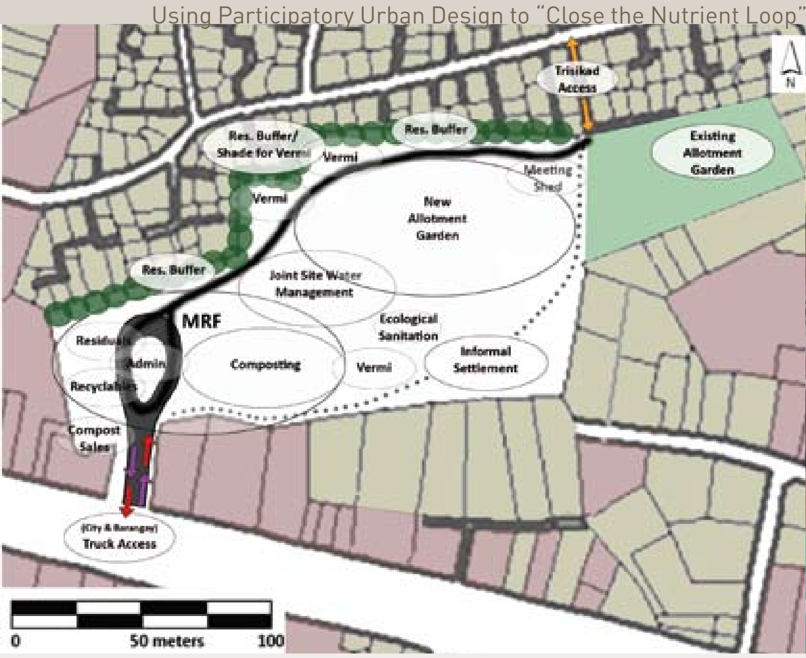
At the end of the week, final presentations were made to barangay officials and other invited guests. Each team presented its proposed pilot project to its respective barangay council. Follow-up consultations were then held in the barangays to provide an opportunity for the community to offer feedback and support for project implementation. In the months that have followed, Community EcoAids in all three barangays have started implementing elements of their project proposals.

Asset mapping in Macasandig
Photo: Jeanette Tramhel

Design proposal for Barangay Lapasan

The primary source of bulk organic solid waste in Lapasan is the Agora market and vegetable landing area (see photo). According to municipal data, it generates on average about 16 m^3 (or 9 t) of organic solid waste per day. By comparison, the unsegregated solid waste that is generated by 320 households in the pilot area would amount to only about 0.5 t per day.[1] The amount of compost that can be produced from this volume varies greatly, depending on the quality of the input material and the processing method under local conditions. Using Indonesian windrows or box composting, 3 t of organic solid waste generates about 750 kg of compost (Eawag/Sandec:2006, 34); conversion rates of 25-27 per cent for these methods seem to be the norm in most Asian countries (Waste Concern: 2007).[2]

Based on precedent studies of similar facilities, it was estimated that to process 1-3 t of organic waste per day, about 1,000 m^2 would be required.[3] A facility of that size in Lapasan could process about one third of the organic waste from the market and landing area and all of the organic waste from about 650-2000 households (or some other combination of the two sources). Based on a 25 per cent conversion rate, such a facility processing 1-3 t organic waste per day could produce 250-750 kg of compost per day (90-270 t per year).



Design concept for the site plan in Lapasan
Photo: Jeanette Tramhel

Sharing success stories in Macasandig
Photos: Jeanette Tramhel

A similar calculation can be made to determine the land area that would be required to "absorb" this amount of compost. It is estimated that, under local conditions, one ha (i.e. 10,000 m^2) can absorb about 12 t of compost per year (Holmer: 2009).[4] Given that the average allotment garden is about 3,000 m^2, one such garden can absorb about 4 t of compost per year. Put in another way: one ha can absorb the organic solid waste generated by about 85 households, and one allotment garden (of 3,000 m^2) can absorb that of about 30 households.

The site that was considered for this design proposal is a piece of vacant land that comprises about 15,000 m^2 in total. Its advantages include its proximity to the market and landing area, to a mill that can supply sawdust and to potential end users (producers en route to market). It also abuts an existing allotment garden and is serviced by good roads with two reasonable points of access.

The site plan that was developed for Lapasan includes an MRF (5,000 m^2) with facilities to process compost, to sort recyclables and residuals, and an adjacent allotment garden (5,000 m^2). As the site is intended to eventually process solid organic waste from the Agora market and landing area as well as that from households, the EcoAids had to consider suitable methods of collection and transport for the two sources. Their plan proposes that the waste from the market be collected by city vehicles along the major roads indicated in red; and that barangay trucks collect the household waste along the smaller roads indicated in purple and by tricycles along the routes indicated in yellow (see map).

The underlying principle for this urban design concept was environmental sustainability. But social and economic sustainability were also considered; the plan integrates the existing functions performed by tricycle drivers in waste collection, takes into account the sales of excess compost to offset some of the operational costs, and promotes mutual support between the MRF and adjacent gardens. As the proposal and site plan were developed as part of a capacity-building exercise, it is hoped that the "EcoAids" return to their community with skills and enthusiasm for project implementation. Ultimately, "closing the nutrient loop" will require a serious team effort and support from the entire community.

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The author wishes to acknowledge the support of an ECOPOLIS Graduate Research and Design Award from the International Development Research Centre, Ottawa, Canada.

Notes

1) This has been calculated as follows: 320 x 5 persons per household x 0.6 kg/SW per person x 50% organic matter.
2) More efficient methods will improve conversion rates; if more of the nutrient content in the organic matter is retained, the result is better-quality compost. Not only does shredding the material hasten the process, it also improves conversion; in experiments conducted at the PeriUrban Vegetable Project at Xavier University College of Agriculture, conversion rates of 67 per cent have been achieved (Holmer: 2009).
3) Box composting requires 800 m^2; Indonesian windrows requires 1000 m^2 (Eawag/Sandec: 2006, 50). This is consistent with information from other studies and operations in other barangay.
4) This has been calculated by PUVeP as follows: A general recommendation is 2 to 4 t of compost per ha for each cropping, depending on the status of the organic matter in the soil: if the level is low, 4 t are recommended, but if satisfactory, then 2 t are adequate. As the duration of a cropping is on average 3 months, it is reasonable to expect 4 croppings per year. With an average application of 3 t per ha per cropping, 12 t of compost would be required per year per ha. This also varies with the type of crop.
5) Suggested size for an allotment garden is a minimum of 3,000-3,500 m^2, to enable a 300 m^2 plot per family (PUVeP Garden Handbook: 2008).

Using Urban Organic Waste as a Source of Nutrients, the need of awareness raising

Hubert de Bon
André Fleury
To Thi Thu Ha

The use of liquid and solid urban waste for animal and crop production in the city is a centuries-old practice. Throughout the world, urban farmers supply nutrients to their crops by applying organic matter and/or chemical fertilisers. In Yaoundé, Cameroon, 63 per cent of urban and periurban farmers purchase recycled livestock wastes and 75 per cent use recovered and recycled fresh and decomposed kitchen waste (Parrot *et al.*, 2009). In Dakar, Senegal, 98 per cent of urban and periurban farmers use organic matter, either from livestock (35 per cent), plant and soil-based compost (46 per cent) or city wastes (19 per cent) (Ba, 2007). In Antananarivo, Madagascar, 100 per cent use livestock manure: 88 per cent use manure from the animals on their own farms, and 12 per cent buy it. Most of these urban farmers also use chemical fertilisers.

But the use of liquid and solid urban waste requires mediation to connect it in the eyes of the public to the production of healthy food.

Urban waste was used for periurban agriculture in **Paris** two centuries ago, but has disappeared because of health concerns. In the 19th century, market gardeners in Paris delivered their vegetables to the central markets, and during the night collected household refuse from the streets as return freight. This was all in agreement with the administration of the city. However, as European cities developed, these practices became increasingly unpopular. The "Great Stink of London" in 1858 and the fear of cholera led to policies that set in motion the construction of sewerage systems as an orderly way to remove waste and wastewater from the big cities. Sewer systems became obligatory in Paris in 1852, but led to pollution of the river Seine (Barles, 2005; Mandinaud, 2005). A solution was seen in market gardening using sewage. Although the restrictions were very rigorous (no contact between the water and consumed parts of the crop, limitation to vegetables that are cooked before consumption), an original urban market gardening zone was created on around 2,000 ha. This system functioned for a long time without any sanitation problems, but after the First World War chemical industries increasingly used the sewerage system, and pollution became a major concern. Still it was at the end of the 20th century, that the authorities prohibited not only market gardening but also other forms of urban waste recycling. Numerous certification processes do not allow the use of sludge in crop production, so it is replaced with chemical fertilisers. This process has had a strong psychological impact, and still many policy makers prefer to build waste incinerators rather than allow the recycling of urban organic wastes.

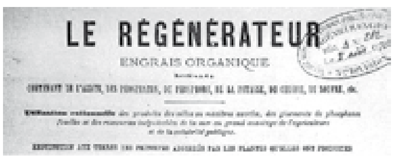

Photo: H. de Bon

Photo: H. de Bon


As in many other cities in developing countries, in **Hanoi**, Vietnam, urban waste recycling is widespread but slowly declining. Of the urban farmers, 56 per cent buy manure, mainly from poultry, but also from pigs and livestock. They also buy compost from the local waste treatment company (Mai Thi Phuong Anh, 2004). The VAC system (Vuo`n Ao Chuo^ng, or literally: garden-pond-breeding), integrates pig breeding with aquaculture, in an effort to close the nutrient cycle. However, the export of products for human consumption necessarily leads to a need for additional inputs. Recent research on urban and periurban market gardening in Hanoi has shown that the majority of added nutrients are supplied by chemical fertilisers, although some organic waste is used. One third of the nitrogen used in urban agriculture in Hanoi is from organic matter, which is applied mainly in the form of pig or poultry manure from the farmer's own animals or a neighbouring farm (To Thi Thu Ha, 2008).

Although a closed cycle that includes all urban wastes and urban agriculture does not exist, it would be a waste of this valuable resource if the current system of recycling, which has proven to be reliable in many situations, disappeared completely. Increasing urbanisation is likely to deteriorate the city/agriculture relationship. However, despite the rapid development of economic activities in Hanoi, agriculture is still an important part of the city and it must be integrated in urban projects. Awareness raising and supportive policies are necessary to make optimal use of available nutrients in the city.

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No Place Like Home: Capacity development in master composting programmes

Anne Scheinberg
Yuan Zheng

Domestic waste in developing countries contains a great deal of organic material – ranging from 60 to 90 per cent (Lacoste and Chalmin, 2007). Some of this waste is routinely fed to animals, or decomposes in heaps in landfills, illegal dumps or transfer stations. There is widespread agreement that composting is a less expensive and more environmentally attractive way to manage this waste, especially in low- and middle-income countries.

