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WASTEWATER USE IN URBAN AGRICULTURE:
Assessing Current Research and Options for National and Local Governments

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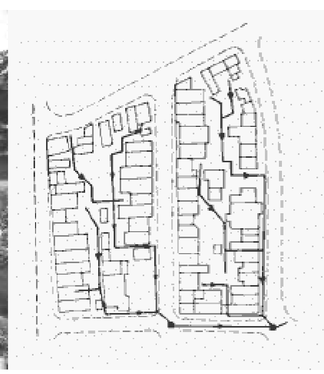
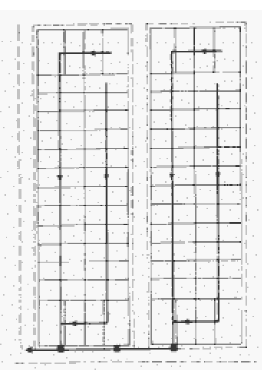


Acronym List

ADS	Arab Development Society
BOD	Biological Oxygen Demand
ENDA	Environnement et Développement – Tiers Monde (Sénégal)
CBO	Community Based Organisation
CFP	Cities Feeding People
ICT	Information and Communication Technology
IDRC	International Development Research Centre
IFAN	Institut Fondamental de l`Afrique Noire (Sénégal)
INWRDAM	Inter. Islamic Network on Water Resource Development and Management (Jordan)
MENA	Middle-East North Africa
NGO	Non-Governmental Organisation
O&M	Operation and Maintenance
PPP	Public-Private Partnership
TSS	Total Suspended Solids
UA	Urban Agriculture
WATSAN	Water and Sanitation
WDM	Water Demand Management
WEDO	Water and Environment Development Organisation (Palestine)
WHO	World Health Organisation

Community wastewater treatment plant using aquatic plants (Dakar, Senegal)

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Executive Summary

Keywords: Urban Agriculture, wastewater reuse, policy, Middle-East North Africa, wastewater treatment, water management

Urban agriculture (UA) is a common and increasingly important economic activity in many cities of the world. Closely linked with this type of production is the reuse of wastewater as an input for UA. Wastewater is used because it is a readily available resource in urban areas, has few costs associated with its use and can actually increase harvests and production, thus increasing income. This report explores the link between UA and wastewater use based on existing literature and applied research on the topic. The objective is to understand both risks and benefits and provide options for governments and researchers in support the appropriate and safe use of wastewater. For evidence, the report draws heavily on recent applied research activities supported by IDRC in the Middle-East and North Africa region.

The first two sections offer a general discussion of urbanization, food insecurity and the reaction of both the poor and policy makers to the use of urban spaces for food production. Water scarcity and the challenges in providing urban water and sanitation services are also discussed. This background is followed in section 3 by a detailed discussion of existing research linking urban agriculture with wastewater use. The health implications and the World Health Organisation (WHO) guidelines for wastewater use are discussed as well as the shift from outright prohibition of the practice to a slow acceptance of its reality and potential. Section 4 takes this further by concentrating on the benefits of wastewater use in alleviating poverty.

In section 5, an overview of water/wastewater management and governance is presented. Decentralization and local level water management – both of which impact small to medium scale urban agricultural production - are also discussed. Section 6 looks at some alternative arrangements and identifies the roles to be played by various key stakeholders. The tradition of building large-scale conventional treatment systems is critiqued while advantages and disadvantages of low-cost treatment are presented. Alternative technical options for municipalities (and other levels of government) are then presented based on recent IDRC experiences. These include both low-cost wastewater treatment options useful at the household and community level. Non-treatment options, for situations where treatment is not feasible, are also reviewed.

Four main conclusions are drawn. First, while health remains a priority concern, wastewater also provides significant benefits to its users. In spite of the health risks, policies prohibiting its reuse have been ineffectual and wastewater continues to be frequently used. Second, in response to a sense that the WHO standards are too strict, there is some movement to offer alternative solutions and policy advice which may include more flexible guidelines and methods to achieve these guidelines. This could positively impact the capability of developing countries to achieve the WHO guidelines. Third, low-cost treatment options offer a great deal of potential, however, there is also a need to recognize that even basic treatment is not always feasible, particularly in very low-income communities. Non-treatment management options are needed. Finally, this review found that despite the current trend to decentralize governance, issues related to water and wastewater remain, for the most part, at the national level. It is here that concentrated efforts are needed for the adoption of appropriate wastewater policy.

1. INTRODUCTION

Rapid urbanization in the developing world is proving to be one of the greatest challenges of the 21st century. Incidences of urban poverty and food insecurity are increasing, while agricultural and urban water demand is outpacing supply leading to scarcity in many regions. Meanwhile, the speed of urban growth is outpacing the provision of water and sanitation infrastructure. Air pollution is threatening habitat and the costs associated with urbanization are burdening governments and economies. This new urban reality needs innovative solutions and approaches to minimize urbanization's negative impact. In reaction to increasing food insecurity, people on all continents are growing their food, whether for home consumption or for market, inside and around urban areas. One common characteristic of urban agriculture is the use of alternative water sources such as domestic wastewater to supplement water supply and lower household costs. The benefit comes from increased agricultural output and lower water costs while farmers and consumers are exposed to a health risk from contact with an unclean source of supply.

How should decision makers react to these realities? The common response of the past 50 years has been to outlaw practices that have been deemed unsafe or even unaesthetic. Local governments have condemned wastewater use while urban agriculture has been ignored and sometimes banned outright. Meanwhile, the donor community often focuses on rural agricultural development in the belief that by improving rural conditions, migration to urban areas can be curtailed. The evidence is to the contrary. Urban areas – and their promise of employment - continue to attract migrants and grow at a rapid rate. To date, both urban managers and the donor community have not fully harnessed the benefits that both urban agriculture and wastewater use have to offer.

Urban agriculture (UA) is a pragmatic and useful activity. The growing population in urban areas creates a huge demand for agricultural produce. Instead of importing food in from rural hinterlands, urban agriculture is close to urban markets and thus transportation costs are lower. In addition, UA improves household nutrition through food self-reliance, reduces the amount of money spent on food while also providing extra income if it is sold in the market. Aesthetically, UA provides greenery to the city. Research on UA has only really developed in the past decade and some trends are emerging. First, UA is a massive informal enterprise that involves a large number of actors. As city governments recognize its usefulness, it is becoming an increasingly formalized activity. Second, there are many economic benefits that accrue from UA. Finally, UA plays a significant role in making vacant lands productive. .

As UA grows into an important economic sector, it is critical that the potential for use of urban wastewater be explored as well. In many developing countries, particularly those where there is a water shortage or scarcity, access to fresh water for irrigation is limited and instead both treated and untreated wastewater is used. Wastewater, notwithstanding important health implications when used improperly, has huge potential as a source of water. Even when untreated, there is a growing body of evidence that proves that farmers will use wastewater to increase their crop yields and lower their water costs (Faruqui and Al-Jayoussi, 2002; ENDA-IFAN, 2002a, 2002b; Cornish and Lawrence, 2001). This creative use of urban wastewater would be straightforward if it were not for the health implications implicit in reusing wastewater. So far, its potential has not yet been harnessed. The question is thus: can wastewater be safely used as an irrigation source in urban areas?

