Productive Use of Urban Water for Urban Agriculture

Final Report WP 5.2

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WP5.2: Productive Use of Urban Water for Urban Agriculture

Compiled by René van Veenhuizen, ETC Urban Agriculture, RUAF
With inputs of other collaborators of WP 5.2

Water and food security are inextricably linked, and cities increasingly are the principal spaces for planning and implementation of strategies that aim to enhance food security in the city region. Urban agriculture is one such strategy, which is the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs and the processing and marketing of products. It relates to integrated water management, including re-use of wastewater for irrigation and recovery and reuse of nutrients from urban organic wastes and wastewater.

SWITCH Work package 5.2 “Use of Urban Wastewater for Urban Agriculture” aimed to contribute to a paradigm shift in thinking on wastewater management and sanitation, and assisted cities in their transitioning towards a decentralised, recycling-oriented approach, linking water, sanitation, resource recovery and local food production. This work package involved applied research in Accra, Beijing and Lima, studying the actual situation and potential of use of rainwater, wastewater and ecosanitation for agriculture, and involving multiple stakeholders under the learning alliances.

In Accra, SWITCH worked at basin level on pollution control and at farmer level on both, improving treatment and use of waste water, and testing the safe collection, storage and use of urine for urban agriculture. In Beijing, SWITCH assisted in the optimisation of a system collecting rainwater from greenhouses, underground storage and re-use in an innovative system for the production of mushrooms. In Lima, SWITCH focused on the promotion of the use of treated wastewater for the watering of parks and other urban greening and in agriculture, the development of policy guidelines and a comprehensive training package in close collaboration with the Ministry of Housing and Sanitation.

The work followed a sequence of implementation. Based on a situation and stakeholder review, working groups were formed, who met and were linked to the City Learning alliances. These working group members were trained in multi-stakeholder action planning and research, and were involved in and informed on ongoing research and demonstrations. Information was disseminated in publications, magazines and newsletters. Guidelines and related training material has been developed. The leading institutes were the RUAF Partners ETC (WP coordinator), IWI (Accra), IGSNRR (Beijing) and IPES (Lima).
1. Introduction

1.1 Urbanisation, water, and food

Urban growth is projected to increase significantly in the coming decades. The world’s urban population is expected to double from 3.3 billion in 2007 to 6.4 billion by 2050, and it is predicted that by 2030, 60 per cent of the world’s population will live in cities (UN 2007), though in many countries this percentage is already higher.

Cities increasingly act as sinks for water, nutrients and organic matter. This waste problem is an environmental and health challenge for city authorities, but it is also an economic challenge. Cities will face new and ongoing challenges in creating sufficient employment, enhancing food security and in providing essential services, such as potable water and sanitation. Cities are thus quickly becoming the principal territories for intervention and planning of strategies that aim to eradicate hunger and poverty and improve livelihoods. Urban agriculture is one such strategy.

The per capita availability of freshwater is fast declining all over the world to the extent that two-thirds of humanity may be living water stressed conditions by 2025. Population growth, urbanisation, changing lifestyles and climate change aggravate this water scarcity. Improved living standards and socio-economic conditions have led to the generation of waste and wastewater, which are mostly discharged untreated into the environment. Insufficient sanitation facilities in many countries, has further led to the degradation of the quality of water resources.

If such a large global population is to be supported, it will be necessary to think of water from an entirely new perspective. Given that 70% of global freshwater withdrawals are used in irrigation annually (IWMI, 2007, Water for Food, Water for Life, London, Earthscan Publishing), it is clear that water security and food security are inextricably linked, especially in arid and semi-arid regions. In addition, the world can be facing the prospect of ‘peak fertiliser’ in addition to this ‘peak water’. It is predicted that economically extractable phosphate will be depleted within the century while sulphur will be depleted within the next 30 years (Brown, 2003).

The old paradigm of centralised treatment for disposal is increasingly seen as unsustainable in developed nations and impractical in the developing world as a model for water management. The infrastructure alone would prove too costly. Simply following the example set by developed nations cannot be a sustainable solution in the long-run. SWITCH aimed to facilitate a paradigm shift in urban water management, changing from ad-hoc actions to a coherent and consolidated approach, and explore divers solutions as part of transitioning to cities of the future.

Wastewater has value as a resource and its reuse presents a solution to the problems outlined by offsetting freshwater use in irrigation and therefore the need for rural-urban water transfers and rising fertiliser costs by recycling nutrients. At the same time, wastewater presents a constant and reliable water source at the rural-urban interface; where proximity to urban markets allows cultivation of perishable but high-value vegetable crops; benefitting not only the food producers but also consumers by giving them access to a wider variety of foods. Over the past decade there has been a growing
acceptance of the importance of wastewater agriculture by governments and international agencies.

Management of urban waste is another concern and high cost for many cities. Domestic waste in developing countries contains a great deal of organic material, ranging from 60 to 90 per cent (Lacoste and Chalmin, 2007). Instead of bringing the waste to heaps in landfills illegal dumps or transfer stations, there is widespread agreement that composting is a less expensive and environmentally attractive way to manage this waste, especially in low- and middle-income countries.

Urban agriculture provides linkages to both the “offer” of wastewater and of (organic) wastes and the “demand” for water and nutrients in and around settlements, with the opportunity to contribute 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. Along with more efficient water use in agriculture, the productive use of recycled urban wastewater, rainwater and organic wastes have been identified as a sustainable way to produce food for the growing cities (SUSANA, 2009).

In order to explore, develop and test new solutions, new generation systems and approaches, it is important to look at waste ‘streams’ go through the system, towards treatment or disposal; and those that bypass this: leaking out or never getting there in the first place (Drechsel et al, forthcoming). Planned resource recovery will only deal with the former, but both streams have to be addressed in sustainable city development.