Photo: WASTE

Yet experience with composting is quite disappointing, particularly in developing countries. Large-scale composting projects fall apart when it turns out that the value of compost does not cover the costs of separate collection and composting at a large scale. Experience in developed countries suggests that composting is able to compete only when the price of controlled disposal in a landfill or incinerator rises above about USD 40 (WASTE, 2009). The result is that much organic waste goes to dumpsites or is discharged to land or water.

Home and community composting – where the compost is used by the household, institution or community that produces it – presents an elegant way out of this dilemma, because there is a closed loop and no external markets are needed. Training households to separate waste and compost themselves has formed the basis for a number of successful initiatives in North America and Europe, specifically in Belgium and the UK (Löffler and Vanacker, 2006). Up until now, however, this home composting has remained mostly a "rich country" approach, and has not really entered the discussion of modernising the solid waste infrastructure in developing countries.

Photo: WASTE

Solid waste management as a social system

Solid waste management is a so-called *system of provision*. It shares certain characteristics with other urban infrastructure systems in environmental management, such as energy, water and transportation systems. Local authorities or the private sector are *providers*, removing solid waste generated by household and business *users* (clients), and transporting it to disposal or treatment sites.

Where there are no providers, such as in slums or periurban or newly settled areas, households and businesses have to live with their wastes or create their own management systems. *Self-provisioning* describes a group of approaches for households to provide their own environmental services. Household-based provisioning is what most households do before the area in which they live is urbanised or modernised, but many of these traditional approaches have *negative environmental externalities*. In modern self-provisioning, environmental benefits are central: households choose to implement their own system in order to protect the environment. In the European Union, in countries like the Netherlands, Sweden, Germany and Denmark, self-provisioning is gaining in popularity as a complement to formal provisioning systems (van Vliet *et al*., 2005).

Home composting puts the provider and user in the same unit: the household, or in some cases the business. Home composting eliminates many of the costs for mechanical collection, processing and transportation. Households are responsible for treating and recycling their own organic waste (Practical Action, 2007). Sustainability in home composting requires organised collective support and capacity strengthening systems: such as through the *master composter approach* (Sherman, 2005).

Master composter programmes

The master composter approach is one way of organising home composting with a built-in marketing and support system for the households involved, which are both users and providers. These systems have been adopted in Belgium on a large scale (Löffler and Vanacker, 2006).

In master composter programmes, the work of waste management is a process of capacity building (Scheinberg, 2007). Master composters go through a training, after which they are prepared to teach households how to manage their own organic materials. As it is a capacity-based improvement approach, the largest part of the investment goes to training. The costs of physical infrastructure are less than USD 100 per household for a system that can manage as much as 75 per cent of domestic waste in most low- and middle-income countries` [1].

A master composter programme is designed to set in motion a "virtual cycle" of practical, self-help solid waste activities, in the framework of modernised self-provisioning. The type of approach is related to the "each one reach one" neighbour-to-neighbour initiatives, but it also has characteristics of "pyramid" sales schemes, such as used by Avon for household products in North America. The objective of the programme is to set up permanent relationships between specially trained individuals in the community, the "master composters", and a fixed number of their neighbours, friends and relatives, the "composting households". The master composters are not required to pay for their training, but they are expected to sign an agreement or contract that commits them to participate for a period of time. This contract also entitles them to status, further training and other benefits (Longman, 2000).

Once they have completed their three-day training, the master composters form a group and continue to cooperate with each other in learning how to compost their own materials at home, something that is absolutely essential if they are to be able to help others. Each master composter progresses through a number of stages, eventually becoming the "compost expert" for 15-25 households in their immediate neighbourhood.

Photo: WASTE

In tropical climates there could be as many as four composting cycles of three months each per year, while in temperate climates this is often limited to two, because compost piles are not very active at ambient temperatures in winter.

role of master composter

Stage 1. Make a commitment to being a master composter

1. Agree to participate for a minimum of 2-3 years, to really get the programme going.

2. Attend the training and apply the lessons to building your own home composting system.

Stage 2. Extend the reach and communicate the importance of home composting

3. Tell others about the programme, especially potential households, the press and media, school and religious groups and government officials.

4. Recruit and subscribe 15-25 households per cycle.

5. Conduct a three-day training which includes choosing and building compost bins on day 2, and agreeing on day 3 which families will start the process by taking the bins home and filling them.

6. Where possible, collect or save organic waste divided into 'green' (nitrogen-rich) and 'brown' (carbon-rich) materials so that one of the composters can be charged with the collected compostables on day 3.

Stage 3. Build capacities for composting at household level

7. Design and conduct training sessions for each of these households, which results in the selection of a household-specific home composting "package" including a (standard or modified) bin, regular visits, support in using or "marketing" finished compost.

8. As each household joins, be prepared to spend one to two hours per household, giving an orientation, identifying the main person in charge of the compost, siting the composting bin, where relevant choosing the type of bin, modifying the existing bin, etc.

9. Visit the household as requested by the household members.

10. Support the household in using the compost at their own house or at another location, such as a separate garden or farming area, or the houses of relatives.

Stage 4. Organise collective solutions for issues households cannot solve themselves

11. Support the household in safe management/marketing of excess compost.

12. Organise removal of partially or completely finished compost if the household cannot use it or market it themselves.

13. Organise as needed the purchase of supplies, materials and tools for groups of households.

14. Facilitate lab testing, agronomic advice, specialised trouble-shooting, etc.

15. Be alert to problems, trends or situations that need attention; write down your observations, and communicate these to the programme coordinators on a regular basis.

Stage 5. Monitor effectiveness and contribute to continued programmatic development

16. Supply each household with self-monitoring forms and teach them how to use them.

17. Visit each household on a regular "route" about once a month to collect the self-monitoring forms and check how things are going.

18. Participate in a quarterly needs analysis and fine-tuning exercise, to develop new programme components such as a "compost bank" or "trouble-shooting tools".

19. Report on each cycle and begin a new cycle at least once, and preferably twice, per year.

20. Cooperate with municipal or NGO programme coordinators and support overall research, monitoring and evaluation.

Master composter as a development intervention

As part of its project portfolio, WASTE, Advisers on Urban Environment and Development (www.waste.nl), adapted and implemented the master composter approach (as a "best practice" in home composting) in three countries. A WASTE-supported master composter initiative was implemented in a Bulgarian village starting in 2007; and monitoring shows modest results in terms of waste separation, but also citizen involvement and awareness of the waste issue. Another master composter initiative also began in 2007 in Hambantota and Kalmunai, respectively Sinhala and Tamil-speaking regions of Sri Lanka. The approach was further introduced in Central America in 2010: in San José, Costa Rica, and in a group of eight periurban communities participating in WASTE's ISSUE 2 programme in Managua, Nicaragua.

Topoli, Varna County, Bulgaria

Implementation of the master composter approach in Bulgaria began in 2007, towards the close of a three-year MATRA project funded by the Dutch Ministry of Foreign Affairs to offer alternative approaches to environmental services in villages. About half the population in Bulgaria lives in villages, each consisting of 200 to 1,000 households (Scheinberg, 2007).

The MATRA project worked with self-provisioning in waste management through on-site composting of household organic waste, sometimes in combination with urine and animal manures. The goal for WASTE's Bulgarian master composter programme was experimentation and testing of an alternative model for waste management. The strategy was to carry out a small-scale experiment in the largest village in the MATRA project, Topoli, to investigate whether this approach would have potential as part of a village self-provisioning strategy in Bulgaria.

The programme started with 15 households. Participation increased in the initial months to about 40 households in that village, but failed to continue expanding beyond this number.

Hambantota, Southern Province, and Kalmunai, Eastern Province, Sri Lanka

In contrast, the goal for the Sri Lanka programme was more practical as it focused on improving the existing system. The plan was to work with local organisations to improve solid waste management through self-provisioning for 10,000 tsunami-affected households in two districts: 7,000 households in Hambantota in the Southern Province and 3,000 in Ampara District. Home composting bins had been distributed widely during the post-tsunami period, but without any training or support. The master composter programme was designed to test whether organised support could improve the performance and satisfaction rate.

The project provided basic training to the first group of master composters in two communities. The two groups were made up of representatives of meso-level organisations, institutions, or other entities in each location and 10 to 20 members of individual households. The aim was for each master composter to recruit 15-25 households to participate in composting within the first year, and 60-100 households by the end of the second year. The training could thus potentially set in motion home composting by as many as 2,000 households in each location within two years. In Hambantota, the project reached several hundred households within the first several years. It was less popular in Ampara District (Scheinberg, 2007), apparently due in part to the expectations created: Hambantota households wanted to improve their own situations, while those in Ampara District came to the training with the expectation that they would be able to earn income from selling compost. About a third of the mostly male participants in Ampara left in disappointment after the first day.

Maria Aguilar, San José, Costa Rica

The Costa Rican training brought together many environmental educators and community activists, and a small number of persons involved in raising worms for vermicomposting. The training was intended mostly for knowledge dissemination, since it was not connected to any specific community. The choice of composting bins focused on those which were simple to build and easy to transport. The group was made up of 30 per cent men and 70 per cent women. The men were more active in building the bins, and the women focused on learning how to manage the compost and disseminate information about the results.

Managua, Nicaragua

The training was given to participants from the host community and seven other nearby communities. It focused on direct improvement of neighbourhoods and the environment. By the second day most of the 25 women and girls and 10 men and boys had already decided whom they were going to recruit next. Participants from one community changed the structure of the whole training by demanding to be able to collect materials and actually started the composting process on day 3. This added a great deal to the training, as it provided an opportunity for the participants to understand practical differences between green and brown materials, and to see how much water to add when.

Conclusion

Master composter programmes appear to be a route to sustainable self-provisioning through the window of capacity development. Their success depends on many factors, including the target group's level of agricultural experience and knowledge.

While the three-day training creates enthusiasm and energy, and develops capacity, reinforcement and encouragement, as well as positive feedback for good results, are also needed to actualise the potential of the "each one reach one" approach.

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Notes

1) Organic waste makes up between 65 and 80 per cent of domestic waste in all but the US and Australian cities profiled in the 2010 UN-Habitat Third Global Report, Solid Waste Management in the World's Cities.

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Producing Organic Fertiliser from Urine-Diverting Dry Toilets in Dongsheng, China

Jan Mertens
Arno Rosemarin

Although batch composting of manure is very common throughout China at both large and small scales, there is little experience with composting of human waste in urban centres. This project, the first on thermal composting of human faeces under indoor controlled conditions, took place in a high-density urban setting in Dongsheng, Erdos Municipality in Inner Mongolia, China.

