018530 - SWITCH

Sustainable Water Management in the City of the Future

Integrated Project
Global Change and Ecosystems

Deliverable 5.2.4 - Annex 2

Analysis of Water Resources, Infrastructure, Demand and Access to Urban Water Services in Accra, Ghana

And

Harnessing the Water -Sanitation-Agriculture Nexus in Urbanizing Countries

Due date of deliverable:
Actual submission date:

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

Organisation name and lead contractor for this deliverable: IWMI (Daan van Rooijen and Olufunke Cofie)

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)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

5.2.4 Action Research and Demonstrations on the Use of Water for Urban Agriculture
Work package 5.2

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. The work package is being implemented in three cities; Accra, Beijing and Lima, and includes the identification and integration of appropriate productive re-use of urban freshwater, storm and waste-water for agriculture into the policy and planning frameworks of these cities.

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.

As part of deliverable 5.2.4, this product contains information on the work of Daan van Rooijen on water resources, infrastructure, demand and access. Contributing products included in this document are:

5.2.4 Ac Briefing Sheet
The Full PhD report is listed under PhD and MSc reports, theme 5, (forthcoming in July 2011), 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

WEDC Developing knowledge and capacity in water and sanitation

Options Analysis for Water Demand Management

By

Sam Kayaga, Daan Van Rooijen & Ian Smout

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Loughborough University

Integrated Resource Planning Framework

- A process in which a full range of both supply-side and demand-side options are assessed against a common set of planning objectives or criteria

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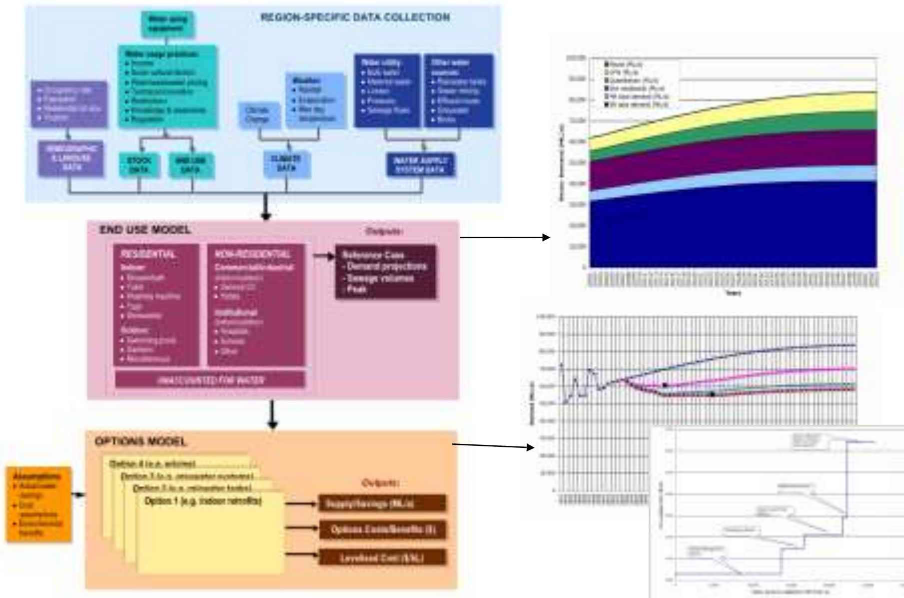
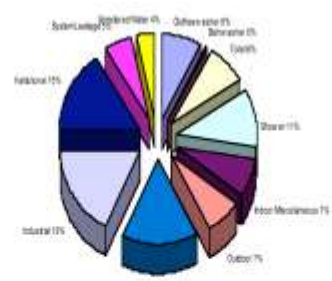
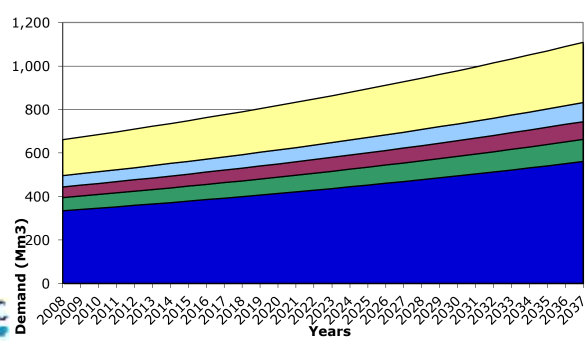
Integrated Resource Planning Framework



Key IRP Components 1

- Disaggregation of demand into end uses for accurate forecasting & targeting for potential savings





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Key IRP components 2

- Consideration of a broad spectrum of viable options that satisfy service needs
  - o Water efficiency
  - o Source substitution
  - o Re-use
  - o Supply options
- Comparison of options using a common metric, boundary and assumptions

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Key IRP components 3

- Participation of the LA – recognising that water service provision interacts with
  - o Other natural resource management systems
  - o Other urban development systems
  - o Consumer preferences
- Adaptive management
  - o On-going learning process
  - o Initiatives decided upon, implemented and evaluated in repeated cycles

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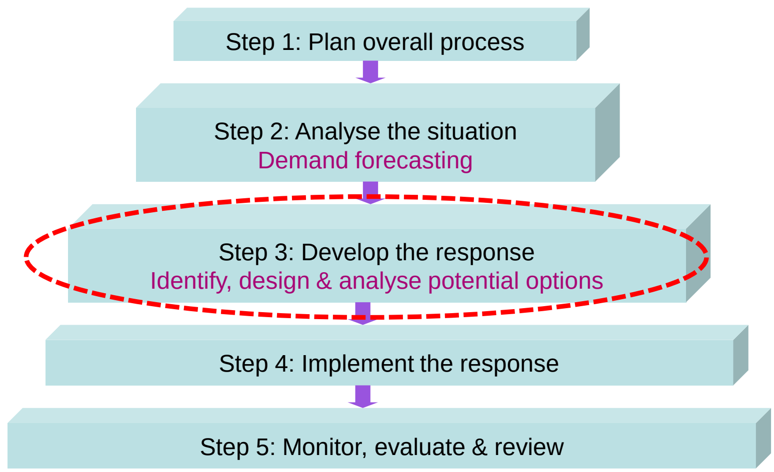
The 5-step IRP Framework