Due to high transport costs, usually waste, in the form of compost, urine or biogas, is (and needs to be) reused close to where it is generated. This makes urban and peri-urban areas hot spots for various options of resource recovery, and urban and peri-urban agriculture an important option to consider.

1.2 Urban Agriculture

Urban agriculture can be defined as the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs, and the processing and marketing of products. Urban agriculture is located within or on the fringe of a city and comprises a variety of production systems, ranging from subsistence production and processing at household level, to fully commercialised agriculture. It is generally characterised by closeness to markets, high competition for land, limited space, use of urban resources such as organic solid wastes and wastewater, a low degree of farmer organisation, mainly perishable products, and a high degree of specialisation.

Although some forms of urban and peri-urban agriculture are based on temporary use of vacant lands, it is still a permanent feature of many cities in developing as well as developed countries. It complements rural agriculture and increases the efficiency of national food systems. Urban agriculture is one of the many different strategies developed by urban citizens to improve their livelihoods and is often combined with other activities. Much urban agricultural production takes place in the informal sector. In West Africa, market oriented irrigated agriculture occupies between 20 and 650 ha in each major city, producing 60-100 percent of the locally consumed perishable vegetables
Obuobie et al., 2006). It is often a response of the urban poor and unemployed to urban poverty and food insecurity/malnutrition. Since poor people generally spend a substantial part of their income on food (60–80 percent, Mougeot, 2005), the savings made by substituting home grown vegetables can be substantial. In addition it may contribute to sustainable urban development, by turning urban wastes into a productive resource through compost production, vermiculture, and irrigation with wastewater, and by greening the city. It also functions as an important strategy for poverty alleviation, community building and social integration of disadvantaged groups. However, if not properly managed, it may include risks, especially in the aspect of water reuse.

Climate change adds to the challenges faced by cities and is recognized as one of the most serious environmental, societal and economic challenges (IPCC, 2007). UPA can play a role in improving the urban environment and adaptation to climate change (and to a lesser extent in mitigation). The World Meteorological Organization (WMO) suggested that more urban farming should take place as a response to climate change and as a way to build more resilient cities (WMO, 2007).

Productive reuse of wastewater in urban agriculture will help to reduce the demand for fresh water supplies as well as reducing the discharge of wastewater into rivers, canals and other surface water sources and thus diminish their pollution (Buechler et al. 2006). Use of urban wastewater as a source of irrigation will help to adapt to risks of drought and flooded roads (hampering the transport of food from rural areas) by facilitating year-round production close by. Urban wastewater can be recycled for irrigation/fertilization of horticultural crops, i.e. floriculture and fruit crops, as well as for irrigation of forest plantations that combat desertification and provide wood for fuel. In many cities, attempts to decrease pressure on wood energy (fuel wood and charcoal) by subsidizing gas or electric technologies have not succeeded. The prognosis for many regions, such as in sub-Saharan Africa, is that wood will continue to be the main source of energy for cooking and heating of the majority of their population (Baudoin & Drescher 2008). Forest plantations can turn steep slopes and low-lying lands into urban ‘green areas’.

Farmers use clean water for irrigation when available, but pipe-borne water for irrigation is rare due to the cost involved, unreliability of supply, or lack of access. In many cities farmers tend to use wastewater to irrigate their crops. Urban producers/farmers have a variety of motives for using untreated or partly treated wastewater. In semi-arid and arid areas it is often the only source of water available and it is available year-round. It is also an inexpensive source, not just of water but also of nutrients. Irrigated urban agriculture provides livelihoods and has an important niche function (Drechsel et al., 2010).

A lack or rainwater, depletion of groundwater and limited access to piped water and access to waste water provides an opportunity for farmers to reuse urban wastewater for agriculture. Sources of wastewater include surface runoff, city drainage canals, sewage, grey water or black water and drainage channels, as well as hospital and industrial wastewater, and combinations of all of these (each with varying concentrations). However, wastewater use for agriculture is often negatively perceived by the public and by government officials. It has risks for producers and consumers and needs adequate management. Risks need to be assessed according to the type of activities for which the wastewater is being used, the type of irrigation method and the type of user group that has the most direct contact with the water.
1.3 Water and Nutrient recovery

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. Ecological sanitation 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.

Huge amounts of urine and other organic wastes are generated daily in urban centres. Excreta are a rich source of organic matter and essential inorganic plant nutrients such as nitrogen, phosphorus and potassium. The organic matter and nutrients contained in excreta can be recycled and reused as fertiliser-cum-soil conditioner, to fertilise crops and fish ponds.

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.

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.

In the conventional approach to deal with urban water pollution, wastewater from households and industrial areas in cities is collected in gravity sewers and transported to central treatment facilities. Although centralised urban wastewater management systems have proven to function well with respect to the protection of public health and the environment - provided treatment facilities are in place and operating - they have several weak points, such as: i) removal of an important source of water out of the urban area; ii) destruction of nutrients that are valuable to agriculture; iii) frequent storm water overflows that result in uncontrolled discharge of wastewater to urban water systems; vi) production of polluted municipal sludge at wastewater treatment plants; v) emissions of pharmaceuticals and endocrine disruptors to water systems, both in the city and downstream.

Innovations in urban wastewater management and sanitation (the ‘supply side’)
Systems that separate grey water, black water and / or urine offer new solutions to urban sanitation shifting the paradigms in wastewater treatment from an approach with centralised mixed systems to decentralised systems based on source control. Potential advantages compared to the ‘central paradigm’ are: avoiding environmental pollution, isolating pharmaceuticals and endocrine disruptors, enabling the nutrient recovery for agricultural use and preserving water for groundwater recharge, irrigation and other purposes. A number of research and demonstration initiatives in and outside Europe.
have shown that these approaches can result in promising new and cost effective options for wastewater management, preventing emission of pollutants to the urban environment and facilitating new local sources of water and the use of valuable nutrients in agriculture.

