**018530 - SWITCH**

**Sustainable Water Management in the City of the Future**

Integrated Project
Global Change and Ecosystems

**Deliverable 5.2.4 - (replaces original deliverables 5.2.5, 5.2.6 and 5.2.9)**

# PhD and MSc Research and Action Research and Demonstrations on the Use of Water for Urban Agriculture

Due date of deliverable: M50
Actual submission date: M60

Start date of project: 1 February 2006 Duration: 63 months

Organisation name and lead contractor for this deliverable: ETC (coordinator)

Revision [final]

| **Project co-funded by the European Commission within the Sixth Framework Programme (2006-2011)** | | |
|---|---|---|
| **Dissemination Level** | | |
| **PU** | Public | X |
| **PP** | Restricted to other programme participants (including the Commission Services) | |
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**SWITCH Deliverable Briefing Note** **Deliverable 5.2.4**

**SWITCH Documents (with RUAF Cities Farming for the Future)**

Deliverable 5.2.4. PhD and MSc Research and Action Research and Demonstrations on the Use of Water for Urban Agriculture

**Deliverable reference:** D.5.2.4

**Author(s) and Institution(s)**

**Various (see below)**

*The aim of Work package 5.2 is to contribute to a paradigm shift in wastewater management and sanitation towards a recycling-oriented closed loop approach, by identifying and integrating appropriate productive re-use of urban freshwater, storm and waste-water for agriculture into the policy, legislative and regulatory, planning and decision-making frameworks of cities. The Work package is being implemented in three cities; Accra, Beijing and Lima.*

*The deliverables of the work package follow a sequence of implementation. Based on a situation and stakeholder review (del. 5.2.1), working groups are formed, meet and are linked to the Learning alliances (del. 5.2.2), they receive training in multi-stakeholder action planning (del. 5.2.3 A), and are involved in, and informed on, specific research by consultants, MSc and PhD or action research linked to the demonstrations, (all under del. 5.2.4). Information has been disseminated in publications, magazines and newsletters (del. 5.2.5), and guidelines and related training material has been developed (del 5.2.3 B and C). The leading institutes here are ETC (WP coordinator), IWMI (Accra), IGSNRR (Beijing) and IPES (Lima), other institutions involved were WUR, IRC and NRI-GUEL.*

**Contributing products to this deliverable are the following:**
**A number of these products have been bundled in one file under the titles in bold.**

**5.2.4 General Overview**
*5.2.4 Ga* Decentralised waste and wastewater systems.
Van Veenhuizen, René en Adriaan Mels. 2008. Integration Paper. Paper presented at the SWITCH Scientific Seminar in Belo Horizonte.
5.2.4 Gb; briefing note on Resource Recovery and Use for Urban Agriculture.

*Also see 5.2.1 Ga Multiple sources of water for multifunctional urban agriculture*
*René van Veenhuizen, Olufunke Cofie, Adrienne Martin, Cai Jianming, Gunther Merzthal, Joep Verhagen*

5.2.4 Accra
*5.2.1 Aa* Baseline study Report on Dzorwulu-Roman Ridge Demonstration site, Accra, Ghana.
Seth Agbottah, Luke Abatania, Adrienne Martin, Olufunke Cofie. 2008. (also deliverable 6.3.1)

**5.2.4 Ab Accra PhD Thesis Ernest Abraham (IWMI, GUEL)**
5.2.4 Ab Briefing Sheet
5.2.4 Ab1 PhD Proposal Ernest Abraham (IWMI, GUEL)
Improving Urban Water Quality based on a Stakeholder Orientated Integrated Planning Approach in Accra's Odaw-Korle Catchment, Ghana.
*5.2.4 Ab2* (forthcoming in July 2011) *PhD thesis*: Ernest Abraham: *Enhancing Urban Water Quality*

*for Crop Cultivation and Other Livelihood Opportunities: Case of Accra's Odaw- Korle Catchment*:
*5.2.4 Ab3* The Challenge of urban flood control: The case of Accra's Korle Lagoon
E.M. Abraham, P. Drechsel and O. Cofie. 2009.
*5.2.4 Ab4* Water-dependent livelihoods in selected communities: Analysis of practices and perception of water quality in Accra Ernest Mensah Abraham, Olufunke Cofie, Liqa Raschid-Sally,Adrienne Martin, IWMI, GUEL. 2009. Presented at the SWITCH SC meeting, Delft.