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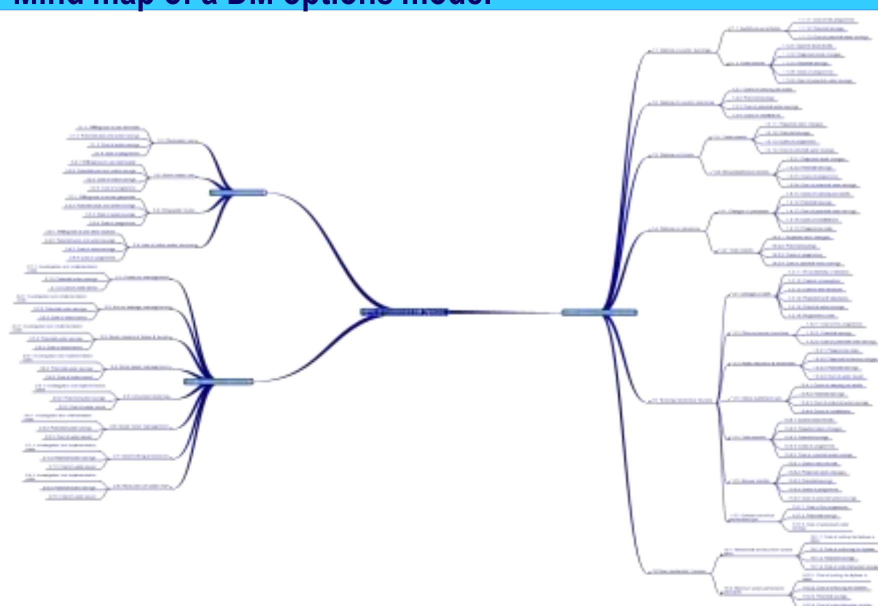
Mind map of a DM options model



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Model design

- Time frame is 30 years, 2010-2040
- 12 water demand management options modelled
- Designed for fictive city, but with realistic assumptions based on Accra & Alexandria
- Model layout still to be made more illustrative
- Non-revenue yet to be specified by:
  - Physical losses
  - Reduction in water theft (illegal connections)
  - Improved metering coverage
  - Improved billing procedures
  - Good practices of installation, maintenance & replacement of meters

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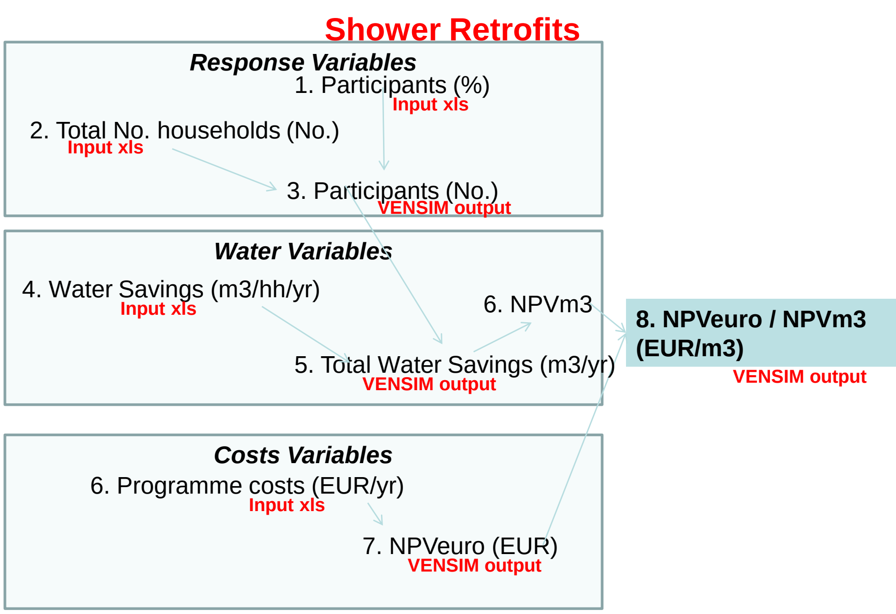
VENSIM WDM options model structure



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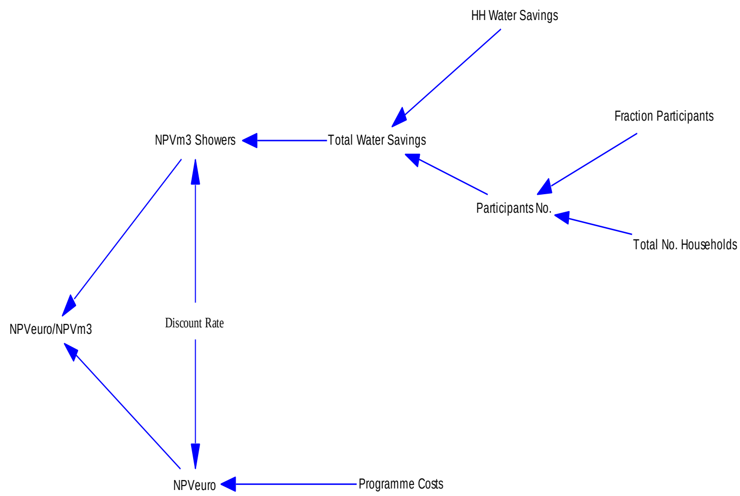
VENSIM layout / shower retrofits