Innovations in the water and nutrient use by urban agriculture (the ‘demand side’)

Urban and peri-urban agricultural producers need water to irrigate their crops and provide drinking water to their animals or fish. In the event of water shortages or decreasing quality of the available water sources, urban producers apply various strategies, including the enhancement of access to existing water sources or using these more efficiently, and using other water sources (e.g. rainwater collection, wastewater). Farmers will take advantage of any water source, especially in the dry season, whether it is polluted or not. Sources of wastewater include surface runoff, city drainage canals, sewage, greywater or blackwater and combinations of all of these. Urban producers/farmers have a variety of motives for using untreated or partly treated wastewater. In semi-arid and arid areas it is often the only source of water available and it is available year-round. It is also an inexpensive source, not just of water but also of nutrients. Irrigated urban agriculture produces very competitive profits, and flourishes and spreads without any external initiative or support. It takes advantage of market proximity, the demand for perishable cash crops, and the common lack of refrigerated transport as well as access to wastewater resources. The introduction of urban water reuse requires changes in policy and infrastructure that would affect various stakeholders. A major obstacle to facilitate the safe use of rain and wastewater lies in the non-recognition of urban agriculture as an urban livelihood strategy. The adoption of any measure or policy depends upon whether the authorities and policy-makers take the activity of urban agriculture seriously. In the SWITCH learning alliances, various stakeholders, including urban producers, engage with policy-makers to encourage a well-integrated, supportive policy environment. Better understanding of farmers’ innovations and perceptions of wastewater use (quality, economic value and health issues) is needed to inform planning initiatives of the policy-makers and the urban authorities. Flexible “response scenarios” need to be developed for specific locations and appropriate risk reducing strategies that are technically, economically, socio-culturally and politically compatible.

1.4 Multi Stakeholder action planning and joint analysis

SWITCH Work package 5.2 “Resource recovery and use of urban waste water for urban agriculture aimed to contribute to a paradigm shift in thinking on wastewater management and sanitation, and assisted cities in their transitioning towards a decentralised, recycling-oriented approach, linking water, sanitation, resource recovery and local food production.

Policy development and action planning on urban agriculture, water and sanitation, should involve various sectors and disciplines: agriculture, health, waste management, water managers, community development, parks and nature management, among others. Better understanding of farmers’ perceptions of wastewater quality, economic value and health issues is needed to inform planning initiatives of the policy-makers and the urban authorities. Flexible “response scenarios” need to be developed for specific locations and appropriate risk reducing strategies that are technically, economically, socio-culturally and politically compatible.
1.5 Objectives of WP 5.2

The work package aimed to:
- To develop a better understanding of, and promote benefits associated with, the role, contributions and potential of urban agriculture and other productive uses of water (along the water chain) to people's livelihoods in the selected pilot cities;
- To establish multi-stakeholder working-groups in each city that engage civil society (e.g. NGOs, CBOs, farmers) with municipal agencies (e.g. policy-makers, legislative and planning authorities), researchers and the private sector, on the integration of productive use of water in urban planning (closely linked to the city Learning Alliances);
- To train members of the working groups and other key players in multi-stakeholder approaches, and to develop local skills and capacity in key agricultural and (decentralised) water management areas;
- To identify and integrate acceptable and appropriate urban water management approaches and strategies into the policy, legislative and regulatory, urban planning and decision-making frameworks of each city;
- To initiate and monitor action research and demonstration projects in each of these cities on productive use of water including freshwater, storm and waste water;
- To disseminate and promote the lessons learnt within the cities and on national and international levels through multiple media channels (workshops, internet, etc) and demonstrations.

2. Productive Use of Urban Water for Urban Agriculture

The work followed a sequence of implementation. Based on a situation and stakeholder review, working groups were formed, who met and were linked to the city Learning alliances. These working group members were trained in multi-stakeholder action planning and research, and were involved in and informed on ongoing research and demonstrations. Information was disseminated in publications, magazines and newsletters and guidelines and related training material has been developed. The leading institutes were ETC (WP coordinator), IWMI (Accra), IGSNRR (Beijing) and IPES (Lima).

2.1 Reviews on Urban Agriculture in Accra, Beijing, Lima, Hamburg

A situation analysis was undertaken in Accra, Beijing and Lima, while an inventory was done in Hamburg. Data have been gathered on water sources, urban water dependent livelihood opportunities options: for on-farm treatment of poor quality water for agriculture (in Accra); co-operative horticulture and agro-tourism using rainwater harvesting (in Beijing); and neighbourhood and household treatment of grey water for urban farming (Lima).

The role and importance of water for urban agriculture and livelihoods varied considerably across the cities, but there were similarities in terms of water management, water scarcity and the need for new and innovative systems to allow for the use of different sources of water (rainwater and waste water). Based on the analysis of the specifics of farming under urban conditions and the actual role of farming in the
livelihoods of the urban poor and the opportunities/constraints for its development, lines of research and demonstration were suggested.

In Accra, both domestic water and wastewater (including storm water runoff and all polluted surface water sources such as city waterways), are used for multiple purposes. Some of the livelihood opportunities of urban poor (most of which depended on domestic water supply) were sale of food and drinks, hairdressing, car washing and irrigated vegetable farming. The Accra working group identified the need for research and demonstration of multiple water uses in an urban watershed, and for development of guidelines for institutional support and minimisation of health risks based on the specific role of urban agriculture in livelihoods.