**5.2.4 Ac Accra PhD Thesis Daan van Rooijen**
5.2.4 Ac Briefing Sheet
*5.2.4 Ac PhD thesis*: Daan van Rooijen: Water Resources, Infrastructure, Demand and Access to Urban Water Services in three cities. PhD Thesis (expected mid 2011) is not funded by SWITCH, but two related papers are:
*5.2.4 Ac1:* Analysis of Water Resources, Infrastructure, Demand and Access to Urban Water Services in Accra, Ghana. Daan van Rooijen
*5.2.4 Ac2* Harnessing the Water - Sanitation - Agriculture Nexus for Improved Irrigated Farming in Urbanizing Countries. Daan van Rooijen and Olufunke Cofie. IWMI Research Report

**5.2.4 Ad Accra Demonstration on the use of urine as an alternative fertilizer in urban agriculture.**
5.2.4 Ad1 Demonstration Proposal Demonstration on the use of urine as an alternative fertilizer in urban agriculture.
5.2.4 Ad2 Full Report, Olufunke Cofie, Philip Amoah, Irene Eygir, Noah Adamtey, Frederick Tettey Lowor. 2011. IWMI-: "Demonstration on the Use of Urine in Urban Agriculture in Accra, Ghana". including report on research, demo and training:
5.2.4 Ad3 MSc Thesis (Briefing Sheet): Mark Kwame Ofei, University Ghana: "Financial feasibility of urine use for agriculture in Accra".
5.2.4 Ad4 MSc Thesis (Briefing Sheet): Patrick Koomson, University Ghana: "Perception and willingness to pay for urine in Accra, Ghana:
5.2.4 Ad5 Identification of Potential Pharmaceutical Residues Present in Urine Samples Collected from a Public Urinary Located Within the Market Adjacent Novotel Hotel, Accra.
MSc, Collins Tay, CSIR Water Research Institute, Accra. 2010.
Report on Training See deliverable 5.2.3;

**5.2.4 Ae Accra Demonstration On-farm wastewater treatment**
*5.2.4 Ae1* Demonstration Proposal On-farm wastewater treatment
*5.2.4 Ae2* Report of Demonstration: Design Considerations and Constraints in Applying On Farm Wastewater Treatment for Urban Agriculture Philippe Reymond, Olufunke Cofie, Liqa Raschid and Doulaye Kone. 2009. International Water Management Institute, Africa Office, Accra,Ghana.
5.2.4 Ae3 Design considerations and constraints in applying on-farm wastewater treatment for urban agriculture Philippe Reymond Olufunke Cofie* Liqa Raschid and Doulaye Kone. 2009.IWMI, Ghana; Eawag\Sandec

**5.2.4. Accra other research papers and reports**
*5.2.4 Af* MSc Thesis (Briefing Sheet) Addressing pollution and river recovery processes in the middle catchment of the Densu River Basin in Ghana *Edmund Kyei Akoto-Danso University of Ghana, Legon.*
*5.2.4 Ag* Analysis of domestic water use for commercial activities among the poor in Alajo and Sabon Zongo communities of Accra, Ghana. Kihinde Odunuga
*5.2.4 Ak1* KNUST Cadmium (Cd) and Lead (Pb) concentrations effects on yields of some vegetables due to uptake from irrigation water in Ghana. 2008. E. Mensah; Herbert E. Allen; Ryo Shoji; S.N. Odai and David M. Metzler. International Journal of Agricultural Research, 3(4): 243-251

*5.2.4 Ak 2* KNUST Influence of transpiration on cadmium and lead uptake by cabbage, carrots and lettuce from irrigation water in Ghana. 2008 E. Mensah; S.N. Odai; E. Ofori and N. Kyei-Baffour Asian Journal of Agricultural Research, 2(2): 56-60.
*5.2.4 Ak 3* KNUST Influence of cadmium and lead concentrations of irrigation water on dry matter yield of vegetables. 2009. E. Mensah; M. Bonsu; S.N. Odai; r. Shoji; N. Kyei-Baffour and E. Ofori, Journal of Environmental Science and Technology, 2(1): 68-72.
*And the following KNUST Students have participated (no papers available)*
-Dela Sipitey (June. 2007). Heavy Metals Uptake By Vegetables Cultivated On Waste Dump Sites In Kumasi, Ghana. Supervised by: Dr. A.N. odai and Mr. Ebenezer Mensah
-Richard Amfo-Out (June, 2007). Behaviour Of Lead And Cadmium Concentrations From Irrigation Water In Soils At Five Urban Irrigation Sites In Ghana. Supervised by: Mr. Ebenezer Mensah and Dr. S.N. Odai
-Barajei Chelteau (July, 2007). Lead and cadmium concentrations in Vegetabels from selected markets in Ghana. Supervised by Dr. S. N. Odai and Mr. Ebenezer Mensah