Composting of human faeces in an urban setting
Photo: Jan Mertens

The project aimed to close the nutrient loop, reduce environmental pollution, provide local farmers with organic fertiliser and improve the soil quality. It was part of a housing project carried out by the local Dongsheng government in collaboration with Stockholm Environment Institute. The first phase of implementation, which included 832 households, or about 3000 inhabitants, was used to train local workers to run the composting plant by themselves.

Urine-diverting dry toilets were installed and the faeces collected in basement bins. These were transferred periodically to an onsite composting facility built for this project. The composting was carried out using a batch technique in a building with six individual, 6 m^3 compartments, each with forced air supplied through small openings in the floor beneath the mass and supplemental floor heating. Temperature, moisture and pH were controlled, so optimal conditions were achieved, thus ensuring sanitisation and composting. The temperature was monitored twice daily and the moisture was controlled daily using a standard compaction method. Effective microorganisms including lactic acid bacteria, purple sulphur bacteria and yeast were inoculated at the start in order to optimise and reduce the compost cycle to 35 days. To sanitise the compost, the natural heat of the composting process itself was used. WHO Guidelines stipulate that 1-2 days at 65°C under controlled conditions is sufficient to kill all pathogens. Therefore, the main task was to reach this needed high temperature. Sawdust was added as an additional carbon source in order to help fuel the composting process. Although the temperature only reached around 61°C, this was sufficient for elimination of E.coli (which was used as an indicator) during a typical 35-day compost cycle.

The households added sawdust as a carrier and desiccant, prior to the composting step in order to regulate moisture levels and reduce odour. The result was a, more or less, pure faeces compost, which determines the fertiliser value. In comparison to animal manure, which contains urine, the nitrogen levels for the faeces-only compost were lower (2.43 per cent of dry mass), but the content of stable organic carbon was high (organic matter was 49 per cent of dry mass). Thus the faeces-only compost is a good source of organic carbon to act as a soil conditioner for water and nutrient retention. This is of particular importance in this part of China where soils are carbon deficient. The increased humus content enhances soil fertility by increasing organic carbon and better water retention. Large-scale agriculture trials, using the compost and urine from the households on potato and maize crops, showed good results.

The work showed that composting of human faeces can be carried out in an urban setting and the compost along with urine provides a competitive alternative to chemical fertiliser.

Content of the finished compost	
Moisture	32
	Percentage of dry mass
Organic matter	49
pH Value	7.3
Total nitrogen	2.4
Available N	0.8
Available P	0.2
Available K	0.2

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The Role of Urban Agriculture in Waste Management in Mexico City

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Agriculture in what is now Mexico City can be traced back to the great city of Tenochtitlán, one of the most important urban centres in Mesoamerica (Palerm, 1990). New forms of agriculture have recently emerged in and around Mexico City, which, like those in prehispanic times, can be categorised as urban ecosystems because the majority of the inputs are obtained from the bioregion.

Mexico City has an average altitude of 2,200 metres, a mild climate with temperatures from 18°C to 24°C and annual rainfall that ranges from 700 to 1,400 mm. The Mexico City Metropolitan Zone (MCMZ) covers an area of 7,860 km². This area includes the Federal District and 54 municipalities, which together have a population of 22 million (INEGI, 1990).

The area's principal production systems can be categorised as urban (family gardens and backyard milk and pork meat production), suburban (vegetables, flowers, backyard and kitchen gardens, greenhouses and dairy production), and periurban (on terraces - *nopal* production, kitchen gardens, corn, silvopasture, milk and dairy production, bees and sheep; and in the valleys - livestock systems, with extensive greenhouses, amaranth and *tuna*-prickly pear production).

Nopal is an important production system
Photo: H. Losada

The inputs for these different urban production systems are either household wastes or by-products from the city.

Organic waste

In general, low levels of external inputs are used. Solid organic waste is an important source of food for animals and comes from markets, restaurants or homes. The amount of solid organic waste obtained from local markets and from the city's metropolitan food supply depot (CEDA) is considerable. Occupying 300 ha, the CEDA receives 60 per cent of the national harvest and distributes fruit and vegetables to the markets in and outside Mexico City. Losada *et al*. (1996) estimated the daily organic waste production (in 1996) to be 725 tonnes. At least 90 tonnes of this waste was used to feed approximately 2,500 dairy cows in the vicinity (east of the city), which produced about 37,500 litres of milk per day. The tomato waste was especially used to feed (about 50,000) pigs, while other waste was used to feed chickens and rabbits.

Organic solid waste from the food processing industry (tortilla factories, *nixtamal* corn processing, mills, bakeries, cookie/cracker factories and others) is used in stables as a food source with a high starch concentration, as well as for backyard livestock (for the production of milk and meat) and pig farming. The latter two systems also receive organic solid waste products from homes. Grass from the sidewalks and traffic islands, constitutes a secondary source of fodder for the dairy stables in urban spaces.

In the suburban and periurban zones, fresh or dry dairy cattle manure serves as an excellent input for agricultural activities. It is a good source of organic material, macronutrients (N, P, K) and water, and it protects crops against low temperatures. The latter two benefits are of particular importance in *nopal* cultivation on terraces. In the suburban *Chinampa* system and in the periurban valleys, excreta in dried form (20 per cent water) is used as compost (*Chinampa*) or added directly to the crops (corn). Unpublished data from Losada et al. (2000) show that the amounts of excreta used are equivalent to 730 tonnes per/ha/year in the *Chinampa* zone, 540 tonnes/ha/per year in the *nopal* zone and 50 tonnes/ha/year in the *tuna* (prickly pear) zone. Plant residues from *nopal* production (14 tonnes/ha/year) serve as an important input in the terraced area during the pruning season (March, April and May). In all cases the waste is obtained for free; only transport needs to be paid for.

Low levels of external inputs are used
Photo: H. Losada

Mass and energy flows

Other external inputs need to be considered in the city' s energy balance (see also the next article). In the more advanced dairy systems these include externally acquired pregnant cows, medicines, semen (for artificial insemination), high-protein foodstuffs, mineral salts, vitamins and other supplements. In more commercial agriculture these are seeds, inorganic fertilisers, herbicides and insecticides, and material for the greenhouses.

Labour input is generally more intense in the production of vegetables, legumes, flowers and *nopal* (both in the *Chinampa* and terrace systems; Canabal and Torres, 1992) than in the livestock systems (with some exceptions, such as in stables). Water and energy use, however, is higher in livestock systems. The higher use of gasoline and transport for agricultural products results from transporting manure from the stables to the field and the harvested products to the market.

The waste consumed by the animals in urban dairy farms is predominantly local and the waste excreta coming from stables and pig farms forms an important input for agriculture in the suburban and periurban zones. Energy balances in these urban systems are not optimal. Research on *nopal* production (Losada *et al.* 1996) shows different degrees of efficiency in the capture of energy as well as in the use of macronutrients.

In contrast to conventional production systems that are highly dependent on non-renewable sources and fossil fuels, the energy and macronutrient flows in these urban and periurban systems depend on inputs of biological origin, which constitute a renewable resource. These systems also have a positive medium to long term positive effect on soil formation.

Urban agriculture

New urban production systems in Mexico City, such as the *Chinampa* system (which is considered more diverse -see the next article-) and the terraced (*nopal* vegetable) and *tuna* (Teotihuacan) production systems are well adapted to the urban environment. They make optimal use of local inputs, use local wastes as a source of nutrients and are interlinked. Like any production system, these systems need proper management (especially in the dairy systems the odour produced and the presence of flies need to be controlled), but they pose relatively little danger to the urban environment.

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Energy Balance in a Suburban Chinampa Agroecosystem in the Southeast of Mexico City

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The *Chinampa* agroecosystem is a very diverse sub-urban production system (Jiménez et al., 1990, Losada et al. 1998) in Mexico City. Soriano (1999) described the whole *Chinampa* system as composed of five interlinked subsystems (*Chinampa* plots, dairy cattle units, backyard production, home gardens and greenhouses). A summary on an evaluation of energy flows and energetic efficiency of the *Chinampa* system is presented here.

Agricultural energetics involves the analysis of energy flows from all inputs and outputs of a crop or an animal production system, most often emphasising the efficiency of interlinked production subsystems. Usually an input-output ratio is calculated as an indicator of the production efficiency of a given product. It can also be used as an indicator of sustainability (Senanayake, 1991): the lower the energy ratio, the more expensive the system. The analysis of any production system depends on the boundary adopted. Energetic evaluations are important because they highlight the depletion of non-renewable sources of energy and the increasing effect this has on prices.

Four *Chinampa* subsystems and three dairy subsystems were analysed. Data on inputs and outputs was collected through interviews with the owners. The energy values of the different inputs and outputs of both sub-systems were determined using standard energetic values (Mega Joules per kg) from different literature sources, or were estimated using vegetables of similar chemical composition. The study looked at the energy required for the production of chemical fertilisers, improved seeds (a high percentage of seeds are locally produced), and feed for animals. Manure was considered to be an input to the *Chinampa* plots and an output for the dairy units. Maize is locally produced, hence only its energetic value was considered and not the energy invested in its production.

Among those studied, the most efficient production system turned out to be a dairy unit owned by Roberto Peña (RP in the table), while the *Chinampa* plots were less efficient. The most important factor affecting the efficiency was the use of external inputs, which increased the energy consumption. As manure is exchanged between the two sub-systems, modifications in the energy balance accordingly showed better energy ratios for the *Chinampas*.

Vegetable production in the *Chinampas* is a low-energy system. The use of local seeds and organic fertilisers accounts for important savings of energy because these inputs do not require extra energy to be produced. *Chinampa* production units that used their own materials (internal inputs) were more efficient, hence, the sustainability of *Chinampa* agriculture depends on the system itself, i.e. on the use of the units' own wastes or recyclable materials.

The use of industrial by-products in milk production improves the efficiency of the dairy systems. Considering manure as an output rather than as a waste gives another dimension to the efficiency of such sub-systems. The use of industrial by-products (wheat bran, milled maize, maize dough, oats straw) is desirable in energy terms, since this uses energy sources that would otherwise be wasted.

Modified energy ratio in the seven production units studied.

	Chinampa plots				Dairy units		
Prod. unit	FR	SF	MF	H	AN	AS	RP
E. Ratio (I/O) MJ input/MJ product	122.48	26.06	3.9	31.9	0.54	1.011	0.19
Energy ratio modified	32.14	8.5	1.5	8.6	4.78	6.01	1.75

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Food Security and Productive Sanitation: Practical guideline on the use of urine in crop production

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The upcoming publication titled *Practical guideline on the use of urine in crop production* gives practical guidance on the use of urine in crop production as a vital component of sustainable crop production and sanitation systems. It also includes guidance on how to initiate activities that will facilitate the introduction of new fertilisers to the agricultural community.