Both treated and untreated wastewater is currently used by urban farmers. Where adequate conventional treatment exists, it is common practice in water scarce regions to use wastewater (California, Tunisia) and there exist guidelines and policies for its management. Where access to conventional treatment is limited, farmers will often use untreated wastewater, both domestic and industrial. Treatment is considered the ideal solution to this problem, but recent experience is showing that conventional treatment, while an important end-goal, is likely far beyond most countries' capacity. The Dublin Principles (1992) regarding water promote local, demand oriented water management as the ideal model for water management. In poorer countries, where a lack of resources impedes infrastructure development, there is an increasing emphasis on low cost treatment systems that allow for water reuse.

In the MENA (Middle East - North Africa) region, wastewater use is currently being practiced on a wide scale in Tunisia, Morocco, Saudi Arabia and Jordan (WDMF, 2002). While most existing sanitation infrastructure are large scale, water borne systems leading to costly treatment plants, IDRC has helped develop alternative projects in Jordan, Senegal, Palestine and Lebanon. These project focus on small-scale treatment technologies as an appropriate method to supplement irrigation of urban agriculture[1]. The projects range from low-cost household systems that provide limited treatment of greywater for use in one's home garden to the use of aquatic plants to treat wastewater and then be used as livestock feed. Each of these projects is centred around finding reasonable alternatives to conventional sewerage infrastructure. Work in this field is also predicated on using wastewater as a resource instead of seeing it as a nuisance.

Despite what has been done, more research is needed on low-cost, semi-collective systems that are appropriate in marginal urban communities. This means systems that are effective at reducing health risks, conserving nutrient benefits of wastewater while being managed and operated locally. This report compiles recent IDRC experiences with wastewater use, both treated and untreated, for urban agriculture. A significant effort has been made to highlight the economic value of wastewater due to the fact that if policy makers are interested in low-cost treatment technologies, it will primarily be motivated by the economics of such systems and the benefits they can have for the poor. The report attempts to synthesize results from on-going projects supported by IDRC as well as previous research into how local and national governments could potentially be involved and benefit.

[1] For examples of this work, see www.idrc.ca/cfp.

2. BACKGROUND AND PROBLEMATIQUE

2.1 Urbanisation

In most cities of the South, poverty is increasingly becoming a grave problem. The combination of rural to urban migration and a lack of employment is increasing the concentration of the poor in urban areas (Mougeot, 2000). According to the World Resources Institute (2000), it was estimated that in 2000, 56% of the world's poor lived in cities (WRI, 2000).

The urban bias of modern economic development has contributed to the rapid growth of cities. Capital is concentrated in urban areas where large pools of labour exist. This in turn is where investment and employment end up being concentrated, thus encouraging rural migrants to come to the city. In the developing world, much of this growth has occurred over the past 40 years. In 1960, West African cities held 13% of the regions population. Today, the proportion has grown to around 40%. In the Middle-East and North Africa (MENA), cities accounted for 60% of the regions population (2000) and were growing at a rate of 4% to 6% per year (World Bank, 2000). Compounding the problem of rapid urban growth is the fact that the MENA is the most water scarce in the world.

Average growth rates, however, can be deceptive. As figure 1 shows, growth rates in informal areas have outpaced the overall growth rate for cities. According to the World Health Organisation (WHO, 2000), African growth rates in informal areas have grown on average 27% per year. It is in these informal settlements, often located on the margins of the city, where the problems of adequate infrastructure provision are most acute.

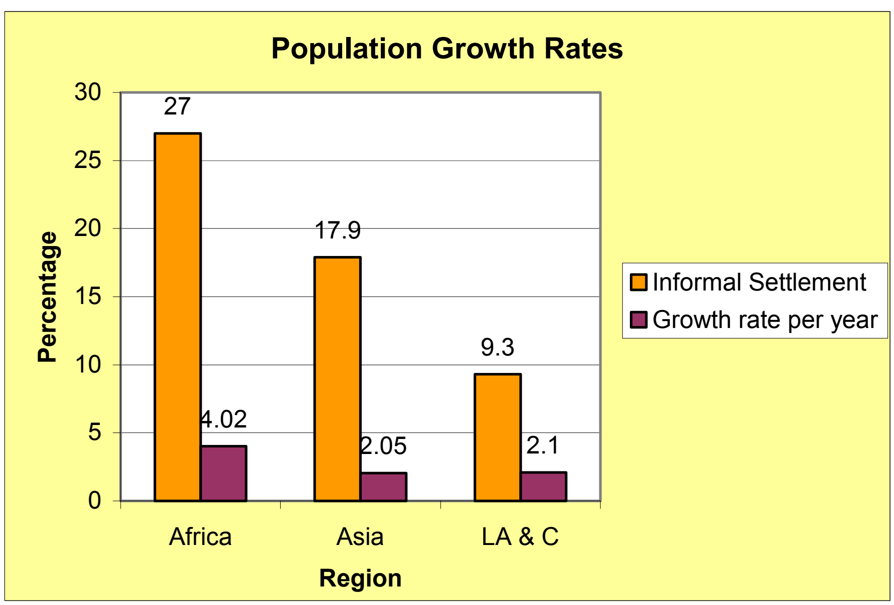

Figure 1: Population Growth Rates compared with the expansion of informal settlements in the regions largest cities
Source: WHO, 2000

In Mauritania, rural-urban migration has been overwhelming. Nouakchott, the capital city, has seen spectacular growth as a result of a major drought in rural areas during the late 80's and early 90's. In 1990, there were 881,000 people living in urban areas in Nouakchott. By 2000, this number had almost doubled to 1.5 million (WHO, 2000). Meanwhile, over the same period, there has been no improvement in water provision nor sanitation with the proportion served staying constant at 34% and 44% respectively (WHO, 2000). Remarkably, in 1980, 80% of the country's urban population was served with potable water. By 1990, this had fallen to only 34%. The reason has been that infrastructure development has been unable to maintain pace with urban population growth.

Mauritania is not alone in experiencing rapid urban growth and associated problems with service provision. In Senegal, Dakar has also seen rapid population growth as a result of migration. Over the past 25 years, the city's population has grown from 941,000 to 2.4 million inhabitants representing a 5% annual increase. In 2001, the rate of growth of Dakar was even higher at 6.1% (RADI, 2002). Urbanisation in other parts of the MENA region is also occurring rapidly. In Jordan, the urban population makes up 78% of the country's total. In MENA as a whole, only 25% of the population was urban in 1960 compared with 57% in 2001. This rate is expected to climb to 70% by 2015, with about one-quarter of the population living in cities of one million or more (PRCDC, 2003).