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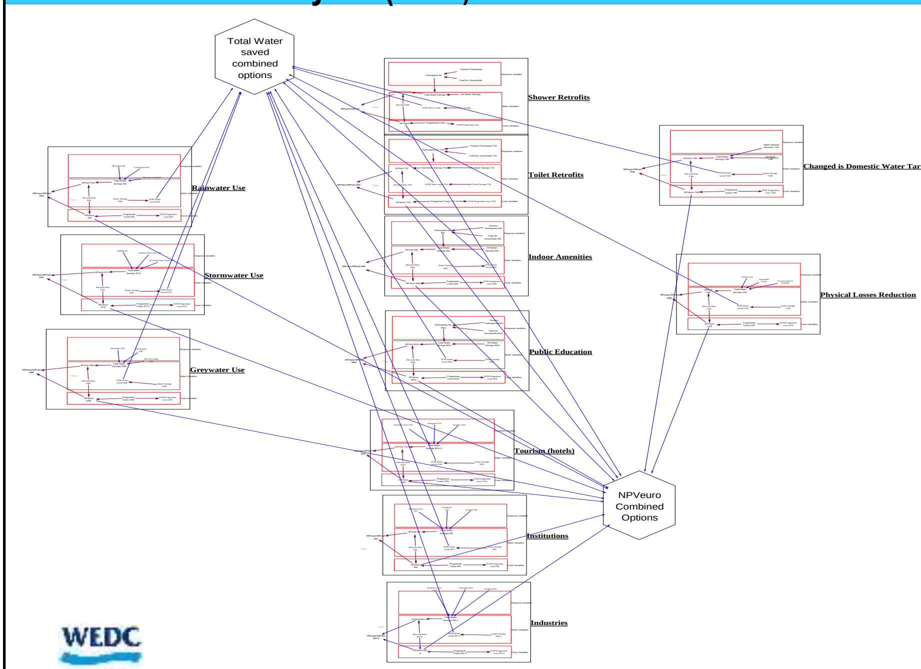
VENSIM model layout (draft)



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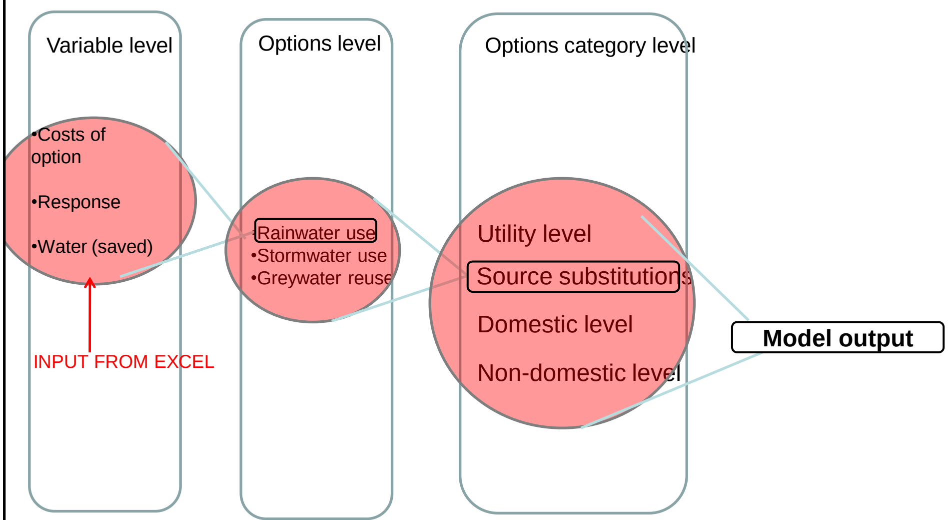
Structure of the VENSIM model



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Results

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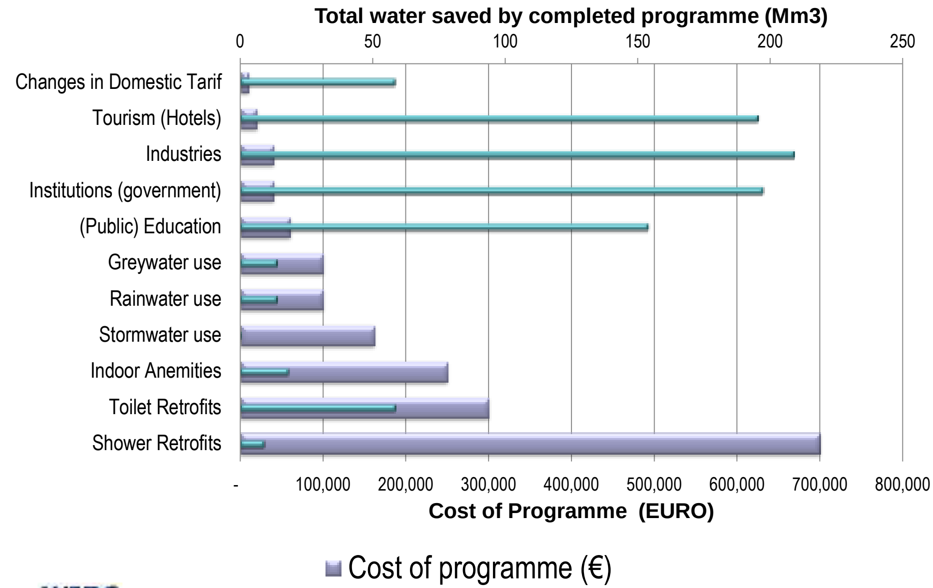
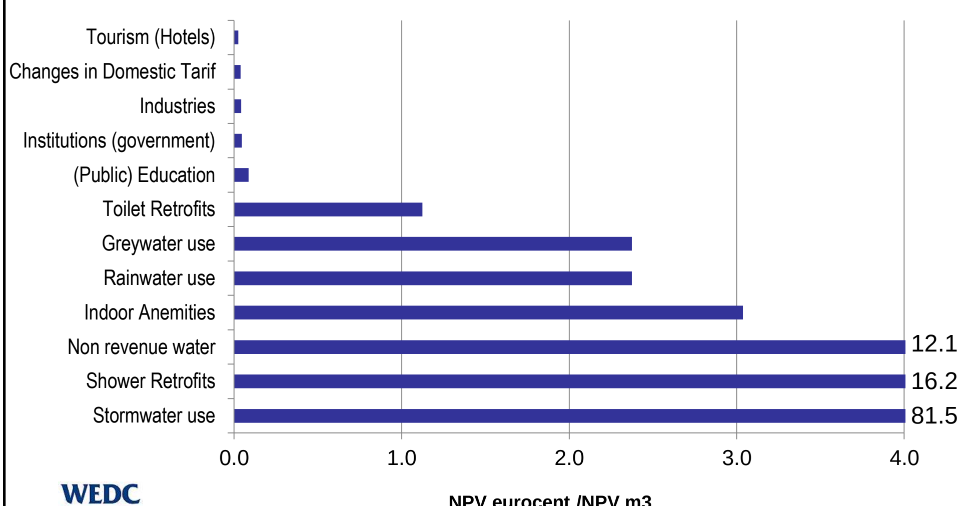
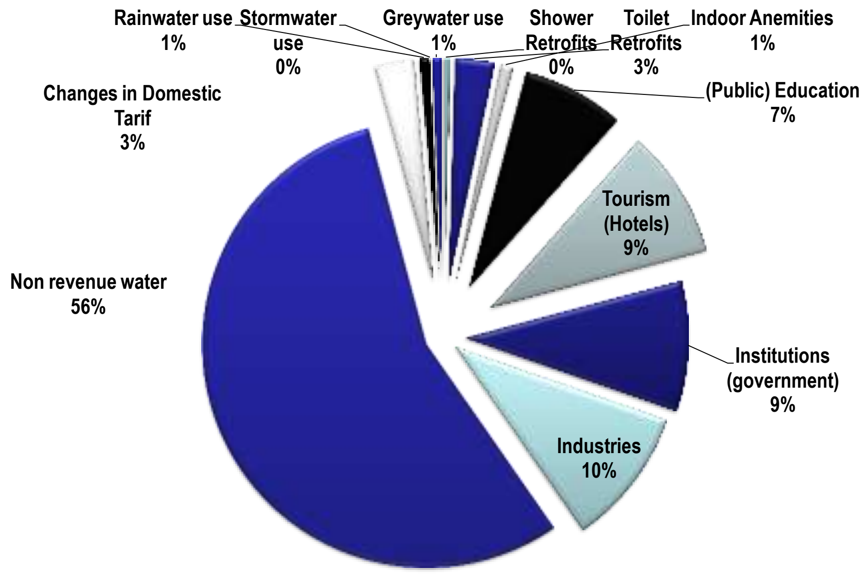
Programme costs vs. water savings