The ecostation in sector 19
Photo: Linus Dagerskog, CREPA

The guideline was a collaborative effort of several international organisations and institutions active in the field of sustainable sanitation and agriculture under the aegis of the Sustainable Sanitation Alliance (SuSanA) working group on Food Security and Productive Sanitation led by the Stockholm Environment Institute (SEI). The guideline is directed towards the donor community and decision makers, extension workers and other professionals active in the areas of agriculture, water and sanitation, planning and the environment. The main target group, however, is professionals in the agricultural sector.

The use of urine as a fertiliser can help mitigate poverty and malnutrition, and improve the trade balance of countries importing chemical fertilisers. Food security can be increased with a fertiliser that is available free for all, regardless of logistic and economical resources. Safe handling of urine including treatment and sanitisation before use is a key component of sustainable sanitation as well as sustainable crop production.

Consumed plant nutrients leave the human body with excreta, and once the body is fully grown there is a mass balance between consumption and excretion. This has three important implications:

- The amount of excreted plant nutrients can be calculated from the food intake, for which data is better and more easily available than for excreta.
- If all excreta and biowaste, as well as animal manure and crop residues, is recycled, then the fertility of the arable land can be maintained.
- Irrespective of the amounts and concentrations of plant nutrients in the excreta, one important fertilising recommendation is thus to strive to distribute the excreta fertilisers on an area equal to that used for producing the food.

Source separation and safe handling of nutrients from the toilet systems is one way to facilitate the recirculation and use of excreta in crop production. Urine contains most of the macronutrients as well as smaller fractions of the micronutrients excreted by human beings. Nitrogen, phosphorus, potassium and sulphur as well as micronutrients are all found in urine in plant available forms. Urine is a well balanced nitrogen-rich fertiliser which can replace and normally give the same yields as chemical fertiliser in crop production (see the other articles in this issue for examples).

The urine from one person during one year is sufficient to fertilise 300-400 m^2 of crop to a level of about 50-100 kg N/ha. Urine should be handled in closed tanks and containers and should be spread directly onto the soil, not on the plant, in N doses equivalent to what is recommended for urea and ammonium fertilisers. At a small scale, plastic watering cans are suitable for spreading the urine, while at larger scale, spreaders for animal slurry are suitable. Air contact should be minimised in order to avoid ammonia losses; and the urine should be incorporated into the soil as quickly as possible.

Ouedraogo Ablassé at the ecostation in sector 27 with some solid and liquid fertilizer by the storage chambers for dried faeces
Photo: Linus Dagerskog, CREPA

The economic value of the urine can be calculated by comparing it to the price of mineral fertiliser on the local market or by calculating the value of the increased yield of the fertilised crop. Calculations in Burkina Faso show that the annual amount of plant nutrients in the excreta from one family is roughly equal to the quantity in one 50 kg bag of urea and one 50 kg bag of NPK (see the next article). The value of this per person is approximately USD 10 , while the value of the increased yield of maize is approximately USD 50 per person. The value of a 20 l jerrycan of urine was estimated to be USD 0.25 .

Health risks associated with the use of human urine in plant production are generally low. Source separation of urine is a strong barrier against pathogen transmission since most pathogens are excreted with faecal matter. The amount of faecal cross-contamination is directly related to the health risk in the system for urine use in crop production. Collection systems for urine should be designed to minimise the risk of faecal cross-contamination. Groups that are potentially at risk are collection personnel and field workers, households, local communities and product consumers. The possible health risks of other contaminating substances excreted with human urine (heavy metals, hormones and pharmaceuticals) are far smaller than those associated with the common sanitation system; and the risk of negative effects on the quantity and quality of the crops is negligible.

The *WHO guidelines for safe use of wastewater, excreta and greywater* (2006) promote a flexible multi-barrier approach for managing the health risks associated with the use of excreta in agriculture. This concept is comprised of a series of measures/barriers from 'toilet to table'. Each of the barriers has a potential to reduce health risks associated with the excreta use. WHO recommends that several of these barriers be put in place as needed to reduce the health risk to an acceptable minimum.

Barrier concept for safe use of urine as a fertiliser

Barriers include for example storage, crop restrictions, withholding periods and reduced contact, correct handling and cooking of the food crop. The *Practical guideline on the use of urine in crop production* gives examples of how urine can be handled safely to minimise the risk of pathogen transmission, as outlined in the WHO guidelines for safe use of excreta in crop production.

Institutional aspects are increasingly important as productive sanitation systems become mainstream. A challenge is to integrate the use of excreta in existing regulatory frameworks. Initially, the following activities are suggested when productive sanitation systems are implemented:

- Identify stakeholders and clarify drivers and restrictions for each one in relation to the implementation of urine use in crop production.
- Include and target the farmers in the initial planning.
- Organise an arena for feed-back and interaction between stakeholders,
- Organise local communities so that there is a structure for implementation and a structure for monitoring.

Knowledge on the use of urine as a fertiliser is best gained and disseminated through local demonstration experiments involving organisations that work with small-scale farmers and local communities as well as local research organisations. The new fertilisers should be introduced with the same methodology that is used when introducing any new fertiliser in the agricultural community.

To implement a productive sanitation system in a local context, it is often necessary to translate or adapt the information given in the *Practical guideline on the use of urine in crop production* to the respective local site conditions. The last chapter of the book gives recommendations on how local guidelines can be developed and reasonably structured and it summarises the most important factors that directly or indirectly influence the farming activities related to the urine use. This information is complemented by examples of existing local guidelines from Burkina Faso and the Philippines.

The Practical guideline on use of urine in crop production is published in 2010 and available from the EcoSanRes and SuSanA web pages www.ecosanres.org, www.susana.org

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The Emerging Market of Treated Human Excreta in Ouagadougou

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Since March 2009, there has been a "human fertiliser" market in Ouagadougou, the capital of Burkina Faso. Human urine and dried faeces are collected and taken to eco-stations, where they are sold to farmers after adequate storage. In this way they increase sanitation coverage, create jobs in the private sector and provide urban farmers with complete and efficient indigenous fertilisers.

The technical, social and institutional problems around an excreta-recycling system at scale may seem daunting, especially for rapidly growing cities in the developing world. Bracken (2008) describes the massive amount of nutrients brought into cities with the food (also see the article on page 8). In a sustainable society these nutrients are recycled back to productive land. Today they often accumulate in deep-pit latrines and septic tanks with the risk of leaching to groundwater together with pathogens. No explicit price can be calculated for wasting nutrients and spreading pathogens through poor excreta management, but this approach does have dire effects in terms of soil fertility loss, increased disease burden and eutrophication. In the absence of political pressure, the market could be an important driving force for the recycling of human excreta. Especially within the context of unpredictable chemical fertiliser prices, exemplified by the price hike in 2008, treated human excreta can provide a reliable nutrient source for agriculture in and around cities.

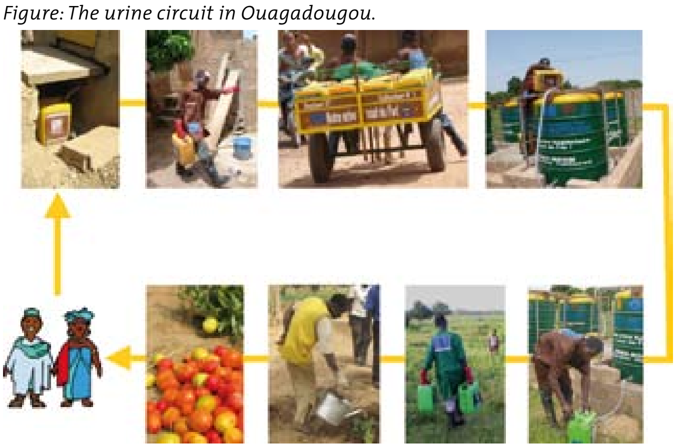
Urban households want a toilet that is comfortable and reliable, but they have in general no interest in using the excreta as a fertiliser. This is why a collection service is needed, providing the link between households and the urban farmers. Such an integrated ecological sanitation (Ecosan) system has been set up in four sectors of the city of Ouagadougou, through the project ECOSAN_UE.

Transport of urine to the fields, Storage of urine and Urine application in Ouagadougou
Photo-: Linus Dagerskog, CREPA

The European Union financed the ECOSAN_UE project, which operated from 2006-2009 and was implemented by CREPA (Regional Center for low cost Water and Sanitation), GTZ (German Technical Cooperation) and ONEA (National Water and Sanitation Authority). The project is active in four out of Ouagadougou's thirty urban sectors, where many urban agriculture activities take place.

Three main components of the eco-sanitation chain in Ouagadougou will be discussed here, starting at the end: the **use** of treated human excreta. It will then look at the **collection and treatment**, and lastly at the **production** of human fertilisers.

Figure: The urine circuit in Ouagadougou.



Use

Even before construction of the toilets began in 2006, efforts were being made to sensitise urban farmers with respect to the value of urine as a fertiliser. This was necessary because if there was no interest in the end product, the whole chain would surely fail. The promotion was based on participative experimentation using urine as a fertiliser in each of the four sectors. The urine had been collected with mobile urinals during a film festival. In a first wave, 70 urban farmers applied urine and compared it to urea on test plots with NPK as base fertiliser (see Bonzi, 2008, for results). Yields of the plots using NPK and urine were higher. Urine was dosed based on its nitrogen content, which was around 5 g/l in Ouagadougou.

Since then, 600 urban farmers have been trained on the use of urine as a fast-acting nitrogen fertiliser, and to a certain extent also on the use of sanitised dry faeces as base fertiliser. The training is based on practical knowledge concerning soil preparation, application period, application method and dose for different plants, and also on safety measures for the plants, farmers and consumers.

In March 2009 an evaluation workshop was held with urban farmers from the four sectors to decide on the transition from "free" human fertilisers to a fertiliser market. The price of liquid and solid fertilisers was based on the NPK content compared to the cost of an equivalent amount of nutrients as chemical fertiliser. Based on earlier calculations by Dagerskog (2007), the work of Jönsson et al. (2004), and considerations that human fertilisers contain organic material and trace elements but also demand more work both in transport and application compared to chemical fertilisers, a reasonable price was set at USD 0.20 per jerry can of hygienised urine and USD 0.10 per kg of hygienised faeces (sold in 25 and 50 kg bags).

The interest in buying Ecosan fertiliser depends largely on the price of the chemical fertilisers, but there are also convinced adopters like Mr. Dera Mouni (see Box).

Dera Mouni, urban farmer for the past 25 years

In the beginning I was a bit sceptical, but after the training first at CREPA and then here in our own fields I was convinced. The liquid fertiliser gives very good yields.