From a socio-economic standpoint, rapid population growth combined with few economic opportunities places a great deal of stress on the provision of basic needs. Adequate basic needs infrastructure is dependent on economic security. Employment leads to incomes that are used to improve individual living conditions as well as the community in general through an increased tax base. Rapid growth in developing countries is rarely met by comparable growth in its basic services sector.

Water Scarcity

Rapid urbanization and water scarcity are closely linked. In times of drought and in countries with a large desert hinterland, urban growth rates are high since rural agriculture is limited or impeded. This shift of population has placed even greater stress on the water resources available to cities in water scarce regions. It is generally accepted that the MENA region is comprised of some of the most water scarce countries in the world. Available water has declined as population has increased. According to the World Bank (1996), the MENA region includes only 1% of the world's freshwater resources but 5% of the world's population. The average per capita availability of water has dropped from $3300m^3$ in 1960 to $1200m^3$ today (World Bank, 2002). It is further estimated the by the year 2025, 19 MENA countries will suffer chronic water stress[2] (World Resources Institute, 1996). Amongst the hardest hit are Jordan, West Bank/Gaza and Yemen whose average per capita water availability is $200m^3$ (World Bank, 2002). In 1998, Jordan's per capita water availability was $160m^3$. Meanwhile, by 2025 it is predicted to decline to 91 m^3.

Natural water scarcity has been exacerbated by human influences (Haddadin, 2001). Major factors impacting on water availability include:

[2] "Chronic water stress" is when water availability is less than 1000 m^3/person/year (Falkenmark, 1992)

- Modern technologies that have provided the means for deep drilling and pumping have led to the over-use of limited aquifers.

- Urbanization and slow economic growth have contributed to an increasing number of people with access to fewer water resources.

- Pollution that is degrading water quality.

- Poor management of the resource and administration of services

Water scarcity is also less a function of availability than one of national and local managerial and governance capacity. For instance, in Senegal, there are water shortages despite the fact that to date only 3% of its surface water and 30% of its groundwater are being exploited which is a relatively low amount (Akinbamijo, 2002). Intermittent supply, failed infrastructure and poor maintenance also plague the water sector even when official statistics proclaim high coverage rates. Amman, Jordan has a coverage rate of 100%, however, 52% of supplied water is lost in the network due to poor maintenance, and most consumers only receive water for a few hours each week.

Water scarcity places pressure on the ability of households to meet their basic needs. The cost of water in urban areas (especially un-served urban areas) is sometimes prohibitively high. Intermittent supply creates a demand for other sources (such as truck borne water for drinking or wastewater for irrigation), which can either be expensive or dangerous to public health. As the single most important input in subsistence agriculture, water is essential for food security.

It might seem obvious to view wastewater as a major source of water for urban areas, particularly for irrigation, however, wastewater use is still not clearly incorporated in national or local policy in most countries. The fear of health impacts, a concentration on increasing supply instead of managing demand and occasionally cultural factors all influence the lack of clear guidelines in support of water reuse. These issues will be discussed further in the coming sections.

2.2 Food Security

Rapid population growth, the pressure on urban resources and international trade liberalization have all contributed to an increase in food insecurity, particularly in the South. With the increase in the size of cities has come a change in existing agricultural practices. As Akinbamijo (2002) notes, food insecurity is the result of either high levels of poverty or the high cost of food. Food is often the single largest expenditure of poor families – up to 77% for many families -- any savings in its purchase can release a significant portion of income for other uses (Drechsel, P et. al., 1999; Abdelwahed, 1998; Egziabher et. al. 1994). As figure 2 shows, the proportion of income spent on food by low-income families can be very high. In Havana, a survey of families producing mostly for home consumption reported a 40% drop in household food expenditures (Moskow, 1999). While comprehensive studies of the overall economic contribution that UA makes to the economy are rare, one performed by the Mazingira Institute in Kenya found that in one growing season (1985), urban agriculture contributed $4 million USD to the Kenyan economy (Mougeot, 2000). An additional advantage is the proximity of food production to its market and thus, lower transportation costs.

City	Income spent on food (%)
Bangkok (Thailand)	60
La Florida (Chile)	50
Nairobi (Kenya)	40-60
Dar es Salaam (Tanzania)	85
Kinshasa (Congo)	60
Bamako (Mali)	32-64
Urban USA	9-15

Figure 2: Percentage of income spent on food by low-income residents in selected cities.
Source: Akinbamijo, Fall and Smith (2002)

International trade and market oriented development also impact food security. Increasingly, food is being produced for the export market as opposed for subsistence purposes or the local market. In Senegal, the groundnut sector has been historically important as an export crop for the international market. While it is still prominent, fishing is increasingly being practiced for export purposes. A full 31% of Senegal's GDP is derived from exports of agriculture and fish. In the short term, the export sector does create important spin off such as employment opportunities; however, an economy dependent on only a few commodities can be susceptible to volatile international commodity prices. Moreover, most cash crops are produced by oligopolies that concentrate production and limit the ability of small producers to reach the market.

Structural adjustment programs (SAP), common in the 1980's, further compromised food security. This has especially been the case in sub-Saharan Africa where international financial institutions have pressed for market solutions instead of interventionist policy (through subsidies, for example). Where this occurred without appropriate market strength, SAP created price shocks and forced the cost of basic foodstuffs higher.

Food subsidies in developed countries damage food producers in developing countries further. It has been shown that 80% of subsidies in developed countries actually end up in the hands of industrial agricultural interests that export their foods to southern countries (Voss, 2002). Small farmers in the south are unable to compete with subsidized food imported from wealthy countries. The net result has been a $20 billion dollar export loss from developing countries and an overall increase in imports of food products from Northern countries (Voss, 2002).

Coping Strategies: Urban Agriculture

The spatial reorganization of people to urban areas has also concentrated food demand in these cities. It is common for migrants to improve their situation through the production of food for auto-consumption and sometimes, for the market (Koc et. al., 1999). Urban agriculture is not a new phenomenon – it has a long history in most of the south. What is new, however, is the growing recognition of its practicality and usefulness in easing the burden of poverty and food insecurity. As an adaptive strategy to fight poverty, UA is incredibly malleable to changing economic situations. Its effectiveness is not limited to poverty reduction. UA also increases urban green space, creates economic spin-off industries and employment as well as improves the urban bio-physical environment (Moskow, 1999). This model of agricultural development is well suited to many cities in both the north and the south.

Urban agriculture has not been defined in absolute terms. Some define UA as inclusive of agriculture and livestock production within city limits, as well as activities that take place in the peri-urban area. Definitions also include spin-off activities such as compost production, small business development, packagers and transportation, for example. A working definition of UA links confined space production, related economic activity, location, destination markets (or home consumption), and the types of products produced in a dynamic interaction that can vary from one urban area to another.