Costs effectiveness of programmes



Share of WDM option in total potential water volume saved



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Spreadsheet layouts

Times series and constant value-input spreadsheet for VENSIM

WDM Options	*discount rate:*	7%	Time step	0	1	2	3	4	5	6
USER INPUT	VENSIM INPUT	CALCULATED	YEAR	2010	2011	2012	2013	2014	2015	2016
general data	households	800,000								
END USE LEVEL										
Shower Retrofits										
Participants	%	25%	1	1%	5%	10%	15%	20%	25%	25%
Water savings	litres/hh/d	5	2							
	m3/hh/year	1.8	3							
	m3/year	365,000	4	14,600	73,000	146,000	219,000	292,000	365,000	365,000
	total (m3)	10,234,600	5							
	NPVm3	3,649,392	6							
Costs	total in EUR	700,000	7	200,000	200,000	100,000	100,000	100,000	0	0
	NPV EUR	590,822	8							
Unit cost	NPV EUR/NPVm3	0.162	9							
Toilet retrofits										
Participants	%	20%	1	1%	4%	8%	12%	16%	20%	20%
Water savings	litres/hh/d	40	2							
	m3/hh/year	15	3							
	m3/year	2,336,000	4	93,440	467,200	934,400	1,401,600	1,868,800	2,336,000	2,336,000
	total (m3)	65,501,440	5							
	PVm3	23,356,106	6							
Costs total	EUR	300,000	7	100,000	100,000	100,000	0	0	0	0
	NPV EUR	262,432	8							
Unit cost	NPV EUR/NPVm3	0.0112	9							
Indoor Anemities										
Participants	%	10%	1	0%	2%	4%	6%	8%	10%	10%
Water savings	litres/hh/d	25	2							

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Spreadsheet layouts

Summary of water savings

Water Savings m3/year		0 2010	1 2011	2 2012	3 2013
End Use Level					
Shower Retrofits		14,600	73,000	146,000	219,000
Toilet retrofits		93,440	467,200	934,400	1,401,600
Indoor Anemities		29,200	146,000	292,000	438,000
(Public) Education		186,880	951,219	1,936,682	2,957,314
Tourism (Hotels)		121,400	1,235,852	1,572,622	2,134,572
Institutions (government)		122,500	1,247,050	1,586,871	2,153,913
Industries		129,917	1,322,552	1,682,947	2,284,320
	sub total	**697,937**	**5,442,873**	**8,151,522**	**11,588,719**
Source level					
Rainwater use		8,760	89,177	113,477	154,027
Stormwater use		400	4,000	5,000	6,667
Greywater use		8,760	89,177	113,477	154,027
	sub total	**17,920**	**182,354**	**231,955**	**314,720**
Utility Level					
Changes in Domestic Tarif		0	1,701,078	1,731,697	1,762,868
Non revenue water		41,322,222	41,322,222	41,322,222	41,322,222
	sub total	41,322,222	43,023,300	43,053,920	43,085,090

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Advantages of VENSIM (over a spreadsheet based model)

- Visualization of relationships between parameters & variables
- With each time step parameters can change; you can play with them..
  - You can explore and better understand interaction between system components
- Sensitivity analysis – easy to do.
- Automatic generation of parameters (with units) and equations used
- Error messages when units are not compatible, when values become unrealistic during modeling, etc.
- Can be used to carry out object-oriented modeling

VENSIM facilitates getting a deeper understanding of the effect of any system and its dynamic

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Further information

- www.switchurbanwater.eu
- s.m.kayaga@Lboro.ac.uk and
- i.k.smout@Lboro.ac.uk

Thank you for your attention

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Harnessing the Water - Sanitation - Agriculture Nexus in Urbanizing Countries

Olufunke Cofie* & Daniel van Rooijen

International Water Management Institute PMB CT 112, Accra Ghana
*Corresponding Author: Email. o.cofie@cgiar.org; Tel/Fax: +233 21784753/2

1. Introduction

Cities around the world are facing dynamic pressures arising from rapid urbanization both in terms of demography and increased intensity of activities by the urban population. The threshold of 50% of the global population living in cities was reached in 2007 following the rate of rural-urban migration and natural growth (especially in developing countries) in the last 50 years (UNDP 2006). The next 30 years will bring greater changes than previously experienced: approximately 4.9 billion of the total 8.1 billion inhabitants will end up in cities by 2030 (Marcotullio et al 2007). It has been reported that almost the entire increase in future urban population will occur in developing countries, where physical and economic resources are already under stress. According to United Nations projections, the towns and cities of the developing world will make up 81 per cent of urban humanity by 2030 (UNFPA 2007). Typically, this rapid urbanisation is only demographic as it is not accompanied by similar rate of infrastructural transformation but rather puts more pressure on limited urban resources. Some of the challenges that go with urbanisation are, limited access to water supply, poor sanitation, rising food demand as well as prices, and poor governance at various levels. The ongoing shortfall of investment in expansion of basic infrastructure and services in many urban areas has only made these challenges bigger.