For the last crop cycle I bought the liquid fertiliser for my cabbage, but this cycle I will grow peppers as well. Peppers respond very well to liquid fertiliser. It is true that I have to invest some more when using the liquid fertiliser. For one plot of 40 m2, I usually apply manure and then 2 kg of urea. The urea costs me around USD 1. With the urine I use around 10 jerry cans, which costs me USD 2 and is also heavier to apply. In return I have fewer problems with insect attacks, and the yields have been great. What I harvest from one plot I can usually sell for USD 50.

Of the 16 farmers who participated in the fertiliser tests on this site I am the only one as far as I know who now buys the liquid fertilisers. Many farmers don't see tomorrow. In order to get them to buy liquid fertiliser, the cost has to come down a little bit more. Once they have gotten used to it, the price can be increased again! I think this system has a future, because the chemical fertilisers kill the soil in the long term, and we know that. The liquid fertiliser is new for us. Regarding the solid fertiliser (sanitised faeces) it will be easy to sell. The treated faeces looks like the manure we are used to.

Collection and treatment

In each sector a collection system managed by a local association was set up. The association collects and transports urine and dried faeces from households to eco-stations, where it is stored for further sanitation. The urine is collected in yellow containers, and stored in tanks for sanitisation. After storage it is tapped into green jerry cans, with the label "Liquid Fertiliser". The sanitised faeces are put in bags labelled "Solid Fertiliser". The associations managing the collection and treatment would ideally cover their own running costs by selling the fertilisers to farmers, as the theoretical cost/benefit analysis shows (see Box).

Cost/benefit

The income depends on the amount of urine and faeces that enters the system and is then sold to farmers. The following calculation was based on the estimation that 40 per cent of the urine and 75 per cent of the faeces produced by a household actually enters the system.

The cost for transport and treatment is about USD 2.30/household/month. A benefit could be obtained of USD 2/household/month from selling the excreta and USD 0.3/household/month from a household collection fee (the fee is USD 0.6/household/month, but the cost for collecting it is USD 0.3/household/month). The costs referred to are only operating costs for the collection and treatment. They do not include investment and depreciation costs for equipment, especially urine storage tanks. These costs need external funding.

Thus, theoretically the associations involved in collection/treatment could cover their operating costs, but this requires that the following operating criteria be fulfilled. In the actual situation, after a year of functioning, none of these criteria were completely fulfilled as of yet.

1. *Excreta volume*: At least the above estimated amount of urine and faeces per household has to enter the system. However, it takes time before the faeces from double vault toilets can enter the system, simply because the first vault is emptied after one year, at the earliest. Also, in practice, less urine from the households enters the system than was predicted. Not all the households with toilets actually use them – some toilets have been built on new lots, which are not yet inhabited; other households stopped using the toilets in anger over the collection fee. In addition, when urinating, many people find it more convenient to use the traditional shower than the toilet.
2. *Fee*: The households have to pay the collection fee. However, about 50 per cent of the households do not pay the fee.
3. *Scale*: The collection system has to operate at full capacity. However, it did not do so in all sectors of the city.
4. *Storage*: There has to be sufficient storage capacity at the eco-stations to handle the volume generated per household in the system. The present storage capacity would not be enough for the "estimated volumes" of urine at the eco-stations. Based on the estimated production of urine and

Double vault toilet with adobe brick superstructure (~340 $)
Photo: Linus Dagerskog, CREPA

A Yellow Revolution in Aguié, Niger

Linus Dagerskog (CREPA), Laurent Stravato (IFAD) and Elisabeth Kvarnström (SEI)

Human urine is collected and used as a liquid fertiliser by more than 700 households in the Aguié province in southern Niger. The "yellow revolution" was triggered in 2009 through participative tests in eight villages, demonstrating the effects of using urine as a fertiliser on cereals and vegetables.

PPILDA [1] is a USD 17.6 million rural development project in Aguié supported by IFAD [2]. One of the main activities is identifying and supporting local innovations in farming communities, often via farmer field schools. In 2007, PPILDA constructed wells around several villages to enable vegetable farming during the dry season. Organic fertilisers were used, but not enough was available to cover the needs, while the chemical fertilisers available in Aguié, mainly urea and NPK 15:15:15, are costly and of poor quality. Looking for alternatives, PPILDA contacted CREPA[3] to see how productive sanitation could improve local nutrient management. It was estimated that the annual quantity of plant nutrients in human urine and faeces produced by an average family in Aguié (9 persons) is roughly equivalent to one bag of urea (50kg) and one bag of NPK (50kg). Two such bags cost around USD 80 on the local market, which is more than most families can afford. It is also known that urine contains the majority of the nutrients leaving the human body, while rarely containing pathogens.

On this basis IFAD granted a pilot project for CREPA, PPILDA and SEI [4] to test the use of urine as a fertiliser and develop sensitisation tools, low-cost appropriate technologies and strategic documents in order to facilitate an upscaling of productive sanitation. The Aguié project promotes productive sanitation via participative agriculture experimentation, sensitisation to the dangers and resources in urine and faeces and the promotion of low-cost reuse-oriented urinals and latrines, adapted to the cultural context. For fertiliser collection, the "no-cost" Eco-lilly urinal [5], a 25-litre plastic jerry can and a funnel, is promoted together with low-cost versions of urine-diverting dehydration and composting toilets (which are subsidised with USD 45). The central message is that proper use of these urinals and latrines helps eliminate the dangers and capture the resources in urine and faeces. Thanks to good yields and good-looking vegetables, the demand has been high for urinals and toilets that make the collection of the "new fertiliser" possible.

In the future it is probable that this kind of close collaboration between sanitation and agriculture professionals will increase, since maintaining or increasing yields will demand the optimal use of all available nutrient sources. And the demand for fertilisers could in turn be the motor for sanitation in periurban and rural areas.

The Aguié project results and tools are available on www.ecosanres.org/aguie.

Notes

1) Projet de Promotion des Initiatives Locales pour le Développement à Aguié
2) International Fund for Agriculture Development
3) Centre Régional de l'Eau Potable et de l'Assainissement à faible coût
4) Stockholm Environment Institute
5) In Aguié this urinal costs USD 2-3. While urine collection is easy, the storage of large volumes is a challenge. Enriching composts and incorporating urine in the field during the dry season can be alternatives to storage.

faeces, the eco-stations must be able to store 200 l of urine (45 days storage + some buffer volume) and 40 kg of faeces (three months extra storage on site + some buffer volume) per household. This could become a major obstacle in the future, as it is not clear yet who will take on the cost for increased storage volumes. The local cost of a high-quality storage tank of 1 m^3 is around USD 300, corresponding to USD 60 per household.

5. *Reuse demand*: There must be a demand for all the excreta entering the system. But so far, the demand for urine has not been very high. Some farmers have bought large quantities, but the urban farmers' willingness to pay has not been up to expectations, partly because of the transporting cost from the eco-stations to the farm-site (around USD 0.05/jerry can).

Production

In Ouagadougou only 19 per cent of the population has access to improved sanitation, like connection to sewers, septic tanks or improved pit latrines. The common pit-latrines in Ouagadougou have several problems. In addition to the risks of groundwater pollution and nutrient losses from infiltration, there are also flies, odours, risk of collapse and difficulties in emptying the pits. There is not yet a system for sludge treatment in Ouagadougou, which means the sludge is informally dumped in and around the city.

To provide an alternative, the project promoted the Urine Diverting Dry Toilet (UDDT). When urine and faeces are kept separate, there are generally fewer problems with odours and flies, the treatment is relatively easy and nutrient losses are prevented. The toilets are built off ground to protect the groundwater and enhance the dehydration of the faecal matter. A range of models with single or double vaults in different materials was available for the households to choose from. In the course of the project several lessons were learned and adaptations made.

Single vault integrated into the house (variable cost)
Photo: Linus Dagerskog, CREPA

Discussion

The project has succeeded in raising awareness on urban excreta and nutrient management in Ouagadougou, and ONEA is planning to continue the toilet constructions in the four pilot sectors. If the collection system continues to grow, it will be necessary to know how much excreta urban farmers potentially can use. Sawadogo (2008) therefore made an inventory of urban farming within Ouagadougou city limits and found in total 201 hectares, 93 per cent of which is dedicated to vegetable farming and 7 percent to horticulture. However, he also found that more than 75 per cent of the urban farmers do not have rights to the land they farm. These urban farmers would only have use for a small part of all the excreta produced in Ouagadougou (less than 5 per cent). The rest would need to be transported to agricultural land outside the city.

This means that, if the authorities decide to adopt ECOSAN on a large scale, agricultural production using sanitised excreta needs to be made a priority in and around the city to avoid high transportation costs. In the case of Ouagadougou, the scarcity of water during the dry period will limit the expansion of urban vegetable farming in the city. Water saving technologies, such as drip irrigation, and the potential of greywater recycling can be explored. It is, however, clear that a large part needs to be applied in rain-fed cereal production.

A related problem is the storage of large volumes of urine until the time of application in the rainy period. All together the population of Ouagadougou generates around 525,000 m3 of urine per year, amounting to 1.2 l of urine per person per day! Simple methods of reducing the volume of urine without losing nitrogen would be of great value. The alternative to storage could be to apply the urine to the land during the dry period, or use it as a nitrogen source for composting.

As it stands now, external funding is necessary to support part of the operating costs of the associations. From 2010, the municipality will take over the coordination and financial support of the system. Instead of paying the associations directly, the subsidy might be more efficient if targeted to the end of the chain, linking it to each jerry can or bag of fertiliser sold and applied in farming. The incentive to sell the fertilisers would then become even greater, and the associations would be stimulated to improve their marketing. It will also be important to have a municipal strategy for what to do when demand does not meet supply, and how to use the excreta elsewhere.

The EcoSan circuit painted on the entry door to the ecostation
Photo: Linus Dagerskog, CREPA

A woman from Saja Manja applying the liquid fertilizer
Photo's: Linus Dagerskog, CREPA

The new Ecosan system in Ouagadougou is by no means ideal, but it has taken some innovative steps in urban nutrient management. The experiences show that the operating costs of collection and treatment can almost be recovered by the sale of treated excreta, if the distances to be covered are relatively short. Public funding is needed for investments in and control of the system, and to a certain extent for running costs, at least in the short term. It is always difficult to mobilise scarce public funds, but if the gain in health and environmental protection could be evaluated in addition to the mentioned agricultural benefits, it would probably prove to be an economically sound public investment.

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Introducing Urine as an Alternative Fertiliser Source for Urban Agriculture: Case studies from Nigeria and Ghana

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Adeoluwa Olugbenga
Philip Amoah

If human urine is properly collected and used for agriculture, it contributes to improved environmental sanitation in cities and reduces the costs of crop production. The innovation lies in the integration of agriculture, environment and sanitation sectors.