SWITCH worked at catchment level on pollution control and at household level on improving treatment and use of wastewater, and on testing the safe collection, storage and use of urine for urban agriculture. Action research and demonstration took place with farmers at the Dzorwulu-Roman Ridge site, within the Accra Metropolitan Area – the Odaw-Korle catchment. There were two main focus areas:
- **Using waste water for urban agriculture in Accra**
- **Collection, storage and re-use of urine for urban agriculture in Accra**

A PhD focused his work on pollution control at catchment level, while one demo and related action research took place related to the improvement of farmer innovations, using dugout ponds. Based on the principle of sedimentation and the use of multiple ponds and macrophytes, improvement in treatment has been developed in a farmer field school setting.

In the second demo, part of the farmers at Dzorwulu were involved in linking production with sustainable sanitation. It involved the collection, treatment and use of urine for farming at the demo site. Urine is a readily available resource for use in urban agriculture, but the cost of transportation is usually too high, hence farmers were encouraged to store urine on farm site in mini disposal units. In addition agronomic field trials, economic feasibility and perception studies were undertaken, while farmers and extension staff were trained and awareness was raised with farmers, vendors and urban authorities.

**Beijing** is a city faced by a shortage of water. Rainfall is unpredictable and highly variable, even across the city, and on average less than 600mm per year. Apart from the traditional food production function, agricultural land use has been fulfilling other functions in Beijing. Agriculture is a big consumer of water. Groundwater levels are decreasing rapidly.

The SWITCH demonstration was developed in Huairou district, in peri-urban Beijing, collaborating with the Agricultural Extension Department and the Huairou Fruit and Vegetable Cooperative.
- **Rainwater harvesting for improved urban agricultural systems in Beijing**

The demonstration aimed to show a system of improved rainwater harvesting, storage, irrigation and improved production for the Beijing market (mushrooms), in addition to agro tourism, groundwater infiltration, and institutional development (linking the water and agricultural bureaus). One PhD was linked to the demo, leading to several studies and a handbook on the experiences.
Urbanisation is high in Lima and Callao city, home to 8,472,935 residents in 2008 while annual rainfall is almost non-existent at around 9 mm a year. The principal sources for water are therefore surface water (through the rivers Rimac, Chillón and Lurín) and subsurface water.

Due to the scarcity of rain and the pressure on the water supply, green spaces and productive activities around the cities use piped water, raw wastewater, treated wastewater or river water. Agriculture in urban areas in Lima has increased in the last decade as a strategy to increase access to food (vegetables) and to generate income and improve the environment. The potential of using treated wastewater for these productive uses has generated interest as national and municipal authorities respond to the need to reduce demand for piped water for uses other than consumption, and to monitor and increase the quality of water used for irrigation of crops in peri-urban areas and green spaces in urban areas.

In Lima, SWITCH promoted the decentralized use of treated wastewater for the irrigation of urban greening and agriculture to support the development of policy guidelines in close collaboration with the Ministry of Housing and Sanitation.

-Inventory of treatment of wastewater and re-use for urban agriculture in Lima

Research to guide the development of the guidelines consisted of an inventory of experiences of treatment and reuse of wastewater in urban and peri-urban Lima and Callao, and an analysis of the normative and institutional framework. A demonstration was developed and implemented in the district of Villa el Salvador, Lima to show the options for decentralised use. It was designed in a participative way through a series of workshops with the community and community based organisations, architects, and authorities.

-Developing Policy Guidelines on the treatment of waste-water and re-use for urban agriculture

This information was used to jointly develop national policy guidelines on the treatment and use of wastewater for greening and production. These were developed, reviewed and finalised with members of the National Learning Alliance in 2008 and approved by the Ministry of Housing and Construction in 2010. The Policy Guidelines will act as a strategic agenda for the institutions involved. SWITCH also assisted in developing training material for national staff.

Both, intra-urban and peri-urban agriculture were included in the study. Urban agriculture is more of a subsistence activity undertaken on community gardens. The area under cultivation is smaller (less than 1000 m2 on average). This type of agriculture often uses clean water. While peri-urban farmers have often been farming long term, intra-urban farmers are most often urban citizens who took up farming recently and have limited experience in farming.

In the meetings with the Ministry and the LA, the lack of legislation and policies on using treated wastewater was identified as a major obstacle. Analysis of the case studies and the legal framework served as main inputs for the elaboration of the first draft of the policy guidelines.
2.2 Working groups on Urban Agriculture

SWITCH aimed to foster alliances of institutions in order to facilitate scaling up of innovations in urban water management. Individual researchers or (working) groups of researchers operated under these learning alliances. Under this work package Multi Stakeholder Working Groups on productive use of urban water for urban agriculture were established in the three cities, Accra, Beijing and Lima. These working groups involved several relevant stakeholders, like farmers, civil society, research institutes and universities, and municipal agencies. Most of them were already involved to a certain extent in the multi-stakeholder platform on urban and peri-urban agriculture under the RUAF Programmes (www.ruaf.org).

These working groups have been involved from the onset in the development of research and demonstration and meet on a regular basis to discuss main findings, facilitated by the SWITCH partners IPES, IWMI, IGSNRR and the city coordinators in Lima, Accra and Beijing respectively. Institutes that were part of the working group also participated in the learning alliance, and as such are exposed and involved in activities of other work packages, but the purpose for these working groups was to guide research and scaling up the experiences.

The working groups were platforms for dialogue, but its members are to different degrees involved in (action) research: problem definition, agenda setting and identification of priorities, joint action planning and budgeting (including the opportunity to obtain grants).

In the three cities, the work on urban agriculture was the main work package of SWITCH involving field research. As such the working groups functioned as the learning alliance (in reality in Beijing) or assured the involvement of all (Lima) or a large part (Accra) of the learning alliance members in SWITCH field activities, thus assuring involvement in decision making on research, in sharing of knowledge and decision making.