**5.2.4 Ba Beijing Phd Water Scarcity Assessment at Regional Scale**
5.2.4 Ba1 PhD. Thesis. Water Scarcity, Risk Assessment and Management in China Li Jiuyi. 2009.
*5.2.4 Ba2* Framework for Water Scarcity Assessment and Solution at Regional Scale
Li Jiuyi, Li Lijuan, Liang Liqiao, Li Bin, Liu Yumei, 2009. Abstract of paper in Chinese.
*5.2.4 Ba3* Water Issues in Beijing-Tianjin-Tangshan Region. Li Lijuan, Li Jiuyi, 2009.
*5.2.4 Ba4* Impact assessment of climate variability on stream flow in the upper and middle reaches of the Taoer River based on the Budyko hypothesis. Li Bin, Li Lijuan 2010.
5.2.4 Bb *PhD. Thesis*, Spatial-Temporal Evolutional Laws of the Key Hydrological Elements in the Lancang River Basin. Li Bin. (in Chinese with English abstract)

**5.2.4 Bc Beijing Phd Optimized use and management of rainwater harvesting**
*5.2.4 Bc1* Optimized use and management of rainwater harvesting, in Beijing. PhD proposal Ji Wenhua.
5.2.4. Bc2 *PhD. Thesis.* Optimization and Management of Rainwater Harvesting and Reusing-A Case Study of Beijing JI Wenhua, (in Chinese with English abstract)
*5.2.4 Bc3* Analysis of an adapted rainwater harvesting technology for peri-urban agricultural production in Huairou, Beijing JI Wenhua and Cai jianming, IGSNRR – China, 2009. Presented at SC meeting in Delft.
*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
*5.2.4 Bc5* Adapting to Water Scarcity: improving water sources and use in urban agriculture in Beijing Ji Wenhua and Cai Jianming. 2008.
*5.2.4 Bc6* New water source for urban agriculture—rainwater harvesting demonstration in Huairou, Beijing Ji Wenhua, Cai Jianming. 2008. Presented at SC meeting in Belo Horizonte

Publications
5.2.4 Bf Potential Estimation of Rainwater Harvesting by Roofs of Residential Areas in Beijing. Ji Wenhua, Cai Jianming, René van Veenhuizen. Published in “Resources Sciences”, Vol.2, 2010 (in Chinese with English abstract□
5.2.4 Bg Efficiency and Economy of a New Agricultural Rainwater Harvesting System. Ji Wenhua, Cai Jianming. Published in “Chinese Journal of Population, Resources and Environment” Vol.8 No.2 March 2010 (in English)
5.2.4 Bh Optimization of the scale of greenhouse agricultural Rainwater Harvesting and utilization project. Ji Wenhua, Cai Jianming. Published in “Transactions of the CSAE” Vol.26 No.8 Aug.2010 (in Chinese with English abstract)
*Also see deliverable on City Assessments, chapter on Beijing under WP. 6.2*

**5.2.4 La Market Study of Urban Agriculture Products IPES. 2007**
(in Spanish, with English summary)

**5.2.4 Lbcd Analysis of case studies on Urban Agriculture and Reuse of Wastewater**
*5.2.4 Lb* Analysis of 6 case studies on Urban Agriculture IPES. 2008. (in Spanish, with English summary)
*5.2.4 Lc* Analysis of 6 case studies of reuse of wastewater IPES. 2008. (in Spanish, with English summary)
*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.**

*Also see deliverable on City Assessments, chapter on Lima under WP. 6.2*

**Publication date:**
-Various, see above

**Audience :** UA working group and LA members in Accra, Beijing, Lima, and Hamburg, WP 5.2 participants, and SWITCH wide audience (SC meeting).

**Purpose :**

The original set up of research under WP 5.2 was concentrated in tasks 5.2.5 (predetermined research) and 5.2.6 (grants to LA members) was changed into one task covering:
- general research (the assessments of treatment and re-use systems in Lima and the PhDs in Beijing and in Accra);
- research related to the demonstrations in the cities of Accra, Beijing and Lima;
and in combination with task (5.2.9): improvement of the demonstrated technologies, would lead to **deliverable 5.2.4**:

ETC coordinated and supported the research, while IGSNRR coordinated the work in Beijing, IPES in Lima, and IWMI in Accra. Other institutions involved were KNUST, WUR, IRC, and NRI in Accra, IRC in Lima and WUR in Beijing. Progress and lessons learned regarding research, training and demonstrations have been evaluated by these institutions for Beijing and Lima under WP 6.2.