Although there is as yet no record of urine collection for commercial agricultural use in Ghana and Nigeria, on-station experiments in some universities show promising results. Factors such as transport logistics, financial feasibility and to investigate the farmers' and consumers' perceptions about using urine for vegetable production influence the adoption of urine as a fertiliser in agriculture.

In Ibadan, Nigeria, RUAF partners implemented a project on urine use among a group of young urban vegetable farmers. Likewise through the EU-funded SWITCH programme, a similar demonstration and research study was implemented in Accra, Ghana. In both cases, the objective was to introduce urine use to urban vegetable producers through participatory action research, training and demonstration, and to investigate the farmers' perceptions about and the feasibility of using urine in their farm locations.

Ibadan

With a population of about 2.5 million people, Ibadan is one of the largest cities in Nigeria. About 200 farmers are active in the target urban and peri-urban site in Ibadan, producing mostly vegetables, such as green amaranths (Amaranthus caudatus), jute melo (*Corchorus olitorus*) and sometimes fluted pumpkin (*Telfaria*).

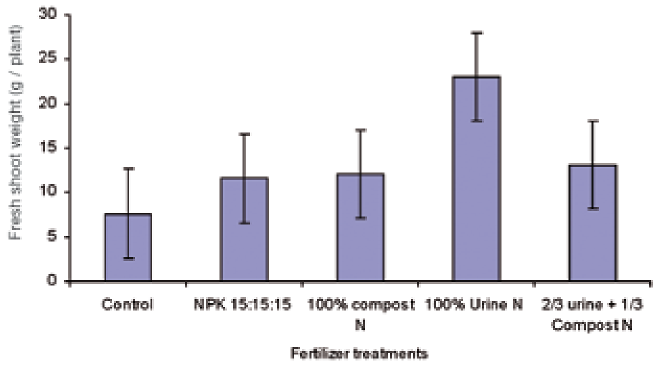
This study was carried out at the vegetable production site in the army barracks of Ibadan North West Local Government Area, Mokola. Temperatures at this site range from 21°C to 31°C and average, bimodal, annual rainfall is 1,280 mm.

Individual interviews were carried out with 161 people in the community (60 farmers and 101 marketers), who were asked about their perception on urine use for crop production. The participants were shown planting demonstrations involving the production of green amaranths using fertiliser treatments at the rate of 100 kg N / ha. The various treatments and the results are given in the figure). The required amount of fertiliser was based on nitrogen composition of the fertiliser materials.

Urine was collected in plastic containers from the male hostel of the University of Ibadan, which is about three kilometres from the farm location. The collected urine was stored airtight for a month before being used (more information: AdeOluwa et al., 2009).

Most respondents were not aware of the possibility of using urine as a fertiliser, and many of them perceived urine use as a good agricultural innovation, 20 per cent of the farmers and 26 per cent of consumers cited cultural norms as a constraint to urine use. Another 26 per cent of the farmers and 38 per cent of the consumers had specific religious objections to urine usage. Nevertheless, many responded that they would use urine for vegetable production if it gives a better yield than other forms of fertiliser, and most consumers would buy vegetable crops grown with urine if it did not pose any health threat.

Using urine rather than conventional mineral fertilisers significantly increases the yield of *Amaranthus caudatus*, (one of the most common vegetables in Nigeria) and could thereby also increase farmers' income. Microbial analysis of harvested vegetables did not show any significant difference in microbial contamination between the differently treated produce.



Effects of fertiliser treatments on fresh weight yield of green amaranths at 4 weeks after planting at Mokola, Ibadan. (source: Adeoluwa 2010)

Accra

Accra, like Ibadan, is experiencing rapid population growth and agriculture is becoming a clear feature in the urban fringes. It is one of ten demonstration cities under the EU funded Project "Sustainable Urban Water Management Improves Tomorrow's City's Health (SWITCH)", one component of which is developing options to effect improvements in agricultural production and other livelihood activities using freshwater, storm and wastewater (see also UA-Magazine no. 20 or www.switchurbanwater.eu).

Testing of urine application and co-composting products in Accra
Photo's: René van Veenhuizen

It is estimated that up to 90 per cent of fresh vegetable consumption in Accra comes from intensive production within and around the city. To maintain soil fertility the farmers often use poultry manure and chemical fertilisers. The high cost of these fertilisers is becoming a constraint to farming activities in the city. Hence alternative sources of nutrients are welcome and could enhance productivity.

Meanwhile, 95 per cent of the city's populace uses on-site sanitation facilities (public toilet, bucket latrines, septic tanks) as the main means of sanitation, making these places potential sources of nutrients and organic matter production for urban agriculture in Accra. Many public urinals are located within some of the most densely populated residential areas and public places, and are not subject to proper collection and management. Consequently urine from the urinals is discharged directly into the drains flowing into the lagoon, resulting in pollution. A study carried out (Cofie et al., 2007) on 14 urinals located within the Central Business District revealed that 7.3 m^3 of urine is generated per day. This is approximately 2,200 m^3 of urine per year. In terms of nitrogen content this volume represents 6.6 tonnes of plant available nitrogen. As part of the SWITCH project IWMI collaborates with Safisana, a private entrepreneur, to introduce urine as a fertiliser to farmers. The entrepreneur manages the transport of urine from the urinals to the farm, while IWMI conducts the necessary research investigation.

Like in Ibadan field trials were set up at Dzorwulu vegetable production site in Accra to determine the effect of urine and other fertilisers on the yield of cabbage. In addition, training and sensitisation was undertaken with urban farmers, extension staff of the Ministry of Food and Agriculture (MoFA), Ghana, and other key stakeholders, about the possible benefits and risks of using human urine as an alternative source of fertilisation. As part of this programme, a seminar was organised for the extension staff of the Ministry of Food and Agriculture (MoFA) at La in Accra, followed by a meeting with about 42 farmers from Dzorwulu, Plant Pool and Ridge, in Accra. Two presentations were made for the farmers and extension staff. To encourage a better understanding of the issues discussed, coloured photographs (showing farmers from other parts of the world, crops fertilised with urine and without urine, crops treated with urine and other forms of fertiliser, etc.) were shown to the farmers. On both occasions question and answer sessions followed the presentations.

The field trials at Dzorwulu area showed similar results (Adamtey *et al*, forthcoming) as in Ibadan. The farmers and the extension staff of the Ministry of Food and Agriculture expressed different concerns on the use of urine in crop production. Among the issues raised by farmers were: how urine can be supplied on a regular basis, how to get storage facilities for the volume of urine to be supplied, the mode and rates of application for various crops and for different soil types (especially sandy soil), the effect of urine on soil characteristics, e.g. soil salinity. The extension staff on the other hand were concerned about the possibility of collecting urine, how to reduce the potential risk associated with urine before use, guidelines on the use of urine, willingness of farmers to use urine as an alternative source of fertiliser, the hygienic quality of crops produced with urine and consumers' readiness to accept and consume such products. In spite of the numerous concerns raised by both farmers and the extension staff of the Ministry of Food and Agriculture, the idea of using urine in crop production was highly welcomed. Participants from both groups expressed an interest in seeing how urine is used and its effect on crops.

Olufunke Cofie, Adeoluwa Olugbenga and Philip Amoah
International Water Management Institute, Accra, Ghana
Email: o.cofie@cgiar.org

Urine storage tanks at the testing site in Accra
Photo: René van Veenhuizen

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AdeOluwa, O.O., G.O. Adeoye and S.A. Yusuff, 2009. Effects of organic nitrogen fortifiers on some growth parameters of green amaranths (Amaranthus caudatus L.). Renewable Agriculture and Food Systems: 24(4); 245–250.

Cofie, O. O. and Drechsel, P. (2007) 'Water for food in the cities: The growing paradigm of irrigated (peri)-urban agriculture and its struggle in sub-Saharan Africa', *African Water Journal*, vol 1, no 2, pp23–32

Adeoluwa, O. 2010. UNLOCKING THE WEALTH IN HUMAN URINE AS SAFE FERTILIZERS FOR FARMING IN IBADAN CITY. Project Technical Report submitted to IWMI. 50p

Books
further readings

African Urban Harvest Agriculture in the Cities of Cameroon, Kenya, and Uganda

Prain, Gordon, Nancy Karanja and Diana Lee-Smith, Editors
A co-publication with the International Development Research Centre and the International Potato Center through Urban Harvest. Forthcoming: Available August 2010, ISBN 978-1-4419-6249-2

Crop cultivation and livestock- raising have long histories in urban Africa, as in other areas of the world, but broad awareness among researchers and policy makers of either the history or the contemporary facts of life in African urban development is much more recent. Based on evidence from studies conducted in Eastern and Central Africa, this book draws out implications for practice, policy, and further research throughout the developing world. Featuring research undertaken in several cities in Cameroon, Kenya, and Uganda, the authors present an in-depth analysis of urban agriculture, livelihoods and markets; urban ecosystem health; and the kinds of policy and institutional change related to urban agriculture that have been achieved in the three countries through the partnership platforms and stakeholder dialogue established in the participating cities (see article in this issue on page 17).

Wastewater Irrigation and Health: Assessing and mitigating risk in low-income countries

Drechsel, P.,Scott, C.A., Raschid-Sally, L., Redwood, M., Bahri, A. (editors) (2009)
Earthscan www.earthscan.co.uk;

Free dowload at:
www.idrc.ca/en/ev-149129-201-1-DO_TOPIC.html

This book approaches the problem of non-functioning wastewater treatment systems resulting in risk to public health because of poor quality water being used for irrigation, from a practical and realistic perspective. It addresses the issue of health risk assessment and reduction in a developing country setting, establishing a connection between agriculture and sanitation. It "represents the best, modern innovative thinking on the topic and symbolises an important turning point in the history of wastewater reuse in irrigation as a major contributor to water and nutrient conservation, public health and welfare." *(Professor Hillel Shuval, Hadassah Academic College and Hebrew University, Jerusalem)*.

Practical guideline on the use of urine in crop production: the Sustainable Sanitation Alliance (SuSanA) working group on Food Security and Productive Sanitation

Stockholm Environment Institute (SEI). Forthcoming 2010

This guideline is directed towards the donor community and decision makers, extension workers and other professionals active in the areas of agriculture, water and sanitation, planning and the environment, especially professionals in the agricultural sector. It gives practical guidance on the use of urine in crop production as a vital component of sustainable crop production and sanitation systems. It covers key aspects of how to use urine as a fertiliser in productive sanitation systems and also includes guidance on how to initiate activities that will facilitate the introduction of new fertilisers to the agricultural community (see article in this issue on page 41).