Beijing

In China the Learning Alliance consisted of stakeholders from Beijing and Chongqing. It was agreed that under the LA, relatively independent working groups would operate in both cities. In that sense the working group in Beijing acted like a city learning alliance. The linkages between Beijing and Chongqing did not evolve as foreseen. The broader (Beijing and Chongqing) Learning Alliance met only three times with all members participating in this. However, many informal meetings between LA partners did take place. The Beijing WG/LA has been facilitated formally and informally by IGSNRR, through all kinds of (bilateral) meetings, mini-conferences, and interviews in which one or more members of the working group participated (live or using telephone and internet).

Lima

Although Lima was not yet acknowledged as a SWITCH demonstration city initially, the main SWITCH partner, IPES decided to design and structure a learning alliance to enable the formulation of policy guidelines and to coordinate different government sectors and civil society. IRC and ETC supported IPES and the selected institutions. The Environmental Department of the Ministry of Housing and Sanitation took the lead, while
a working group worked on the review and was trained in action research, and later became the LA at municipal level.

SWITCH Lima developed learning alliances at two levels (national and local) to support research activities, involve actors in the process and set a basis for disseminating action-oriented research products. The National Learning Alliance was made up of governmental organisations linked directly or indirectly to the formulation and approval of policy guidelines for the use of domestic treated wastewater. The Local Learning Alliance (Lima) integrated local government, the private sector, academic/research institutions, producer organisations, etc. with experience of treating or using treated wastewater for irrigation of green, forestry and agricultural areas, and related research or academic institutions. All the local learning alliance members contributed to the identification of constraints and potential for use of treated wastewater, information that was used in the elaboration of the National Policy Guidelines. IPES as facilitator of both platforms supported exchanges between them, by publishing information and organising joint meetings of both platforms.

**Accra**
The Accra learning alliance has had several meetings and became quite well established. The working group consisted of some members of the LA and several members of the Accra Working Group on Urban Agriculture (AGWUPA). This working group has been actively involved in the research and demonstration activities. A first start up workshop was organised to assure the participants involvement in the multi-stakeholder process, to discuss the current use of water, identify constraints and opportunities; prioritize issues for water intervention; and formulate action plans for implementation, based on the situation analysis on urban water use for agriculture in Accra, and related to three thematic areas: water for livelihood; water for urban agriculture; and urban agriculture for livelihood. In a second meeting, the working group members were trained in action research and developed a research framework, using micro scenario’s, focusing on improved management (local practices and improved options for treatment) and awareness raising.

The Multi Stakeholder Working Groups on productive use of urban water for agriculture in the three cities were trained in multi-stakeholder processes and action research.

### 2.3 Action Research and Demonstrations

Based on the reviews research and demonstration projects were designed and agreed by the working groups. For each city the linkages between livelihoods-water-agriculture, innovation and institutional support has been looked at.

**Accra**
Irrigated urban vegetable production in Accra provides up to 90 per cent of the city’s need for the most perishable vegetables, especially lettuce, which benefits around 250,000 people daily. Moreover it yields an average monthly net income of US$ 40-57 per farm. Nevertheless, it is associated with health and environmental risks from the use of polluted water and attendant contamination of vegetables with pathogens. Local and international initiatives have responded to some of these constraints. Notably are research projects on safer vegetable production as supported by IWMI, WHO, IDRC, FAO, and RUAF (www.ruaf.org). SWITCH built upon these experiences by developing technological and institutional innovations designed to minimise risks associated
especially with urban wastewater reuse for agriculture within the context of integrated urban water management. The work concentrated on a sub-basin within the Accra Metropolitan Area – the Odaw-Korle catchment.

The research operated at both catchment and plot levels and demonstrations at plot level. The main goal of research and other activities at the catchment level was to understand the interrelationship between livelihood activities, stakeholder interventions and institutional responses, and the impacts these have on urban water quality. The action research and demonstration at plot level took place with farmers at the Dzorwulu-Roman Ridge site.

Research focused on improvement of irrigation water quality and volume, as well as on appropriate crop management and social-economic implications. Treatment options are evaluated for microbial pollution reduction and nutrient recovery.

In Accra the working group on water use for urban agriculture initiated participatory action research activities on technological innovations to minimise risks associated with urban water reuse for agriculture. The purpose of the demo was to demonstrate the potential of on-farm wastewater treatment to minimize health risks associated with urban water use for agriculture, and focused on further development of existing farmers' practice of on-farm water storage ponds, for improved irrigation water quality and volume.

Action research was based on a participatory approach linking field observations and informal discussions with farmers at Roman Ridge farming area, Accra, looking at two different settings: 1) grey-water derived from gutters in a ponds-trenches system; 2) individual ponds filled periodically with water pumped from a stream. Design modifications were implemented on-site and were tested. It provided for continued trials by farmers, supported by Ministry of Agriculture, on on-farm pond design modifications.

In the long term, and in a perspective of Integrated Urban Water Management (IUWM), the best solution seems to adopt the drains upstream for agricultural purposes downstream (upstream action). This has been discussed in the working group and the learning alliance of Accra. A system of floodgate installed in the drains themselves should allow creating retention ponds during the dry season and letting the water flow freely during the rainy season. Drains should be made much wider upstream from farming areas to be able to store large volumes of water. In addition to this, one PhD investigated upstream behaviour and pollution prevention measures.