The difficulty in settling on a precise definition of the phenomenon has impacted the extent of research on the subject. Research, and slowly policy, is now acknowledging that peri-urban and urban agricultural systems operate in a very different context than rural systems. Some examples of this difference are land-values, access to markets, soil quality, urban development pressure, scale and crop diversity.

As the global scope of research into urban agriculture becomes mainstreamed, more and more data on both its positive impacts and what limits UA are being produced. The data that does exist on UA is compelling. Smit (1996) estimates that 15-20% of the global food output is grown in cities – a figure that is corroborated by the UN (1996). By 2005, estimates suggest that UA will increase its share to 25% to 30% of the global food output. This is based on assumptions that urbanization will increase, technology transfer will continue, there will be an increase in decentralized waste re-use, markets will continue to grow, and urban managers will institute supportive policy options. In Africa and Latin America, 40% and 50% (respectively) of urban people are involved in farming in some capacity (Egziabher et. al, 1994). One estimate suggests that as many as 800 million people are involved in UA worldwide (Smit, 1996). In Dakar, urban producers meet 60% of urban vegetable demand (de Zeeuw, 1999). Meanwhile, an extensive survey done in Lusaka demonstrated that 50% of respondents use gardens as their primary source of household food (Ogle, 1999).

Considering the contribution of UA to household income generation, the role of women is important. Women often play a central role in both food production and marketing. Still, women are often faced with difficult challenges in accessing services (capital, extension, technologies, labour), legal and customary land tenure issues and also, with regard to asset ownership. While inequity is common, urban farming has the potential to afford women more control over household economic decision-making and an independent source of income.

Other benefits are difficult to quantify and subjective, but are nevertheless worth mentioning. Moskow (1999), points out fringe benefits of UA such as neighbourhood beautification, improved safety and an enhanced urban ecology. Economic spin-offs from related industries have yet to be researched thoroughly.

Constraints to Urban Agriculture

While the benefits of UA are increasingly evident, the practice still faces numerous constraints that have prevented its formal integration into the economy and its sectored development. Urban policy has often been antagonistic towards the practice (Abdelwahed, 1992; Egziabher et. al., 1994). Most urban planners view agricultural land uses as inconsistent with cities. Some municipalities regard UA as a nuisance activity and have rendered it illegal through zoning and health regulations. This contrasts sharply with the view of UA as an activity with positive economic, health and environmental benefits. Wastewater use is commonly employed for irrigation and has nutrient benefits for crop production, however, it is banned outright due to the fear of an outbreak of disease.

Perhaps the greatest impediment to successful integration of agriculture in urban areas is land tenure. For many, urban agriculture is a coping strategy based on their knowledge of farming from rural areas. In Dakar, 60% of those employed in urban agriculture are rural migrants (ENDA-IFAN, 2002b). However, because many urban poor have recently migrated they are often without legal title to the land they occupy. Without legal title, residents are less likely to invest in their properties and household economic activities.

There are also often conflicts in land-use planning related to tenure. For example, in Dakar, the 1964 National Land Act, the eminent existing legislation regarding land, grants tenure to "those who cultivate it". However, the same law grants discretionary powers to local community leaders. These community leaders are often not well advised on the advantages of UA. Combined with pressing urbanization and housing needs, valuable land currently farmed is instead being developed (Mbaye and Moustier, 2000; Faruqui, Niang and Redwood, 2002). For example, the municipality of Dakar has included a large green area – known as the Niayes - into its development plans for housing and a technological business park. The Niayes happens to be on of the most desirable and productive agricultural areas. Small farms cover the area that is now being considered for development. With many residents without secure tenure, neither the will nor the capability to fight this exists. Urban development concerns are trumping agricultural land uses.

Secure land title has frequently been cited as a precondition of housing and infrastructure development (Gilbert and Gugler, 1982; Hogrewe et. Al, 1993). This is based on the premise that those with tenuous access to land will be unwilling to support much investment into their households – investments that may be the precursor to on-site sanitation and water reuse systems (Choguill, 1996). Where there is more secure land tenure - and thus a greater sense of ownership - there is interest in improving the household. This is especially true among the urban poor because their home and small plot of land is often the only property they own (Hameed Khan, 1996). Even *perceived* security of tenure and the existence of infrastructure have shown to be important in encouraging incremental household and land improvements (Wahba, 2001).

Tension between formal and informal urban settlements is a recurring, crucial issue in developing cities that is in need of a sustainable solution (Gilbert and Gugler, 1982; Choguill, 1996). Formal settlements are generally close to the center of town and are legally recognized by municipal authorities and thus part of official plans and urban development programs. As such, they often receive adequate sanitation and infrastructure facilities. On the other hand, most of the poor reside in informal peri-urban areas that have tenuous legal status and do not get access to most urban services. In these areas, agriculture is a common economic activity and wastewater is most frequently used for irrigation. Without adequate security of land tenure for the urban poor, or recognition from municipal authorities, the people on this land have little incentive to invest even a small amount into their household. Mara and Feachim (2001) estimate that 9$ trillion USD worth of urban land is occupied by urban resident who do not have secure tenure. Regularizing such settlements, and acknowledging the value of the land they occupy, would provide a tremendous incentive for occupants to improve on their land and homes.

Another result of weak UA policy is the lack of support services existing for its development as a viable economic sector. Most UA occurs outside of the formal economy. Credit programs, one of the most important methods to formalize the practice, are few (Abdelwahed, 1998; Egziabher et. al., 1994). Weak policy has also prevented efforts to curb pesticide and raw wastewater use; practices that are widespread and can have serious health impacts when not done properly. Finally, agricultural policy is often directed at medium and large-scale farming and is developed at a macro, or national level. Thus, small landowners, especially urban producers that are not privy to "extension" services, inevitably fall through the cracks (Cornish and Lawrence, 2001).

Opportunities for Policy Action in Urban Agriculture

Advocates are hopeful that UA will increasingly be included in the urban policy agenda. Smit (1996) points out that there has been a shift from ignorance of UA (1970's) to some places having generally supportive UA policies in place (1990's). The change has been slow but noticeable. Nevertheless, in most instances, a clear municipal or national policy for UA is lacking. If UA is to play a larger role in poverty reduction, it will have to be done concurrently with the development of supportive municipal policy and institutions. As a result, in most cases, policies have been prohibitive as opposed to supportive. A narrow view of development as well as economic and political interests have limited the adoption of policies for UA. Policy has preferred to use UA as an "environmental" option to green cities. These policy environments are exacerbated by low legislative and enforcement capacity amongst municipal authorities. Where municipalities do not act, the void is often filled by the NGO and CBO community (Mbiba, 2001).

Policy options that can be used by the public sector to encourage UA are plentiful, however, they are not always readily adopted because of the constraints mentioned above. Still, a brief overview outlines options available to policy makers to support UA. In Dar Es Salaam, comprehensive legislation has been enacted in support of UA. This legislation is updated through a multi-stakeholder process (Bakker et al, 2000). The municipality also supports UA producers through the Urban Vegetable Promotion Project. As a recognized land-use in Dar Es Salaam, agriculture is much easier to control and manage.