**Background : Resource recovery and use of urban waste water for urban agriculture**
Water and food security are 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.

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 sought to

assist cities in their transitioning towards a decentralised, recycling-oriented approach, linking water, sanitation, resource recovery and local food production. It involved applied research in Accra, Beijing and Lima, studying the actual situation and potential of use of rainwater, wastewater and ecosanitation for urban agriculture, involving multiple stakeholders in this work. 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.

**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.

Action research focused on 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. 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. With WP 4.1 part of the farmer groups was involved in a demonstration of linking production with sustainable sanitation. This involved mainly the collection, treatment and use of urine for farming at the demo site. This 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. The study included an economic feasibility and a perception study, and an agronomic component in the form of field trials.

**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 up-scaling 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.

In 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 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.

**Lima**

Urbanisation is intense in Lima and Callao, home to 8,472.935 residents in 2008. Annual rainfall is almost non-existent at around 9 mm a year. Metropolitan Lima and Callao city get their water from surface and underground sources, with a high dependence on the Andes glaciers. Around 75% of the available water is used for human consumption, 22% by agriculture in peri-urban and urban areas and the rest (3%) on green spaces and for industrial and mining activities.
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. It is supported by the agricultural customs and traditions of the new inhabitants who came to the city from rural areas of Peru. Less than 15% of parks and gardens in the city are irrigated with treated wastewater. 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.

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;

**Potential Impact**

Multiple functions

Food
Water
Linking to Ecosanitation

**Accra**

**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)
-a combination with agro tourism;
- surplus water was used for groundwater infiltration;
- the various (often new) sectoral institutions (water and agricultural bureaus) were involved.

The PhD Research in Beijing is very much related to this demonstration. 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.

The demo was linked to opportunities of bottom up innovations in the central planning system in China. However the participative process as envisaged in the SWITCH LA process is more difficult, since research institutes are expected to provide good science on innovations, before assembling higher-level authorities of the different stakeholders to discuss this.

PhD student Li Jiuyi and prof. Li Lijuan provided information on water resources and demand, and different scenario's in the Beijing-Tianjin-Tangshan Region. In addition PhD student Ji Wenhua and Prof Cai Jianming published several papers related to water sources for urban agriculture. The new insights of these studies are predominantly linking existing sources of information (water sources and demand and use for urban agriculture in Beijing). Through the action research and the demonstration in Huairou Ji Wenhua analysed different types of rainwater harvesting (propagated by the Beijing Agricultural Bureau), on their efficiency and cost/benefit, and specifically looked at the improved systems as developed with the Huairou Cooperative, which combines an improved RWH system with improved production. PhD student Xiao Liang (of work package: 6.3) supported this analysis. 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 agri-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 waste water, linked to improved production and income, with both the Beijing Water Bureau and the Agricultural Bureau.

The research has not been truly demand-driven, but it is to a large extent determined by the foregoing work of IGSNRR with the cooperative in Huairou, and it does reflect the needs of local stakeholders. Universities and research institutes are seen as neutral and are optimal facilitators in China. In addition, networking is key.

The RWH technologies were not new. The combined innovations: the technology of combined greenhouses, the storage pool, the improved production, as well as the organisational model (the cooperative) and institutional linkages were. Finding the best RWH technologies and models for agricultural development in Beijing and supporting its uptake is considered an important issue. The Beijing Agricultural Bureau has been experimenting with several RWH models, and is now including the one supported by SWITCH. Discussions on these have been held in the working group meetings. The PhD student 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.

The potential of the adapted technology of RWH combined with improved production is high. Available surface- and groundwater is less that demanded in Beijing, while the South-North Water Transfer project is delayed and even than this would be primarily for domestic use. RWH is key 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.

The current acreage of agriculture land under glasshouses, and the potential for further development is high in Beijing, while the current proportion of irrigation using rainwater harvesting is still very low, accounting for less than 1 percent. IGSNRR agreed with the Beijing Agricultural Bureau, one of the key stakeholders, to undertake more joint action research at selected demonstration sites on RWH.

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 waste-water and the adapted technologies are scaled up in various other areas.

**Lima**

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.

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. 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).

In Lima, the team also analysed the normative and institutional framework related directly or indirectly to water management with a focus on wastewater, and suggested changes in the legal framework and identified the need for capacity development of and inter-institutional collaboration. After the inventory, IPES and MVCS/OMA, with the new 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 are 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.).

The 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). They were formally approved in November 2010 by the Peruvian Government. The Policy Guidelines will act as a strategic agenda for the institutions involved. IPES and the Ministry have developed a training package for capacity building of these institutions.

**Recommendations** (Direct at target audience above).