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 m3 of urine is generated per day. This is approximately 2,200 m3 of urine per year. In terms of nitrogen content this volume represents 6.6 tonnes of plant available nitrogen. No record of urine
collection for commercial agricultural use in Ghana has been found, but on-station experiments in some universities show promising results (amongst other some studies done in another SWITCH work package on ecosanitation). Factors such as transport logistics, financial feasibility as well as farmers’ and consumers’ perception of and willingness to use urine for food production influence the adoption of urine as a fertiliser in agriculture. A second demonstration and research study by SWITCH, was implemented in Accra, Ghana with the same farmer group in Dzorwulu Farming area in Accra, with the objective 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. The demo was jointly undertaken by SWITCH (work packages on ecosanitation and on urban agriculture) in collaboration with a private entrepreneur in Accra, Safisana, to introduce urine as a fertiliser to farmers. Action research was undertaken to determine the effect of urine and other fertilisers on the yield of cabbage.

Beijing
Research focused on the technological and organisational innovations in production and related income improving activities, by developing and testing an improved rainwater harvesting and storage system. After the general review on water and urban agriculture, one PhD focused on the issue of water scarcity. He made an assessment of the potential of water sources and cycles at catchment level applied to greater Beijing area, and the potential of these different sources of water for productive uses, using RS and GIS technologies.

A second PhD closely monitored the development, performance and scaling up of the demonstration in Huairou District, Beijing. In 2007, after negotiation with the staff of Huairou District, Agricultural Extension Department and the Huairou Fruit and Vegetable Cooperative, a location and planning of the demonstration was approved. The research was highly participative: the PhD was part of the working group, and they jointly designed, adapted and closely followed water availability, rain capture, storage, and use in addition to organizational aspects as regulations, cooperative organization, marketing, and financing. Guidelines and training material are being developed on the development of rainwater harvesting and treatment in Beijing.

After negotiation with the staff of Huairou District, Agricultural Extension Department and the Huairou Fruit and Vegetable Cooperative, a location and planning of the demonstration was approved. The demonstration would show a system of improved rainwater harvesting, storage and irrigation for a market oriented cooperative. The demonstration fitted in the attention for integrated approached to increase access to water for peri-urban agricultural development, using wastewater, rainwater and by more efficient water use (e.g. by village water managers and farmers’ water use cooperatives) in Beijing.

The demonstration project comprised of collection of rainwater from the outer surface of a, a rainwater collection flume, a deposit pool, and use of this water by using micro (drip) irrigation. The farm in Huairou depended totally on groundwater, since there was no access to surface water, but this groundwater needed to be pumped from about 40 m. Using rainwater would reduce the cost of water and increase the total amount of available water (sometimes the water could not be pumped up). Other innovations demonstrated were:
- Improved cooperative vegetable production for the Beijing market (grapes, dragon-cactus, mushrooms);
- Agro tourism;
- Groundwater infiltration;
- Involvement of both (often new) sectoral institutions, such as the water and agricultural bureaus.

Research by one PhD was fully dedicated to this demonstration and this research showed that the higher returns did not only compensate for water fees, but also enabled farmers to pay for the relatively high investment of rainwater harvesting facilities. The demonstration project showed positive results providing high quality irrigation water and increasing farmers' income substantially. Local government, which participated in the working group (Huairou District), acknowledged these results and support further application of the developed technology. It is expected that the results can be integrated into current policies and under the 12th five year plan (2011-2015), while some, more suitable, policy guidelines regarding effective water use and management will be developed.

Different types of rainwater harvesting (propagated by the Beijing Agricultural Bureau) were also analysed on their efficiency and cost/benefit, supported by research under the economics work package. The research also analysed several of the other systems, located in 6 other districts in Beijing and the potential for use in Beijing. The system developed with the Huairou cooperative is seen as a promising technology, but will not suit all types of farmers/cooperatives, since the cost of the sealed underground pool might be too high. These studies showed the potential of RWH for agricultural production, but also underlined the need of continued Governmental support (subsidies in combination with legislation and support in improving productive use such as agricultural production or agro-tourism).

The potential of the improved system in the context of scarcity of water and linked to potential sources of water as improved irrigation, management, and re-use of treated wastewater, linked to improved production and income, with both the Beijing Water Bureau and the Agricultural Bureau. The Beijing Agricultural Bureau has been experimenting with several RWH models, and is now promoting the one developed by SWITCH. RWH is seen as important in the forthcoming years in Beijing, to ensure water safety. Attention to rainwater reuse develops quickly in and around Beijing. IGSNRR and the Huairou Cooperative have patented the technology.

SWITCH started in China with research and practical pilots (the demonstration) in a "learning by doing" mode. The Ph.D. research was important in providing the necessary scientific information related to integrated water management at greater Beijing level and the innovations at the demo. The SWITCH partner IGSNRR is an important advisor to the national government on (peri-)urban planning, incorporating lessons in several other cities in China. Through the formal and informal linkages with different government institutions, urban agriculture, use of wastewater and the adapted technologies are scaled up in various other areas.

Lima

SWITCH Lima aimed to increase the access to and use of treated wastewater on the basis of:
- Research and demonstrations, involving a (local) learning alliance to provide evidence and convince key stakeholders on safe reuse of treated wastewater;
- Development of policy guidelines with, and agreed by, the Ministry of Housing and Sanitation, involving key stakeholders through the (national) learning alliance, and scaling up of safe reuse of wastewater.
- Communication/dissemination to and capacity building of the main stakeholders to participate in this process;

Research consisted of an inventory of experiences of treatment and reuse of wastewater in urban and peri-urban Lima and Callao. The inventory identified 37 experiences of reusing treated wastewater, 20 of them in peri-urban areas and 17 in urban areas. If half the cases the water was used for green spaces, in more than a third it was used for agriculture and the others used it for a combination of greening, aquaculture and agriculture. A separate inventory of urban agriculture identified 42 experiences, of which (only) 5 used treated wastewater for irrigation, and 19 used piped water (all of them in urban areas).