Zoning and the use of vacant lands for UA have also been enacted in a number of municipalities including Kumasi, Ghana and Kampala, Uganda. Urban expansion plans in Kinshasa, Dar Es Salaam, Dakar, Bissau and Maputo all include provisions to adopt agricultural lands. An IDRC supported project in South America has been developing city

Wastewater Treatment Levels

Increasing cost ↓

Preliminary (or pre-treatment)	Basic level of treatment which could include screening (using sand, bar screens) and grit removal. Designed to remove larger solid particles.
Primary	Sedimentation of solids (This level of treatment is regarded as adequate for restricted irrigation of many crops)
Secondary	Use of a biological process to reduce common pollutants further (BOD & SS)
Tertiary	Removal of a specific pollutant (eg. nitrogen, phosphorous or heavy metals)

Figure 3: Wastewater treatment levels

policies in three urban areas (Rosario, Argentina; Cienfuegos, Cuba; and Gobernador Vallerades, Brazil) to support the use of vacant lands for UA[3]. The pace of adopting methods and practices in support of UA is accelerating. In the three aforementioned places, GIS, real estate analysis, a participatory city budget allocation process, zoning and multi-stakeholder processes are all tools being employed to develop the UA sector.

In order to encourage municipal support for UA, IDRC has sponsored a number of declarations signed by municipal policy makers, mayors and researchers that declare their intent to support UA[4]. Nevertheless, there are still many avenues of support, research and opportunities that need to be explored before the full potential of UA is realized. The declarations explicitly recognize the value of urban agriculture as well as wastewater use in urban poverty reduction. The Hyderabad Declaration on Wastewater Use is included in Annex I of this document.

2.3 The challenge of the Water and Sanitation (WATSAN) sector

Early initiatives in the provision of wastewater treatment and conveyance systems in developing countries focused on a supply driven approach to managing water. The model is based on reacting to demand by providing more water, instead of conservation, or demand management. As a result, a supply driven approach is in need of expensive infrastructure – often subsidized by the state or international donor organizations – to develop water resources. In addition to being costly, such systems were often implemented with little community

[3] For information and outputs related to this project, visit www.idrc.ca/cfp and follow links to project # 100983.

[4] A number of municipalities and policy makers in Asia, SSA and Latin America have signed IDRC supported declarations. See www.idrc.ca/cfp and then "UA Declarations".

participation and highly centralized (Gomez and Nakat, 2002). In many instances, emphasis has also been placed on water supply neglecting the collection and disposal of sewerage.

Beyond technical and financial constraints are those relating to management. In general, the WATSAN sectors of most developing countries, have a poor management record. Costly mechanical water intensive collection and treatment systems have been chosen when it is clear that the capacity to maintain and pay for such systems is lacking. When transferred to arid developing countries, such systems often fail. Unaccounted for water (UFW) is often cited as an indicator of infrastructure effectiveness. In the MENA region, UFW rates are variable, with most not meeting "good practice" guidelines (15%-25%) set by the World Bank. In Amman, 52% of water extracted is lost before it reaches its destination. In Algiers, 51% is lost while in Dakar, the reported rate of loss is lower at 27% (WHO, 2000 part II)[5].

Most important, however, has been the inability of supply driven approaches in wastewater management to meet the needs of the urban and peri-urban poor. Marginal populations are excluded from centralized service a) due to their inability to pay for service and b) because many urban services do not extend to the urban periphery. The growth of cities has outpaced the growth of water and sanitation infrastructure. Armed with this knowledge, there is a growing body of research and effort being made to prove the efficacy of smaller decentralized systems as an alternative to conventional systems. If investment efforts were made into developing relatively simple conveyance and treatment technology, especially that which allows for wastewater use for agriculture, their could be significant positive impacts in poor urban communities.

Such systems can be employed at various scales (household, semi-collective). Some examples include pit latrines, septic systems and small bore sewerage. Other examples of decentralised, low cost treatment include small household greywater treatment systems, semi-collective biological treatment using aquatic plants. Larger alternatives include waste stabilization ponds. As they are quite simple in design and function, there are operational, financial and managerial advantages to such systems, however, there are also potential disadvantages. For example, if not installed properly, problems such as negative health and environmental impacts can result. For this reason, in the absence of data on the effectiveness of on-site treatment, many decision-makers are hesitant to support them. Choguill (1999) argues that such systems could be effective in developing cities if they can be progressively improved over time and maintained appropriately. This model, obviously entailing its own set of problems, has nevertheless proven itself to be a useful solution in certain instances.

Financing Sanitation Infrastructure

Perhaps the greatest impediment, and certainly the most widely discussed amongst policy makers, is the financial sustainability of infrastructure services. Serageldin (1994) has shown that water infrastructure is among the least financially autonomous of all infrastructure (telecom, electricity etc.). Failure to recover investment costs in developing countries is linked with the construction of large-scale, water borne sewerage systems based on systems in the West and a major impediment to meeting national and international goals to improve water and sanitation provision. The high cost of centralized water borne systems creates a dilemma

[5] It should be noted that in the north, UFW rates are also frequently high.

when attempting to serve poor urban regions in the developing world. Meanwhile, less costly and more appropriate systems have only begun to be considered as a legitimate infrastructure option.

Full-cost recovery in the water sector is a very difficult task, however, if at least operations and management (O&M) costs can be covered, it is considered `good practice` according to the World Bank (World Bank, 2000). A survey of water and sanitation in urban areas of MENA cities indicates only Tunis has succeeded in recovering O&M costs through service charges (see figure 4).

Failure to recover costs in this sector have been staggering. When compounded with increasing water scarcity, growing urban populations and urban poverty, the challenge seems enormous. In Amman, Jordan, it is expected that the future cost of water and wastewater provision will be *four times* higher than at present – a figure that is comparable to Mexico City, Hyderabad and Lima.

	Gaza	Amman	Tunis	Sana'a	Algiers	Casablanca	World Bank Good Practice
Unaccounted for Water	31%	52%	21%	~50%	51%	34%	15-25%
Water coverage	99%	100%	100%	65%	100%	100%	100%
Continuous supply	No	No	Yes	No	No	Yes	Yes
Per capita water use (liters/day)	70	~80	~80	50	~70	110	120-150
Sewerage connection	25%	78%	77%	22%	70%	70%	--
Employees /1000 connections	7	5.5	10	10	8.6	6	4 - 6
O&M recovery costs	No	No	Yes	N/A	No	No	Yes

Figure 4 – Selected performance indicators of water and sanitation utilities
Source: World Bank, 2000.