Emerging Water and Sanitation issues in Urbanizing Countries

In urbanizing countries, many cities suffer from water scarcity primarily because of insufficient capacity to withdraw, treat and distribute the water. Water shortage is further worsened due to deterioration and subsequent dropping out of local and traditional water resources such as groundwater and streams. Water scarcity affects one in three people on every continent of the globe. Almost one fifth of the world's population (about 1.2 billion people) live in areas where the water is physically scarce. One quarter of the global population also live in developing countries that face water shortages due to a lack of infrastructure to fetch water from rivers and aquifers (WHO/UNICEF 2008). Although 86% of urban areas is assumed covered as compared to 50% in the rural areas, much urban coverage refers to vendor supply rather than household connection. Households that are dependent on water from vendors often have no other choice and usually pay up to 10 times more than the official water tariff (Varis 2006). Only 16% of the population of sub-Saharan Africa (SSA) has a household connection while it is 20%

and 28% in Southern Asia and South-eastern Asia respectively (WHO/UNICEF 2006). Since a great number of urban dwellers (for example 52 million out of 373.4 million people in urban Africa (UN-Habitat 2008) lack access to improved water supply, the possibility that this limited water resource will be used for agriculture in and around cities is minimal. As a matter of fact, many municipal authorities forbid the use of domestic water for irrigated agriculture even at the lowest scale. Even though agriculture is considered generally as the greatest consumer of water in the world, withdrawing up to 70% of freshwater resources, the intersectoral competition in urban agglomerations presents a different scenario from the above: there is greater proportion of economic activities concentrated in space confined urban areas, competing for same water resources where agriculture stand very limited chance.

Urban Water Supply

The provision of sufficient water to urban areas in rapidly urbanizing countries is a real challenge for local water companies and municipal authorities. Access to water is especially problematic in the new peri-urban fringes being subject to urban sprawl, and that are not covered by a piped water distribution network. Similarly, wastewater disposal may cause environmental problems where on site treatment systems (most commonly septic tanks) have not been constructed.

Doubts have arisen as to whether conventionally perceived ideals such as 24/7 hour water supply and 100% private sanitation coverage could be reached in the current challenging realities of cities with highly insufficient budgets for infrastructural development. Besides governmental challenges, there are questions as to whether water will be available in sufficient quantity and quality to meet future demands. Water competition between agricultural and urban domestic and industrial use is on the increase in many cases due to rapidly increasing non-agricultural demands at the city and basin level (UNFPA 2003; Molle & Berkoff 2006; van Rooijen et al. 2009).

The way in which urban water supply, sanitation and agriculture are interrelated is through water (Fig. 1). Water is being abstracted from upstream sources, treated and pumped into the urban area. After water has been used, most of the remaining 80% finds its way into the urban drainage network where it eventually flows into downstream water bodies like rivers, lakes, swamps or oceans. Along the way down, this lesser quality water is being used on agricultural fields for food production. In water scarce cities, the circle is often round where water-after-use is being used again for any productive purpose (Lundqvist et al. 2003).