Also the normative and institutional framework related directly or indirectly to water management were analysed with a focus on wastewater, changes in the legal framework were suggested and the need for capacity development of and inter-institutional collaboration identified. After the inventory, IPES and MVCS/OMA, with the newly established institutes: the National Water Authority and the Ministry of Environment, identified case studies for research into using wastewater for productive use. In all, 12 twelve experiences (6 of wastewater reuse and 6 urban agriculture cases) were studied in more detail. A framework for analysis was developed and applied in this research with the five dimensions of sustainability (FIETS), taking into consideration both the treatment and the reuse aspects.

Recommendations of the legal and institutional study were to:
- Promote centralised treatment systems (public, private or mixed service providers in sanitation) and decentralised reuse, with municipalities to coordinate the irrigation of green areas and parks and urban producer associations;
- Support the development of privately managed, decentralised treatment and reuse systems;
- Show interested parties the linkages between treatment and reuse systems;

The demonstration project was designed and implemented in the district of Villa el Salvador, Lima to validate part of the policy guidelines and to establish a research and demonstration site, as an example of (central) treatment and (decentral) use of this wastewater in an productive green area in a poor neighbourhood.

The Eco-Productive Park, named OGAPU, (in Spanish, an acronym for Optimising Water Management to Combat Urban Poverty) was designed in a participative way through a series of workshops with the community and community based organisations, architects, and authorities. It has four components: recreation (games for children, chess table); sports (a grass football field, cycle path); production (growing ornamental bushes that are sold to city parks); and a tertiary treatment pond for wastewater. OGAPU aimed to show how this decentralised (re)use of treated wastewater would green a 2 Ha area of what was fairly typical desert like area. The project looked into the possibility of using the water for food production, but it appeared not possible because legislation did not permit (yet) using wastewater for this purpose. However, it did demonstrate the improvement of
other functions of the area: social (community building, recreation, social inclusion, etc.),
an economic (income), and environmental (green space, improvement of air, reuse of
waste, etc.).

Guidelines were reviewed and finalised with members of the National Learning Alliance
in October 2008 and presented in December 2008 at a special session of the National
Conference on Water and Sanitation (PERUSAN), and act as a strategic agenda for the
institutions involved. IPES and the Ministry have developed a training package for
capacity building of these institutions (see further below).

2.4 Guidelines
Based on the findings of research and demonstrations in the three cities, training
material and guidelines were developed on (use of) selected technologies by IPES,
IWMI and IGSNRR, all supported by ETC and where necessary by WUR, and linked to
other work packages.

Based on the research on wastewater in Accra, a manual was developed and IWMI
contributed to a Guidance note for National Programme Managers and Engineers;
Options for Simple On-Farm Water Treatment in Developing Countries: Third edition of
the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater in
Agriculture and Aquaculture. IWMI, FAO, WHO, IDRC.

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. 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.

A Handbook on Rainwater harvesting, Storage and Use for Beijing (guidelines in
Chinese, translated in English) for famers and technical staff on the background and
how to develop the developed rainwater harvesting system using greenhouses, and
improved storage and production). Training has been given using this handbook. It has
been designed in such a way that farmers can decide on adapting their own systems in
the most optimal way. The handbook presents info on different kinds of RWH systems,
storage, irrigation and multifunctional use of the water and the developed infrastructure
(using for instance the storage tanks for mushroom farming), and provides suggested
analysis for its sustainability. The SWITCH system has been copied in several other districts of Beijing and is being propagated outside Beijing (and is being patented).

In Lima, the Preparation of National Policy Guidelines for the treatment and reuse of wastewater in urban areas had been selected as one of the key areas to work on by the National Learning Alliance (see deliverable 5.2.2). The development of these guidelines was a participatory process, under the leadership of MVCS, including a SWOT analysis, the FIETS analysis, and dialogue between stakeholders. The National Policy Guidelines for the treatment and reuse of wastewater in urban areas in Peru were approved after a long process in November 2010 through a Ministerial Resolution.

The guidelines identify 5 main objectives:
1. Contribute to the national management of water resources, by including the reuse of municipal and domestic wastewater for irrigating urban and peri-urban green areas in the national water and sanitation policy.
2. Encourage the use of effective and adapted water treatment technologies for reusing domestic and municipal wastewater for irrigating urban and peri-urban green areas, and support the implementation of research that contributes to improving sanitary quality and reducing costs.
3. Establish mechanisms that promote the participation of the public and private sector, civil society and international organisations to invest in developing water treatment systems geared toward reusing domestic and municipal water for irrigating urban and peri-urban green areas.
4. Promote social participation and public access to information about stakeholders involved in the treatment and reuse of domestic and municipal wastewater, in order to ensure transparency, control and efficiency.
5. Strengthen the capacities of sanitation service providers, governmental bodies responsible for the sector and users of domestic and municipal treated wastewater.

The guidelines consider the development of a National Strategy for promoting the reuse of domestic and municipal wastewater for green urban and peri-urban areas as a priority. Implementation of the guidelines will be overseen by a Multi-Sectoral Committee, which is the continuation of the National Learning Alliance and which is composed of ministries of Housing, Health, Environment, and other institutes such as ANA and SUNASS.

The National Learning Alliance prioritized one of the key objectives identified in the Guidelines: a National Training Course on Treatment and Use of Wastewater. The National Training Course was conducted by IPES and MVCS/OMA in 2010 supported by other members of the learning alliance and jointly financed by SWITCH and the Ministry. It trained 100 representatives of municipal service providers, local and regional governments, producers association, local water authorities etc. The Training Course was designed for municipal officers and water and sanitation technicians of enterprises managing wastewater treatment systems and oriented towards the reuse of treated wastewater in agriculture, forestry and green areas. It is intended to strengthen the use of SWITCH project findings, support the implementation of the policy guidelines and promote the scaling up of the recommendations at national level. It is expected that this training will be repeated for the Andean and Amazon cities in Peru.