While low-cost wastewater conveyance and treatment systems are an obvious alternative to the high costs of major infrastructure works, there are also some weaknesses. For example, to date, there are only a few examples of self-sufficient decentralized systems in existence. Initial expenditures will be needed on research, data generation and pilot testing. Further costs are associated with ensuring and testing the appropriateness of a technology in different urban contexts. A well functioning, low-cost technology may not be applicable in all municipalities.

Governance, Water and Sanitation

Perhaps the greatest challenge facing the adoption of appropriate WATSAN policy is low capacity amongst the institutions responsible for water and sanitation services. In addition, frequent changes in government impede consistency in infrastructure planning. In Africa, where institutional capacity is frequently low, municipal governments and public utilities have access to few resources and are unable to provide even basic necessities. Community participation in the planning process is often lacking raising the likelihood of project failures.

Due to its sensitive nature and its status as a public good, water planning and rights are most often legislated at the national level while municipal and para-municipal agencies are left with operating infrastructure services and doing local planning. Many national governments have created a multitude of institutions with different roles and responsibilities related to water and often, they lack effective coordination. At the national level, ministries responsible for water, agriculture, environment, natural resources, urban development and health usually have some responsibility for water. National agencies (with varying degrees of separation from the government) will sometimes be charged with coordinating legislation, planning and management for the resource. To complicate things further, the administration of basic services is often divided amongst three levels of government, national, state (or provincial) and local (or municipal). A regulating authority is also charged with ensuring appropriate pricing of the resource. This complex chain of actors can work well when properly funded and with access to the necessary expertise, however, this is rarely the case.

One common failure in infrastructure provision has been the lack of power delegated to the regulatory authority to monitor performance. Often, there has been insufficient distance between the regulating agency and those being regulated (Yepes, 2001). Those mandated to provide services are not always endowed with the financial capability to do so. With too few resources to provide water and sanitation to everyone, and with the lack of separation between providers and regulators, political interference in infrastructure provision is common (World Bank, 1994). Water and wastewater services are used as political bargaining chips to curry favour with communities with a degree of political loyalty (Redwood 2000). In order to avoid such an occurrence, some countries have opted for an increasing private sector role in infrastructure provision. In the hands of the private sector, it is assumed, political interference would be reduced and there would be substantial efficiency gains in both provision of services and administration (see below).

In recent years, good governance has been a key theme in the water and sanitation sector. And this support for good governance is yielding results. Legislation separating the regulating agency from paramunicipal, parastatal and private water and sanitation providers has been encouraged to reduce the potential for corruption and political interference.

A strong regulatory structure with enforcement capability is acknowledged as a key ingredient to the success of national water plans. Support for entrepreneurial ideas and innovation as well as capacity building and training for NGO's and local community groups are more recognized ingredients for success.

Private Sector Involvement in WATSAN[6]

As noted, the infrastructure sector is increasingly shifting towards the private sector for capital and to improve the efficiency of operations. In its policy paper on infrastructure development

[6] A great deal more can be found on public-private partnerships from the IDRC supported Water Demand Management Forum from: (www.idrc.ca/waterdemand/docs/english/pblc_prtnr.shtml).

for the 1990`s, the World Bank writes that urban infrastructure policy "…will involve a shift in the role of central governments from direct providers of urban services to 'enablers', creating a regulatory environment in which private enterprises, households and community groups can play an increasing role in meeting their own needs" (World Bank, 1992). Models of private sector involvement vary from contracting out certain, limited functions - Public Private Partnerships (PPP) - to full privatization with the government acting as a regulatory authority but having little, or no role in provision, operation and maintenance. Such arrangements have experienced both success and failure. The debates surrounding privatization have been polarized between advocates, who see the private sector as the panacea to managerial and operational problems in the infrastructure sector, and detractors who see the privatization of public goods (such as water) as setting a dangerous precedent. There is more nuance than this black and white approach. In fact, there are many degrees of privatization and rare is the case where full privatization is implemented. Most models involve a degree of public control (i.e. over water rights) while certain functions are contracted out to the private sector (such as management or operations)[7]. Regarding water, such arrangements can work well by concentrating ownership of the resource in the public while still accessing capital from the private sector.

Examples of PPP in WATSAN are increasingly common. In Amman, Jordan, a management contract was awarded in 1999 to an international consortium – LEMA - comprising of familiar names such as Lyonnaise des Eaux, Montgomery (British) and also a Jordanian company Arabtec Jardaneh. The 4-year management contract provided a fixed fee ($8.8 million) to the group in addition to bonuses if water delivery performance targets were achieved. In the end, the contract was a qualified success having improved human resources, met most of its performance targets and significantly increased cost-recovery. One area identified as deficient in the contract was the excessively small penalty in cases where targets were not met (Abu-Shams et. Al, 2003).

Public-private partnerships are gaining credence, but will only work if there is an enforced commitment to equity and environmental standards. The private sector often seeks assurances that their profit will be protected thus keeping the risk firmly within the public sector. Weak statutory legislation (and thus regulation) regarding PPP, leads to an increased possibility of failure or abuse. Consequently, it is important to develop a strong statutory framework for the successful operation of PPP. Key to success of PPP, as demonstrated from the lessons of the Amman experience, are performance targets and timeframe that are realistic, as well as appropriate incentives to meet these targets.

PPP offers some real possibility of merging the important role of public authorities in managing WATSAN, with the financial and administrative capabilities in the private sector. One thing is for certain and that is that any private sector involvement needs to be transparent and involve public consultation or participation. The current climate of distaste for private sector involvement in urban services, particularly when involving the poor, will change as more examples of success become apparent.

[7] Kessides (1997) is a thorough review of institutional arrangements for urban infrastructure.

3. URBAN AGRICULTURE AND WASTEWATER USE

Urban agriculture cannot be seen separately from wastewater use. In urban areas, where domestic wastewater is readily available, urban farmers will use wastewater for irrigation. Its value is two fold. First, it is a readily available and abundant source of water (especially in urban areas) and second, it contains nutrients that are advantageous for crops. According to the FAO, a city with a population of 500,000 and a water consumption of 120 liters/day/person produces about 48,000 m^3/day of wastewater. If treated and used in irrigation, it could supply water for 3,500 hectares of farmland. In Dakar, a city where there is a water shortage, over 100,000 m^3 of wastewater is dumped into the ocean daily amounting to 40% of the city's entire daily water use (Niang, 1999). If there is an adequate treatment to reduce health risks, wastewater use for irrigation is a realistic policy option (Pescod, 1992).

The reasons for its use are numerous and frequently dependant on context, however there are several recurring themes:

- Wastewater is used to reduce the cost of expenditure on piped water;
- Wastewater provides many nutrients that are not present in potable water which
- Raises agricultural productivity and;
- Lowers costs paid for other fertilizer.

The nutrients available in wastewater include nitrogen, phosphorus and potassium.