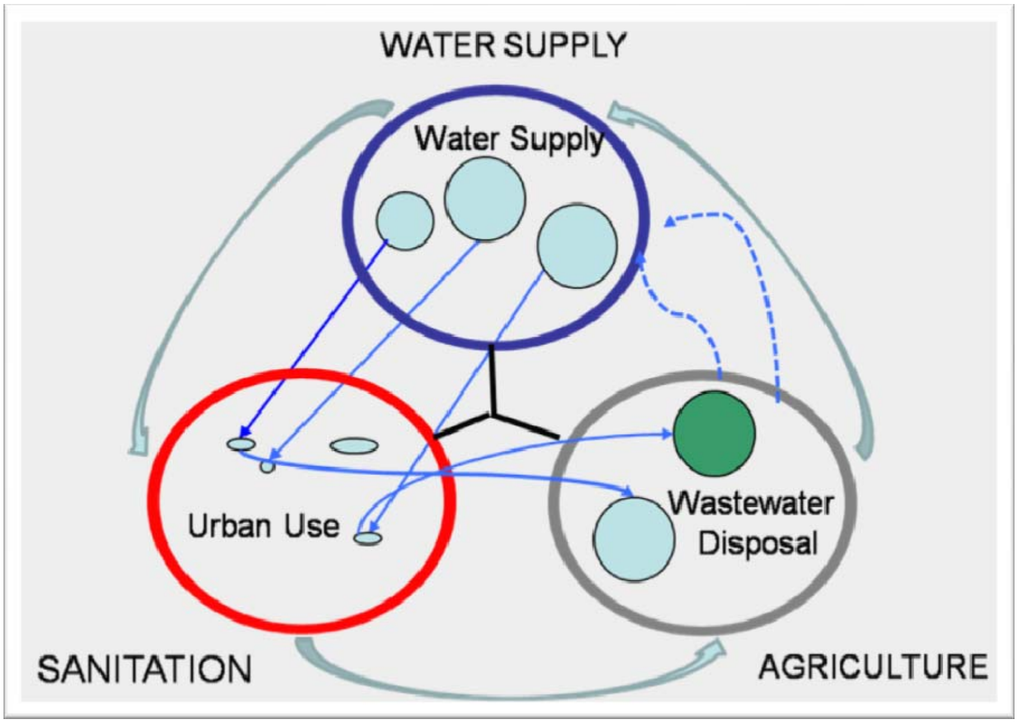

Fig.1: Schematisation of the Water – Sanitation – Agriculture Nexus

Sanitation

In urbanizing countries insufficient sanitation facilities and wastewater treatment have led to the degradation of the quality of water resources. Although the proportion of people with access to sanitation services in urban areas is considerably greater than in rural areas (WHO/UNICEF 2006), it is difficult to maintain let alone increase coverage rates in the face of rapid demographic growth. However, another argument to improve sanitation in urban areas is the high population density in especially the lowest income areas, which increases the risk of spreading of (water-borne) diseases. Improved living standards and socio economic conditions have led to generation of more waste and wastewater which are mostly discharged untreated into the environment (Bahri 1999). Open drains function as sewers for domestic wastewater, surface runoff and as dumping sites for urban wastes. The bulk volume of untreated domestic wastewater flowing directly into water courses and polluting the environment is of concern and has been reported extensively. Water supplies are compromised, rivers/drains become polluted and stinking and aquatic life is endangered. Improvement in urban sanitation will not only improve hygiene but also protect scarce water resources and enhance the value of water supply.However, the reality is that most urbanizing countries have developing economies and cannot invest substantially and appropriately in improved sanitation. Moreover there is the lack of political will to invest in sanitation improvement as there are quite often other local priorities.

Agriculture in relation to emerging food issues in urbanizing countries

In parallel to pressing sanitation needs, global food demand is increasing with population growth in urban areas. The current rise in food prices has shown that agriculture is going into an uncertain and shaky phase. Urban poor people are affected the most and tension is rising in a number of cities. It has also pushed agriculture high on the political agenda with request for more applicable, diverse and flexible food systems. In recent times, farming in and around cities has become one of the coping strategies to respond to rising food demands in urbanizing countries. The so called Urban and Peri-urban Agriculture (UPA) is the production, processing and distribution of food and related products from crops, animals, trees, fish, ornamentals etc in and around urban agglomerations. UPA consists of Peri-urban agriculture (with rural & urban "footprint") and Urban Agriculture (UA). It is made up of several production systems such as backyard gardening (e.g staple crops, poultry, small livestock, mushrooms), open-space market oriented farming (e.g. maize, rice, vegetables), It also has a large marketing and processing sector. Agriculture in and around cities is an old practice all over the world. It has attracted a lot of positive attention in recent times for various reasons: 1) the increase in urban food demand and changes in diets from the traditional staple high energy intake to more diversified food crops including vegetables; 2) food related health problems due to inadequate or unbalance diet causing malnutrition; 3) the dependence of low income earners on emergency sources of food especially during civil unrest and wars; 4) market opportunities; wastewater availability in cities; 5) the growing food establishments such as restaurants, hotels, fast food places, supermarkets; 6) the important linkage with water and sanitation as UPA can turn liquid and solid urban wastes into useful resources.

There are documented experiences in the world on the contribution of UPA to urban food supply, livelihood, waste reuse, social inclusion, participatory governance and other socio economic issues (Nugent 2000; Moustier 2001; Cofie et al 2003; van Veenhuizen 2006; Obuobie et al 2006; Drechsel et al 2006). More than 800 million people worldwide are engaged in some form of UPA, mostly for subsistence purposes (UNDP 1996). In West and Central Africa for example, at least 20 million out of about 162 million city dwellers are currently living in urban households with some kind of agriculture. Besides backyard subsistence farming, an estimated 200 million people around the world are involved in market gardening who predominantly depend on urban water resources (UNDP 1996). In each major West African city, there are between 30 and 650 ha under vegetable cultivation, with up to 10,000 ha in peri-urban fringes (Drechsel et al 2006).

Nevertheless, farming in cities (especially irrigated farming) is hardly supported by local government for several reasons, some of which are genuine while others are misconceptions. There are concerns that UPA pollutes the environment and serves as breeding grounds for malaria parasites. However, compared to generally poor urban sanitation and resulting pollution of urban resources, the contribution of urban farmers is marginal; pesticide contamination is as well possible in large and intensive rural production; heavy metal intake through urban farming could be a risk depending on the location and polluting status of industries. With regards to the contribution of urban farming to malaria incidence, it is not confirmed as there are many non-farming potential breeding sites in cities (Afrane et al 2002). In Accra, some of the agricultural water sources consist of muddy dugout ponds connected to big drains that are too dirty for the *Anopheles* mosquito to breed. Nevertheless, some water sources support active *Anopheles* population but not to the mature stage. As the malaria vector prefers clean water for breeding, any farmer that uses dirty gutter water in principle may not boost malaria incidence. The most serious genuine concern of local authorities for UPA is the use of polluted water for crop production which indeed poses health risks for both farmers and consumers.

2. The Significance of Urban Water Use in Agriculture

Use of Urban Water

Urban water resources used for UPA include surface water, groundwater, surface runoff, piped water and wastewater. For example, in West Africa, major water sources for urban vegetable production include water from shallow wells, storm water, wastewater, etc. (Table 1). Farmers use clean water for irrigation when available, but this is often rare due to the high cost involved, unreliability of supply, or lack of access. In many cities farmers tend to rely on wastewater or polluted water to irrigate their crops, in the absence of cleaner water sources.

Urban/peri-urban farming provides opportunities for effective use of different types of water for agriculture. Important sources can be rainwater, groundwater and, as discussed earlier, wastewater. Actual use depends on availability and the infrastructure needed to withdrawal water from these sources.