Based on the research, demonstrations, training and guidelines, contributions were made the SWITCH Training Kit Managing Water for the City of the Future (Sub Module
3C: Managing Wastewater in the City of the Future, including cases on Lima, Beijing and Accra), and to the training package on ecosanitation and urban agriculture.

3. Conclusions

Urban challenges related to the water-sanitation-agriculture nexus call for a number of initiatives or interventions, advocacy, multi-stakeholder dialogue and joint action planning. New forms of governance, institutions and policies are needed.

SWITCH Work package 5.2 “Resource recovery and use of urban waste water for urban agriculture aimed to contribute to a paradigm shift in thinking on wastewater management and sanitation, and assisted cities in their transitioning towards a decentralised, recycling-oriented approach, linking water, sanitation, resource recovery and local food production.

Urban and peri-urban agriculture are different from, but complementary to, rural agriculture in enhancing food security in urban settings. It is an integral part of the urban food production system, contributing to the urban economy, livelihoods, food security, preservation and recycling of natural resources, and reduction in green house gas emissions within the cities. Urban agriculture not only enhances food security for the urban poor, but also contributes to the social, economic, and environmental dimensions that support city life as a whole. The actual and potential role and importance of water for urban agriculture and livelihoods varies across cities.

Access to water and irrigation is a crucial requirement for farmers to earn sufficient revenues to pull them up and over the poverty line. Sufficient profits with niche products may also allow them to innovate and adopt improved technologies that will improve the complementary role of urban agriculture in the city. While market proximity supports urban farming, urban expansion and environmental pollution constrain its sustainability.

Issues related to productive agricultural use of urban water, needs to be addressed through innovative thinking and strategising, utilizing a multi-prong approach. On the technical side, adequate infrastructure for reclamation, storage and distribution must be planned with end-uses in mind. With sufficient economic resources, wastewater can be treated to primary or secondary levels, appropriate to its agricultural end-uses, made more efficient by separation. A major challenge lies on the demand-side. Pricing policies need to be designed to reduce freshwater use and make reclaimed water more competitive while protecting farmers’ livelihoods. Wastewater must be considered an economic good, whose price reflects its true value to farmers. From the farmers’ perspective disincentives include distrust of the quality of reclaimed water, concerns about marketing crops and acceptability among consumers, concern for health impacts, religious prohibition or simply psychological aversion.

In the long run these relations may change, as part of resilient cities. Farmer involvement is critical to the success and sustainability of reuse. Effective education and awareness campaigns should be implemented using simple, everyday language, have focused content and should be lead by respected experts who supplement teaching with demonstrations of best practice in the field.
Locally appropriate solutions need to be supported by standards. For example, if 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. 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, and transitioning to the city of the future requires multi-stakeholder consultation, joint planning and joint decision-making, in order 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. Applied research and demonstrations at city level are needed to assess risks and risk management options in support of the local policy dialogue.

References


WHO 2006, Guidelines can be downloaded from www.who.int/water_sanitation_health.

Deliverables WP 5.2
A full list of deliverables is available with SWITCH and with the author(s)

General
Key Outputs:
5.2.4 Ga Decentralised waste and wastewater systems.

Accra: Using waste water for urban agriculture
Key Outputs:
5.2.4 Ab2 (forthcoming) PhD thesis: Ernest Abraham: Enhancing Urban Water Quality for Crop Cultivation and Other Livelihood Opportunities: Case of Accra’s Odaw- Korle Catchment:
5.2.3 Ba 1/5.2.4 Ae2 Report of Demonstration: Design Considerations and Constraints in Applying On Farm Wastewater Treatment for Urban Agriculture
5.2.4 Ba 2/5.2.5 Ac Guidance note for National Programme Managers and Engineers; Options for Simple On-Farm Water Treatment in Developing Countries: Third edition of the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture. IWMI, FAO, WHO, IDRC.

Accra: Collection, storage and re-use of urine for urban agriculture
Key Outputs:
5.2.4 Ba 3 /5.2.4 Ad2Demo and Training Report of MoFa and Farmers on Urine storage and use.
5.2.4 Ad3 MSc Thesis: Mark Kwame Ofei, University Ghana: "Financial feasibility of urine use for agriculture in Accra".
5.2.4 Ad4 MSc Thesis: Patrick Koomson, University Ghana: "Perception and willingness to pay for urine in Accra, Ghana:

Beijing: Rainwater harvesting for improved urban agricultural systems
Key Outputs:
5.2.4 Ba1 PhD. Thesis. Water Scarcity, Risk Assessment and Management in China Li Jiuyi. 2009.
5.2.4 Bc4 Diversification of water sources and more efficient use in urban agriculture in Beijing JI Wenhua, CAI Jianming, René van Veenhuizen. 2009. Presented at SC meeting in Delft.

Lima: Inventory of treatment of waste-water and re-use for urban agriculture in Lima
Key Outputs:
5.2.4 Ld Analysis and demonstration of treatment and re use of waste water in Lima.
Castro, Merzthal, Bustamente. 2008.
5.2.4 Le Report on Demonstration in Lima IPES 2010.

Lima: Developing Policy Guidelines on the treatment of waste-water and re-use for urban agriculture
Key Outputs:
5.2.3 BL1 Policy Guidelines to promote treatment and use of domestic wastewater for irrigation of green areas and other uses in urban and peri-urban areas. (In Spanish: Lineamientos de Politica 2009).
5.2.3 BL2 Training Module (National Course) on the treatment and use of wastewater for parks and (urban) gardens (2009).