In a survey of urban farmers in Dakar, Niang et. al. (ENDA-IFAN, 2002b) 23% of farming costs were attributed to acquiring water supply. As a result, 33% of farmers used wastewater primarily for economic reasons in order to avoid paying for potable water. A further 37% cited the nutrient richness as the main reason they used wastewater. Wastewater use was also found to be an activity that is associated with household agricultural production. Approximately 99% of those using wastewater identified urban agriculture as their primary economic activity (ENDA-IFAN, 2002b). In Amman, an extensive survey of urban farmers has found that 40% use greywater for their gardens (DOS, 2001).

Socio-cultural elements also impact wastewater use considerably. The WHO guidelines recognize that while the use of human excreta as fertilizer is acceptable in some places (China, Japan), it is looked upon with disaffection or indifference in others (the Americas, Africa), while it has a history of being viewed with hostility in some Muslim countries (Mara and Cairncross, 1992). Faruqui et. al. (2001) challenge the notion that wastewater use is contrary to Islamic principles by arguing that it is actually a natural extension of water conservation, which is an Islamic principle, as long as it is treated to the extent necessary to protect public health. This is especially true in regions such as Saudi Arabia and Tunisia, both very arid, where national wastewater use plans have been developed with the backing of Muslim clerics. A 1978 *fatwa* of the Saudi Arabian clergy made in concert with government policy makers decreed that wastewater use was acceptable as long as the water was treated well to protect public health in its intended use. Now, the kingdom has determined to have 10% of its water demand met by water reuse (Abu-Zeid, 1998). Many in civil society have also accepted wastewater use, especially when the need for alternative water sources is clear. In Palestine, 80% of people surveyed in a study of wastewater use and urban agriculture were found to be willing to practice wastewater use (Faruqui, Biswas and Bino, 2001: 81).

As UA is more readily accepted as a legitimate economic activity in urban areas, it is logical that new policies recognizing the usefulness of wastewater as irrigation supplement (ideally treated) and attempts at mitigating risk need to be developed.

3.1 Health Impacts and the WHO Guidelines

The obvious reason that public authorities have not embraced wastewater use is its potential negative public health impact. Wastewater use may have some important benefits for poverty reduction, yet it is not a panacea. The central health issue is that wastewater contains pathogens (bacteria, viruses and protozoa) and helminthes that cause gastro-intestinal problems and other illnesses in humans. In 1970, a cholera epidemic in Jerusalem was directly linked to vegetables irrigated with the city's wastewater (Shuval, et. al, 1986). In Dakar, an outbreak of typhoid in 1987 was also linked to farmers who were using raw wastewater to irrigate their gardens. A survey of farmers in Dakar using untreated wastewater found that gastrointestinal infection rates varied between 40% and 60% (ENDA-IFAN, 2002). In Eritrea, research on the health impacts of untreated wastewater revealed a giardia infection rate of 45% of farmers using wastewater. Amongst consumers of the vegetables from these same farmers, infection rates were lower at 7% (Srikanth, 2003). There is no doubt that associated health risks are a major constraint on the liberal use of wastewater for irrigation.

Another problem is posed when heavy metals are present from, for example, industrial wastewater. Heavy metals can have a long-term impact on human health and soil quality. Cadmium (Cd) and mercury (Hg) are metals commonly found in untreated wastewater and have been linked to kidney disease (in the case of Cd) and brain and nervous system damage in the case of Hg (Delta Institute, 2001). In order to get around this problem – and in the absence of expensive industrial wastewater treatment technology – source separation of waste into domestic and industrial streams is recommended whenever feasible.

More problematic is the use of sewage without any treatment whatsoever. In Pikine, a region within Dakar city limits where wastewater is frequently used, 28% of farmers use untreated wastewater (Niang, 1999). Often, this water is mixed with well and groundwater, however, it still poses a significant health risk. Of the farmers surveyed, 52% claimed that they were *unaware* of the health risks involved (Niang et. al., 2002b). In Ouagadougou, a survey found that 40% of farmers using wastewater claimed they were unaware of the health risk. Acknowledging and understanding health risks related to wastewater use is the precondition to education related to precautionary measures. Some measures include stopping irrigation several weeks before harvest or washing and cooking produce prior to consumption (Niang, 1999).

The concept of "acceptable risk" is debated in health circles and has a bearing on the topic of wastewater use. Feachem et al (1983) consider the fact that pathogenic transmission from wastewater is much more dangerous and prolific in places where adequate hygiene and housing are at a relatively high level. When pathogens are introduced (say via contaminated produce) into a moderately wealthy neighbourhood, the level and rate of transmission is extremely high. Meanwhile, in a community where sanitation is basic, contamination from waste use will not have nearly as high an impact. This is related to how many people are already infected, or how present the pathogens already are without before considering the use of waste. This, of course, should not encourage inaction, but simply some consideration of what might be an acceptable risk allowing poorer farmers to use wastewater. Again, the question can be asked: do the benefits of wastewater use outweigh the risks?

The World Health Organisation (WHO) has recognized both the potential and risk of untreated wastewater use and so has developed guidelines for policy makers attempting to legislate permission for the safe use of wastewater (Mara and Cairncross, 1992). The guidelines stipulate that two parameters, fecal coliforms and intestinal nematodes be used to assess the microbiological quality of water (see figure 5). While the WHO standards are somewhat flexible, the capability of many countries to attain them is limited by cost. Factors such as energy costs, operation and land costs (related to waste stabilization ponds (WSP), for example) can impede the implementation of treatment solutions. Meanwhile, most national standards are predicated on very high western health standards and are strict. Not only does cost limit the capability of poorer countries to achieve these standards, but the treatment process itself removes many of the fertilizing benefits of the wastewater in order to meet these standards (WHO, 1989; Khouri et al, 1994; Rose, 1999). In spite of this debate about what exactly are realistic and appropriate standards to have, the WHO guidelines have become an important basis for policy on wastewater use in many countries.

Category	Use Conditions	Intestinal Nematodes (/litre)	Faecal Coliforms (/100ml)
Unrestricted Irrigation	Irrigation of crops likely to be eaten raw, sports fields and public parks	<= 1	<=1000
Restricted Irrigation	Irrigation of cereal crops, industrial crops, pasture and trees	<= 1	None set

Figure 5: The WHO Microbiological Guidelines for Wastewater Use (Mara and Cairncross, 1989)

In the 1989 guidelines, the WHO acknowledged that most previous standards were unnecessarily high for public health protection and not reflective of the reality of wastewater use on the ground. For example, the experience of Nouakchott, Mauritania has shown that even treated wastewater exceeds acceptable WHO guidelines substantially (IWMI, 2002). If untreated wastewater is used, as it often is, than the guidelines are unreasonably high. Alternative options such as proposing the "best available" quality based on an assessment of locally available technology has been suggested as an alternative. In addition, suggesting "acceptable risk levels" within which untreated wastewater can be used. Health dangers are still present and the development of low-cost treatment systems is still be the preferred long-term solution. More recently, experts have suggested a step by step approach taking into account the best possible options based on the capacity of the relevant sanitation authorities. By setting realistic goals with incremental targets, risks can be minimized until the optimal sanitation system is in place.