Table 1. Major water sources used for urban vegetable production in West Africa

Water sources	Abidjan	Nouak-choti	Accra	Bamako	Cotonou	Banjui	Dakar	Freetown	Kumasi	Lome	Niamey	Ouagadougou	Yaounde
Shallow (dugout) well	•		•	•	•	•	•	•	•	•	•	•	•
Storm water drain (usually highly polluted)	•	•	•				•	•	•		•	•	•
Deep well		•			•	•				•	•	•	
Pipe-borne water		•	•				•		(•)				
River and stream (often polluted)			•	•					•		•	•	•
Partially treated wastewater		•	•				(•)					(•)	
Larger water tank or reservoir												•	
Inland valley								•	•				•

Source: Drechsel et al 2006 •: common; (•): few cases

Wastewater in urbanizing countries often consists of domestic effluent and urban runoff. The fraction of industrial effluent is very small as industrial activities that generate wastewater are (still) marginal. Domestic effluent is made up of both greywater and blackwater. Although both treated and untreated wastewater is used for UPA, due to poor sanitation infrastructure in most cases, the wastewater stream used for irrigation is mainly of poor quality. An extensive review of the extent and implications of agricultural reuse of untreated, partly treated and diluted wastewater in developing countries has recently been documented by Keraita et al (2008). About 20 million hectare of land is irrigated with raw or diluted wastewater mostly in Asia, Latin America and sub-Saharan Africa and approximately 10 % of the world population consumes food produced by wastewater. An assessment of wastewater use for agriculture in developing countries was carried out in the frame of the Comprehensive Assessment of Water Management for Agriculture and reported by Raschid-Sally and Jayakody (2008) (Box 1). There are both positive and negative aspects of using wastewater for agriculture. On the positive side, it supports urban livelihood, gives significant profits – often higher than rain-fed farming in rural agriculture, and allows continuous cultivation on the same plot for many years and multiple yields per year. Thus, agricultural use of urban wastewater appears to be one of the most productive and income generating farming systems in and around cities, notwithstanding the disadvantage of using marginal soils and the problem of insecure land tenure. In Asia, and Africa, UPA can contribute up to 80% of urban vegetable supply (Ensink et al 2004; Raschid-Sally et al 2005; Drechsel et al 2006).

Box 1. **The footprint of wastewater agriculture in developing countries**

Global assessment of wastewater use for agriculture was carried out by IWMI in 53 cities/countries in Asia, Africa, MENA and LAC. The study shows that the main drivers of wastewater use in irrigated agriculture are in most cases the combination of three factors: increasing urban water demand and return flow of used water, treated or untreated into the environment; urban food demand and market incentives favouring production in city proximity where water sources are usually polluted; lack of alternative water sources. Cultural constraints and awareness of risk did not prevent use of wastewater for agriculture. Although controlled recycling of treated wastewater is well documented, the true extents of irrigation with partially or untreated wastewater are usually under-reported or underestimated especially in Africa, and so Asia, Latin America and the Caribbean. This gap usually affects the quantification of numbers of beneficiaries from wastewater agriculture including farmers, traders and consumers. Nevertheless, in four out of five cities where wastewater is used (treated, raw or diluted) in urban and peri-urban agriculture, approximately 0.4 million ha are cultivated by a farmer population of over one million with 4.5 million family dependants. Wastewater agriculture was most prevalent in Asian cities especially Vietnam, China and India. For obvious reasons, African cities have smaller areas and numbers of farmers under wastewater irrigation. While wastewater agriculture is not necessarily a phenomenon associated with the poor countries/cities (many cities in middle income countries especially in water scarce regions had large extents of wastewater agriculture) low income cities with higher poverty index have significant proportion of urban agriculture, the bulk of it under wastewater irrigation. In eight out of ten cities, wastewater agriculture and consumption of wastewater irrigated produce, was seen to take place essentially within the urban areas. Three out of five cities produced vegetables with wastewater, particularly “exotic vegetables”, its popularity as cash crops being explained e.g. by the emergence of particular urban diets.

Regional breakdown of wastewater agriculture

Region	Cities with data (no.)	Total farmers (no.)	Total area cultivated (ha)
Asia (AS)	19	992,880	214,560
Africa (AF)	9	3,550	5,100
Latin America (LA)	8	88,300	142,160
Middle-East (ME)	3	3,320	34,920
Total	**39**	**1,088,050**	**396,740**

Source: Raschid-Sally and Jayakody (2008)

On the negative side, use of untreated or partially treated wastewater in agriculture has significant health risks mostly due to feacal contamination. Contamination of irrigated water especially in low income countries is seldom through heavy metals due to a low stage of industrialization. Studies from Nigeria, Ghana, Senegal, Burkina Faso, Pakistan and Vietnam confirmed that bacteriological levels as well as levels of eggs from intestinal nematodes of urban water sources used for agriculture generally exceed irrigation standards of WHO and FAO, and can contribute significantly to crop contamination (Niang et al 2002; Keraita & Drechsel 2004; Faruqui et al 2004). In addition, there could be negative environmental impacts on groundwater, and adverse effects from accumulation of chemical compounds in the soil, like soil salinization.

Minimizing risks in the use of polluted water

As discussed earlier, farmers resolve to the use of wastewater or polluted water for obvious reasons. Regarding livelihoods concerns, it is important to minimize the health risks while maximizing the benefits of irrigated agriculture in cities. In this regard, both treatment and non-treatment options are available to minimise risks. A number of low-cost options have been documented in literature (Keraita et al 2008). Where full treatment is not possible, a combination of partial and non-treatment options adaptable to developing countries is permissible in the revised WHO guidelines for wastewater use in irrigation (WHO 2006). It is possible to locally adapt the guidelines at different entry points using treatment and/or non-treatment options (e.g. drip kits, on-farm treatment, crop restrictions, good vegetable washing) as pathogen barriers. Examples of such local adaptation have been tested in Ghana and reported by Keraita et al (2007) and Amoah et al (2007). In addition to adoptation of the WHO guideline, other management options can be used by the local government to minimise risks. These include among others, applying the 'polluter pays' principle, offering alternative land with safer water sources for irrigation as well as providing incentives (such as market channels) for safer crop production.

Use of Excreta

Given the fact that close to 90% of urban population in developing countries are served by on-site sanitation facilities, which in turn has generated and concentrated large volumes of human excreta, UPA can take advantage of using these high nutrient and organic loads to boost agricultural productivity. A case study on this in Ghana is presented in Box 2. More perspectives are being put on excreta and urine use in agriculture through international initiatives such as EcosanRes (www.ecosanRes.org) and the Sustainable Sanitation Alliance (www.suSanA.org) which is a network of partners jointly responding to the UN goals for the International Year of Sanitation (in 2008). The benefits of excreta use in agriculture include improved soil organic matter content and structure, increased water holding capacity hence reduction in water needs. It could also reduce environmental pollution from sludge dumping sites. However it is necessary to monitor possible heavy metal accumulation as well as health risks from improper handling and application of excreta.