Decentralised Composting for Cities of Low- and Middle- Income Countries: A users' manual

Rothenberger, S, Zurbrugg, C., Enayetullah, I. and Sinha, A.H.M.M. (2006)

This book is about converting organic waste into a resource. It is based on Waste Concern's experience in implementing several decentralised composting projects in Dhaka and replicating them in Bangladesh and other Asian cities. This manual provides step -by- step guidelines on how to initiate a decentralised composting project in a developing country. These include identifying stakeholder interests and preparing a business plan; developing a collection system; the design, construction, operation and maintenance of a composting facility; and the actual marketing of the compost. http://www.eawag.ch/organisation/abteilungen/sandec/publikationen/publications_swm/downloads_swm/decomp_Handbook_loRes.pdf

Greywater use in the Middle East, Technical, Social, Economic and Policy Issues.

Edited by Stephen McIlwaine and Mark Redwood. Practical Action Publishing. 2010. 208 pages. Paperback. ISBN 978 1 85339 698 4

In water scarce areas of the Middle East, greywater (which is household wastewater excluding toilet waste) is commonly used by poor communities to irrigate home gardens, supplementing water availability in the household and improving food security. This book draws together material presented at a conference in Jordan in 2007, and examines the technical approaches to treating and using greywater for irrigation, including its associated risks to health and the environment.

Disposable Cities: Garbage, governance and sustainable development in urban Africa

Myers, G.A. , Ashgate Publishing Limited, Hampshire, UK (2005)

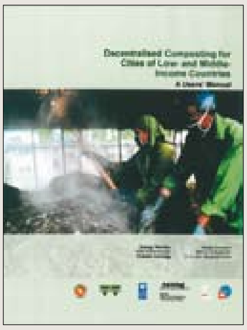
Based on in-depth fieldwork in three cities, Dar es Salaam, Zanzibar and Lusaka, this book provides a critical analysis of the United Nations Sustainable Cities Program in Africa (SCP). It also puts forward a historically grounded critique of neoliberalism, good governance and sustainable development discourses.
http://www.amazon.com/Disposable-Cities-Sustainable-Development-Re-Materialising/dp/0754643743

Books
further readings

Integrated Nutrient Management, Soil Fertility, and Sustainable Agriculture: Current issues and future challenges

Gruhn, P., Goletti, F. and Yudelman, M., International Food Policy Research Institute, Food, Agriculture, and the Environment Discussion Paper 32 (2000)

The authors call for an Integrated Nutrient Management approach to the management of plant nutrients for maintaining and enhancing soil that uses both natural and man-made sources of plant nutrients. The key components of this approach are described; the roles and responsibilities of various actors, including farmers and institutions, are delineated; and recommendations for improving the management of plant nutrients and soil fertility are presented. http://ageconsearch.umn.edu/bitstream/16236/1/dp000032.pdf



Composting – Decentralized composting in low-income countries: A case study from the Republic of Guinea / West Africa (2008)

DVD: Austria, 40 minutes, Languages: German, English and French

Based on the project "LPCC-Guinée: Recirculation of local organic waste in urban and rural agriculture - the impact on soil functions in Guinea / West Africa", an educational film was produced by the Institute of Waste Management. This activity was funded by the Commission for Development Studies at the Austrian Academy of Sciences. The film intends to provide information on the importance of organic waste management and periurban agriculture especially in urban agglomerations of low-income countries. The biodegradation process is explained and what factors of influence have to be considered in day to day composting activities.

The target groups for this film are state / municipal officials, students, researchers, public utility companies, people carrying out composting and farmers in urban and periurban agriculture.

http://www.wau.boku.ac.at/12714.html?&L=1

Utilization of organic waste in (peri-) urban centres. The decision makers' guide to compost production

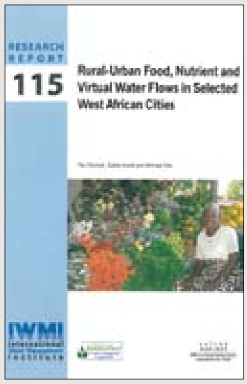
GTZ-GFA. 1999. (includes financial analysis tool); Software Tool - Economic Model, Version 0.9 E, GFA, Germany

Before establishing a composting business, it is necessary to make sure that compost production and marketing will be an economically attractive and self-financing activity. In 1999, a GTZ project on municipal waste composting compiled a useful set of materials to assist planners and decision-makers in making feasibility assessments. The information package included a computer-based tool called the "Decision-makers' guide to compost production". The software offers users a quick and easy method to determine, right from the outset of the planning process, the costs that will have to be covered and gives a break-down of those costs. The book and software, originally available free of charge, are out-of print. The last available copies of the source book and software can be ordered from GFI Umwelt.

http://www.gfa-group.de/publications/home_beitrag_868146.html

Rural-Urban Food, Nutrient and Virtual Water Flows in Selected West African Cities

Drechsel, P., Graefe, S. and Fink, M., IWMI Research Report 115, International Water Management Institute, Colombo, Sri Lanka, (2007)



This study quantifies rural-urban food flows in Ghana and Burkina Faso and analyses the dependency of four cities – Accra, Kumasi, Tamale and Ouagadougou – on food supplied from rural, peri-urban and urban areas as well as from imports. Furthermore, the report discusses the role of urban and periurban agriculture and options to reduce the environmental burden by closing the rural-urban water and nutrients cycles.

http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB115/RR115.pdf

Phosphorus Recovery from Human Urine

Gethke, K., Herbst, H., Montag, D., Bruszies, D. and Pinnekamp, J. in Water Practice & Technology 1:4 (2006)

At the Institute of Environmental Engineering (ISA) of RWTH Aachen University, several research and development projects concerning phosphate recovery have been carried out. In the context of these projects the decomposition processes during the storage of human urine were observed and a process to recover phosphorus from urine was tested. A precondition for this process is the use of no-mix-toilets separating urine and faeces. These toilets have been integrated in some new settlements in Germany provided with ecological sanitary systems. The recovery process is based on struvite crystallisation.

http://themas.stowa.nl/Uploads/nieuwe%20sanitatie/Informatie/Bibliotheek/Overig/Gethke%20et%20al.%20(2006)%20-%20Phosphorus%20recovery%20from%20human%20urine.pdf

References from page 30

Note

1) Exchange rate: 1 USD = 1800 pesos colombianos

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- González Rojas, C. P. 2007. Technologies for the Production of Edible Plants in Bogotá, Colombia. In: UA-Magazine no. 19: Stimulating Innovation in Urban Agriculture
- National Administrative Department of Statistics (DANE) 2009 http://www.dane.gov.co/daneweb_V09/
- Tibaitatá-Corpoica Research Center. 2009. Technical report of Urban Agriculture, Bogotá

Weblinks

www.waste.nl
WASTE works towards sustainable improvement of the urban poor's living conditions and the urban environment in general. Their programmes and projects have a focus on bottom-up development in relation to recycling, solid waste management, ecological sanitation and knowledge sharing. WASTE, located in the Netherlands, teams up with organisations in Africa, Asia, Latin America and Eastern Europe that share its goals and approaches.

www.sandec.ch
Sandec is the Department of Water and Sanitation in Developing Countries at the Swiss Federal Institute of Aquatic Science and Technology (Eawag). Its mandate is to assist in developing appropriate and sustainable water and sanitation concepts and technologies adapted to the different physical and socio-economic conditions prevailing in developing countries.

www.skat.ch
Skat is an independent Swiss resource centre and consultancy company working in the fields of development and humanitarian aid. Since 1978, Skat has provided technical expertise and management support, as well as training and research facilities. Skat's areas of expertise are: water supply and sanitation, building and settlements, mobility and transport, governance, economic development and environmental management.

www.fibl.org
The Research Institute of Organic Agriculture (FiBL) is one of the world's leading organic research institutes. Interdisciplinary research teams and collaboration among research, extension and education are the strengths of FiBL to ensure rapid knowledge transfer to beneficiaries. FiBL research projects can be found in different parts of the world be it in Europe, South America, Africa or Asia.

www.wau.boku.ac.at/abf.html
"The Institute of Waste Management at the University of Natural Resources and Applied Life Sciences, Vienna (BOKU) evaluates waste management objectives of political and legal relevance with regard to their short- and long-term ecological and economic impact. Technologies for sound treatment and disposal of waste are developed, based on natural processes. The goal is to develop adapted waste management measures, that include technological (e.g. decentralised composting), organisational (e.g. documentation system for hazardous wastes) and educational measures (e.g. curriculum development, training courses).

http://phosphorus.global-connections.nl
The Nutrient Flow Task Group (NFTG) is a Dutch initiative facilitated by the Development Policy Review Network (DPRN) that strives to accelerate the search for solutions for phosphorus depletion and its global impact. The NFTG is a broad network of public parties (the Ministries of Agriculture and Spatial Planning, Water Authority de Dommel), NGOs (WASTE, ETC-RUAF, ICCO), the private sector (Grontmij, Thermphos, SNB, GMB-Watertechnology, Royal Haskoning, Tebodin, Orgaworld 3R-Agrocarbon), knowledge institutions (Plant Research International, Alterra, Wageningen University, Unesco-IHE) and network organisations (Netherlands Water Partnership, Aqua for All). Contact person: Ger Pannekoek, Email: g.pannekoek@nwp.nl Or visit www.nwp.nl ; http://www.phosphaterecovery.com/

www.reseaucrepa.org
Set up in 1988 as a regional project, CREPA (Regional Centre for low cost Water Supply and Sanitation) is now an intergovernmental institution with 17 member countries, all francophone except Guinea Bissau. Thirteen national representations are coordinated by the headquarters in Ouagadougou, Burkina Faso. Research, training, demonstration projects and communication are focused on low-cost appropriate technologies, community participation, alternative financial mechanisms and the role of the local authorities. EcoSan is one of CREPA's core programmes together with Basic Community Services, Integrated Waste Water Management and HCES/Sludge Management.

http://phosphorusfutures.net/
The main objective of the GPRI is to facilitate quality interdisciplinary research on global phosphorus security for future food security. In addition to research, the GPRI also facilitates networking, dialogue and awareness raising among stakeholders and the community on global phosphorus scarcity and possible solutions.

www.ecosanres.org/
Ecosanres - Closing the loop on sanitation. Key resources on this website are: factsheets on sustainable sanitation issues and publications, including "Toilets That Make Compost", "Pathways for Sustainable Sanitation" and "Ecological Sanitation: Revised and Enlarged Edition".

www.susana.org/index.php/lang-en/working-groups/wg05
Working group 5 of the "Sustainable Sanitation Alliance" aims to raise awareness about the reuse-oriented sustainable sanitation approach and its prospective contribution to global food security and to promote this approach on a large scale. Factsheet available at: http://www.susana.org/images/documents/05-working-groups/wg05/en-wg5-factsheet-2008-05-28.pdf

Events

Mini Seminar on Phosphorous Shortage (at the European Parliament in Brussels, Belgium), and International Workshop of the Global Phosphorous Research Initiative

[Linkoping, Sweden]

25-26 February

Both events have been held already, but information on the results and forthcoming activities can be obtained at:

- http://phosphorus.global-connections.nl *(on the Brussels event)*
- http://phosphorusfutures.net/ *(on the international workshop).*

World Urban Forum 5: The Right to the City - Bridging the Urban Divide

[Rio de Janeiro, Brazil]

22–26 March 2010

In the space of a few short years, the World Urban Forum has turned into the world's premier conference on cities. Among the concepts that drove the discussions in Rio included were reducing inequality and poverty, participatory democracy, sustainable urban development, equal access to shelter, health, water, sanitation and the *right to the inclusive city.* RUAF organized a special event (see www.ruaf.org). More information: http://www.unhabitat.org/categories.asp?catid=584

Multiple Geographies of Urban Agriculture in the Global North: Integrating Perspectives from Planning and Design, Ecology, Public Health, and Political Economy

[Washington DC, USA]

14–18 April 2010

Urban agriculture (UA) is undergoing a renaissance in North American cities; communities and individuals have launched innumerable initiatives to farm and garden in empty lots, at schools, in back yards, and on roofs and stoops. The goal of this conference was to bring critical human geography into conversation with planning and design, public health, and ecological and environmental sciences to both "ground" theory in on-the-ground UA experiences and provide critical insights into the histories and assumptions informing these initiatives. More information: http://www.aag.org/

Land Management Strategies for Improving Urban-Rural Inter-Relationships

[Hannover, Germany]

09-11 May 2010

GLL Hannover (the agency for Geoinformation, Land Development and Real Estate) supported by GTZ is organising an International Land Management Symposium in Hannover. The Conference will deal with best practice and regional solutions in urban-rural inter-relationships. Topics include: the management of peri-urban areas, migration, and the development of sound integrated development approaches. More information with: Bodo.Richter@gtz.de or Vera.Koeppen@gtz.de

1st World Congress on Cities and Adaptation to Climate Change

[Bonn, Germany]

28–30 May 2010

Resilient Cities 2010 is the first edition of an annual global forum for exchange, learning, networking, debating and policy making on approaches and solutions for climate change adaptation and resilience-building in cities and municipalities. The latest scientific findings, effective approaches and state-of-the-art programmes will feed the discussions and set the direction for future planning and investment. The event will bring about policy propositions and impulses for innovation. RUAF and FAO collaborated in the organization of a special event. More information: http://www.iclei.org/index.php?id=10242

NAREA Workshop on Economics of Local Food Markets

[Atlantic City, USA]

15–16 June 2010

The 2010 Workshop on the Economics of Local Food Markets will immediately follow the annual meeting of the Northeastern Agricultural and Resource Economics Association (NAREA). The goal of the workshop is to highlight current research and bring together researchers, extension educators, private sector participants, and policy makers to exchange ideas and develop a common set of priority research and education needs for local food systems. More information: http://www.narea.org/2010/

World Cities Summit 2010

[Singapore]

28–30 June 2010

World Cities Summit brings together practitioners and policy makers with leading experts in their field to identify innovative solutions to the most pressing challenges facing cities today. The inaugural summit in June 2008 brought together 800 senior delegates including leaders, mayors, policy makers and the civil society. The emphasis of the second summit is on the two broad themes: *Liveable and Sustainable Cities for the Future and Building Sustainable and Eco-friendly Cities.*
http://www.worldcities.com.sg/

Events

Innovation and Sustainable Development in Agriculture and Food

[Montpellier, France]
28 June – 1 July 2010

This event will include various workshops, including "Agriculture, Nature and Cities: enhancing innovations for sustainable development". The symposium will combine different types of sessions with key note lectures, round tables, and parallel thematic or regional workshops to reflect upon future choices, to identify new concrete proposals for research agendas and for political action, and to discuss how innovations systems can better achieve sustainability. More information:: www.isda2010.net

Linking Health, Equity and Sustainability in Schools

[Geneva, Switzerland]
10–11 July 2010

This meeting is organized by the Swiss Network of Health Promoting Schools (SNGS), the Schools for Health in Europe Network (SHE network) and the International School Health Network (ISHN) in collaboration with the foundations of global and environmental education (SBE and SUB). The international symposium is open to all who are interested in questions of health and sustainable development in school, in particular young people and other stakeholders, researchers, NGOs and government officials. The symposium will be preceded and followed up by on-line discussions and webinars as well as a coordinated set of presentations in the large international IUHPE conference being held immediately afterward.
More information: http://www.docstoc.com/docs/document-preview.aspx?doc_id=19431182

Local Food Systems in Old Industrial Regions: Challenges and Opportunities

[Toledo, Ohio, USA]
3–7 August 2010

The conference aims to bring together both academics and practitioners to share their knowledge, experience, and expertise with regard to developing and maintaining local food systems in old industrial regions. The conference is sponsored by the International Geographical Union but is open for participation from individuals in a variety of academic disciplines (including, but not limited to, geography, planning, public policy, public health, environmental science, horticulture, women and gender studies, sociology, anthropology, and economics).
More information:http://uac.utoledo.edu/igu_commission/ToledoMC2010-Home.htm

Growing Power's National-International Urban & Small Farm Conference

[Milwaukee, USA]
8–9 September 2010

Hosted by Growing Power, this international conference will teach the participants how to plan, develop and expand small farms in urban and rural areas. Learn how you can grow food year-round, no matter what the climate, and how you can build markets for small farms. See how you can play a part in creating a new food system that fosters better health and more closely-knit communities.
More information:www.growingpowerfarmconference.org or www.growingpower.org/conference

9th Canadian Urban Forest Conference (CUFC9) "Water, Trees and Communities"

[Truro, Nova Scotia, Canada]
5-8 October 2010

The conference, organised by the Town of Truro and Tree Canada, will bring hundreds of arborists, foresters, city planners, environmentalists and engineers together to discuss and share knowledge related to the theme of "Water, Trees and Communities". Trees are increasingly recognised as playing an important role in "green infrastructure" by regulating the hydrologic cycle and protecting municipal drinking water supplies.
More information: www.cufc9.ca

Managing the Urban Rural Interface

[Copenhagen, Denmark]
19–22 October 2010

The conference is the final event of the PLUREL project (Peri-urban Land Use Relationships – Strategies and sustainability assessment tools for urban-rural linkages) funded by the European Commission's sixth Framework Programme for research (EC FP6 036921). The conference aims to present the status of scientific approaches to assess the periurban land-use relationships and associated effects on sustainability, to set the agenda for future research in the field, and to enhance international research cooperation.
The event targets a broad spectrum of participants, recognising the multidisciplinarity of research in urban and rural linkages. This includes, but is not limited to, those in the fields of land use, urban and rural development, planning, architecture, geography, economics and social and environmental sciences. Contributions may address methodological, theoretical issues, applications or dissemination, and participatory aspects.
More information:
http://www.plurel.net/Default.aspx?id=87

We would like to receive your contributions or suggestions for the next issue of the UA Magazine

RUAF CELEBRATES 10 YEARS OF PROMOTING URBAN AGRICULTURE WORLD WIDE

NO. 25: RUAF 10 Years; Promoting Urban Agriculture (DECEMBER 2010)

Please send us your contribution before:
1 SEPTEMBER 2010

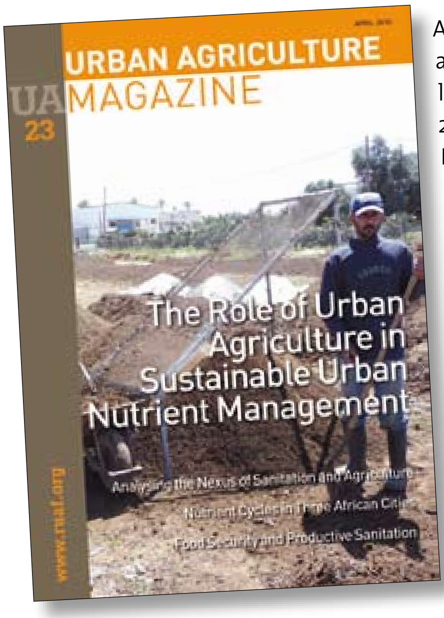
Ten years ago, ETC Foundation initiated a programme named: "Resource Centre on Urban Agriculture and Forestry" (RUAF). The RUAF project developed into an **international network of 1 global and 7 regional Resource Centres on Urban Agriculture and Food Security,** which in 2004 obtained independent legal status as the **RUAF Foundation**.

In addition to ongoing networking, documentation, awareness raising, and policy lobbying, the RUAF partners, with the start of the **"Cities Farming for the Future"** programme in 2005, focused on capacity development and support to multi-stakeholder policy development and action planning in urban agriculture in 20 cities, involving local authorities, NGO's and urban producer organisations in 17 countries.

And since 2009 in the **"From Seed to Table programme"** this has been broadened with strengthening urban producers organisations and enhancing local capacity in the development of "From Seed to Table" projects with urban producer groups (participatory market analysis to identify consumer demand, group business planning, urban producer field schools, processing / packaging units, direct marketing to consumers interested in ecological products).

This work has had important effects on local institutional capacities and enhanced political awareness and important policy change at city and national level.

International recognition of the potential and impacts of urban agriculture for urban food security and nutrition, poverty alleviation, recycling of urban wastes, adaptation to climate change has grown substantially in this decade.



An overview of **main RUAF publications** to date can be found at the RUAF website (www.ruaf.org) including a number of leading publications like "Growing Cities, Growing Food" (DSE, 2000), "Cities Farming for the Future" (IIRR, 2006), "Women Feeding Cities" (Practical Action, 2008), "Cities, Poverty and Food" (Practical Action, 2010) and 24 thematic issues of the Urban Agriculture Magazine (6 languages, 7000 subscribers).

RUAF will organise a number of activities in 2010, to celebrate this anniversary, including a **special issue of the Urban Agriculture Magazine.**

NO. 25: RUAF 10 Years; Promoting Urban Agriculture (NOVEMBER 2010)

We would welcome **your contributions in the form of photos and short stories** that show the development of urban agriculture in the past 10 years in a certain city or country and its impacts, or that analyse the role urban agriculture can play in answering major challenges in the near future (e.g. urban food security, climate change, productive reuse of wastewater and nutrients, etcetera).

23
Urban Agriculture magazine

The Role of Urban Agriculture in Sustainable Urban Nutrient Management

ISSN 1571-6244
No. 23, April 2010

UA Magazine is published two times a year by the Network of Resource Centres on Urban Agriculture and Food Security (RUAF), under the Cities Farming for the Future Programme, which is financed by DGIS, the Netherlands, and IDRC, Canada.

UA Magazine is translated into French, Spanish, Portuguese, Chinese, and Arabic, and distributed in separate editions through the RUAF regional networks, and is also available on www.ruaf.org.

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Editors, No. 23
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