Box 2. Excreta use by urban and peri-urban farmers in Ghana

The adoption and use of human excreta as an alternative to inorganic fertilizer in crop production was investigated in four urban agglomerations in Ghana. The study focused on three systems of recovery: farmland application of excreta, extended storage and co-composting with organic waste. In three of the four urban areas, excreta has been used by farmers for years. There are no cultural barriers to the use of excreta as users recognised the agronomic benefits and the fact that it does not contaminate crops. Nevertheless, the foul smell and perceived health risk for farmers remains a source of concern because most users do not take precautionary measures. There is 64% percentage gain in farm incomes due to the use of excreta. In Kumasi, a pilot investigation was carried out to: (1) explore the potential of recycling excreta through co-composting with municipal solid waste; and (2) provide vital information for the planning and implementation of proposed co-composting project at a new landfill site. Fresh public toilet sludge and septage mixed in a ratio of 1:2 were dewatered on a drying bed. Faecal biosolids were mixed with solid waste as bulking material in a volume atio of 1:2 for co-composting. After three months, helminth eggs were reduced to < 1-3 viable eggs/g total solid level, allowing for a safe use in agriculture. Similar observation was made in Accra where excreta from settling tanks was mixed with saw dust and heaped for three months while monitoring the helminth concentration. In wet humid areas as in Kumasi and Accra, co-treatment of excreta with organic waste could be a good approach to recover locked nutrients and organic matter for urban and peri-urban agriculture (UPA). In the dry areas such as Tamale and Bolgatanga, appropriate land application of excreta can improve the productivity of UPA substantially. However, in both ecozones, the heath environmental as well as institutional aspects of recycling excreta have to be properly addressed. The use of excreta can be supported by making it available in the required quantity and quality. In addition, farmers need to be educated on precautionary measures to avoid health hazard.

Source: Cofie et al. 2005 and 2008

3. Harnessing the benefits of water - sanitation - agriculture nexus in cities

In order to realise the potential that the water-sanitation-agriculture nexus offers in urban agglomerations, significant shifts in conventional thinking on urban water and sanitation management will be essential. The current approach and methods that focus on either water or sanitation are unlikely to result in a sustainable (finances, environment and society) system. The issues are complex and many actors are involved. Development planners, policy makers, and the society at large need to realize the benefits and opportunities that lie in the productive use of urban water resources (in particular wastewater and also human excreta) for urban livelihoods. It will be a challenge for all to aim at efficient, sustainable and equitable use of scarce urban water resources. In the light of this, the most radical shift will be to see public sector officials actively integrating their thinking on urban planning with an approach that enables the combination of public sector resources and private sector self interest. Involving the necessary people[1] through multi-stakeholder processes[2] will not only empower stakeholders but will facilitate participatory governance in each local context. Until this shift occurs, there may not

[1] Such as Government Agency/Ministry, Funding Agency, Metropolitan Authorities, NGO's , the business sector, Media, User Groups/associations, community/Opinion Leaders etc

[2] Social processes to move sustainable urban resources management across research-policy-implementation interfaces

be innovative policies on planning, and management of water and food security that can result in an improved quality of life, especially for the urban poor.

Some global initiatives advocate a paradigm shift in the management of urban resources. For example, the EU funded SWITCH programme (www.switchurbanwater.eu**)** facilitates learning alliances on Integrated Urban Water Management - linking activities and sharing knowledge in urban water management within the city and between sectors, to increase effectiveness and to link planning across the urban water cycle. The RUAF's Cities Farming For the Future programme (www.ruaf.org) applies multi-stakeholder processes for action planning and policy formulation (MPAP) approach to support the integration of UPA into city development plans in Africa, Latin America and the Caribbean, Middle East and North Africa, and ASIA regions. The MPAP brings together major stakeholders in a new form of communication, dialogue, co-determination of issues, joint decision-making, planning and implementation. This approach ensures empowerment by giving partners the opportunity to influence decision-making. It also ensures ownership of facilities, services or processes by target institutions. Another global initiative following a similar approach is WASPA (www.iwmi.cgiar.org/WASPA) which seeks to work with stakeholders in alliances especially in Asia, to improve environmental sanitation and hygiene in poor urban communities, and alleviate poverty through productive and safe use of wastewater.

4. Conclusion and Recommendation

The existing linkages between water supply, sanitation and agriculture have been acknowledged by various researchers over the last decade (Varis & Somlyody 1997; Niemczynowicz 1999; Lundqvist et al 2003). To address the real challenges of households and farmers in water scarce cities, it is essential to start changing the way water is being managed. As our analyses has pointed out, a better integration of addressing the needs for improvement of urban water supply, wastewater disposal and urban agriculture, could benefit all water use sectors and improve water use efficiency while reducing environmental pollution with wastewater.

It has been made clear that municipal authorities in many cities are facing enormous challenges to cope with a massive population growth and associated challenges to deal with basic human needs such as water, sanitation, and food. The way in which these challenges are addressed, affects the quality living of people directly and cuts across geographic and governance boundaries. Traditional development aid with a focus on rural areas usually excludes the urban poor. Quite often, priority is given to water and sanitation services mainly in terms of infrastructure development but factors beyond infrastructure (e.g. governance, institutions, socio-economic- cultural factors) affect both upstream and downstream users. Climate variability and climate change also affects the urban water system. The urban water system itself is very complex with multiple stakeholders and parallel planning and implementation processes. There is a need to respond to urbanization related water, sanitation and food challenges. An established link lies in the recycling / reuse of waste/wastewater for food production. Urban and peri-urban agriculture creates an avenue for recycling readily available urban organic wastes as well as reusing water and recycling human excreta, thereby improving the productivity of farming systems as well as environmental health.

There is the need to put adequate sanitation systems in place, which do not only treat, but make the nutrient (and water) resources in wastewater/excreta available for use in agriculture. The problem of environmental pollution in developing countries where sanitation coverage is poor, treatment (where present) is not effective, high pollution burden coupled with low agricultural productivity (hence food insecurity), is considered a valid justification for recovering resources inherent in urban wastes. By doing so, we close the nutrient and water loops in urbanizing countries, improve agricultural productivity, enhance public health, protect the environment and improve the livelihood of urban dwellers and farmers.

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