This debate, while important, is only relevant in places where treatment is possible. As already noted, urban agriculture using wastewater is very common and continues regardless of national or local policies prohibiting its use. Regulations are simply ignored and there is little enforcement power that bears on farmers using the resource. Once it has been discovered as a cheap (free) source of fertilizer and water, people will use it regardless of the health consequences and often, regardless of what kinds of laws are in place prohibiting its use (Niang, 2000).

As mentioned, the WHO guidelines are perhaps too strict for most countries. If one recognizes that wastewater is used, despite health risks, the question becomes what is an acceptable level of risk. Are there any alternatives to banning the practice of reuse when it is clear that there are significant economic benefits to wastewater use? This question has been debated, notably during a conference in Hyderabad, India in 2002. As a result of the discussions amongst experts in the field, the WHO guidelines are being revised based on new epidemiological evidence and to provide a pragmatic framework in which countries can develop policies that ensure scarce resources are applied appropriately to reduce health risks to farmers. Options vary from low-cost treatment to non-treatment management options. These are discussed in sections 6 and 7.

Box 1: Tunisian Wastewater Reuse Policy

Tunisia was one of the first countries in the MENA region to pioneer policy related to wastewater reuse. Most of the pressure to do so came from water scarcity and the need for new sources for irrigation. The reuse of wastewater in agriculture dates back to the early 1960's and has steadily increased. In 1992, it was estimated that 20% of wastewater was being reused for irrigation (Bahri and Brissaud, 1996). Although this is relative low, it can be partially explained by the relatively short period (6 months) in which irrigation is necessary.

Part of the success of Tunisia's wastewater reuse policy has been the combination of having an strict national policy regarding the use of raw wastewater, while clearly articulating where treated wastewater can be reused. The 1975 Water Law prohibits the use of *raw* wastewater for irrigation under any circumstances. Meanwhile, a 1989 decree specifies that treated wastewater may be used on crops provided that they are not consumed raw (Bahri and Brissaud, 1996).

The expansion of the reuse of treated wastewater is linked closely with the costs associated to farmers to purchase the wastewater. A 1997 presidential decree subsidizes the use of wastewater by farmers so that they are only paying $0.01/m3. This is significantly lower than the $0.14/ m3 cost for treatment (Shetty, 2002). While this incentive has been important, the low price for wastewater has not been as successful as imagined due to lingering farmers concerns over health and sanitation.

3.2 Viewing Wastewater as a Resource

In dry regions, wastewater is increasingly becoming a recognized source of water for large-scale irrigation. California, the Middle-East, North Africa and Latin America all have notable wastewater treatment and use projects. In Tunisia, 15% of available water resources are treated wastewater (Bahri and Brissaud, 1996). In Israel, this amount is even higher at 36%

(Shelef and Azov, 1996). Jordan considered wastewater recycling in its water budget (Faruqui et. al, 2001; Abderrahman, 2000l; Bakir, 2001). The Jordanian Department of Statistics reports that 40% of surveyed households use greywater in market gardening (DOS, 1998). In Morocco, it is estimated that 7000ha of land are irrigated with wastewater. Some countries, such as Tunisia (see box 1) have a national wastewater policy that explicitly supports its use for irrigation of certain crops (Bahri and Brissaud, 1996).

Most existing policy on wastewater use in MENA is directed towards large-scale treatment infrastructure. As noted earlier, such systems can be costly and entail a great deal of capital investment and operation and maintenance capacity. New, low-cost strategies for wastewater use are being attempted – strategies that aid in the development of agriculture and promote related economic activity. Considering the potential health impacts, national governments, and in particular, health authorities, are not necessarily the most effective agents of change in this regard. This leaves municipal authorities and the NGO sector to develop local water management strategies.

Instead of prohibiting its use - a strategy that has failed - the challenge for researchers and policy makers is to encourage ways in which wastewater may be used safely. Current research shows that the economic potential of the resource is significant and make the development of infrastructure for its use not only a feasible option, but one that should be encouraged. The question is now how can the benefits of wastewater use be *safely* harnessed for poverty reduction.

4. BENEFITS OF USING WASTEWATER IN UA

The economic value of wastewater use is based upon several factors related to water management. First, urban water consumption needs have been met primarily through costly investments into supply infrastructure and water intensive collection as opposed to demand management or conservation. As a result, water sources have been overexploited, especially in water scarce regions, raising the marginal cost of supply and provision, and eventually, increasing the cost burden on society. These increases have not been reflected properly in pricing and cost recovery policies related to water. To continue this supply oriented path would exacerbate the cost to already struggling southern economies.

The basic economic premise in support of wastewater use is that reusing wastewater increases the amount of the available resource and protects valuable potable water supplies. An increased supply will reduce costs of extracting and providing fresh water. Another important secondary economic benefit from properly treated wastewater use is its effectiveness as a fertilizer for agriculture. This would reduce fertilizer costs while increasing agricultural output and yield. The economic benefits of wastewater use are particularly significant in urban areas where the cost of water can be up to 10 times higher than in rural areas (Gibbon, 1986).

4.1 Economic Equity and Pricing

The difference in service quality between wealthy urban neighborhoods and the urban poor has significant implications for equity. Residents of poorly served communities acquire their water through the informal market mostly provided by truck borne water. Due to the essential nature of water (everyone must have it), pricing in the informal market is characterized by gauging and excess. Prices can be 10 to 20 times higher than those paid for formalized piped water service (Marvin and Laurie, 1999; Faruqui, 2001). Rates of 80-100 times have been found in some municipalities (Bhatia and Falkenmark, 1993). Moreover, as water supply is prioritized, these communities rarely have wastewater collection and treatment beyond pit latrines and basic disposal. Subsidies in the water and sanitation sector have also been inequitable: the ratio of public subsidies to the rich versus the poor has been found to be between 1.4 and 2.8 times higher than subsidies to the poor (World Bank, 1994: 80).

In order to eliminate price gauging, water pricing policy needs to include a lifeline tariff that is affordable to all sectors of society. However, as use increases, so should the price. This is best done through the employment of an increasing block tariff structure. Such a pricing structure would not only maintain affordability for the marginalized, but also open up the possibility of recuperating most, if not all the costs of provision, collection and treatment. The burden of cost should also rationally fall on those who use the most water as well as those who pollute the most. In terms of water provision, the price elasticity of water has been found to be –0.45 meaning that a 10% increase in price would be accompanied by a 4.5% decline in demand for water. Therefore, based on the disproportionate use of some wealthy areas, there is room to increase the rate for wealthier and connected residents in order to help serve the poor (Faruqui, 2001). Moreover, such a policy is considered a cornerstone of an effective water demand management strategy.

Box 2: Recommendations on valuing wastewater as a resource

- Include full-cost pricing into water and wastewater planning and policy while eliminating subsidies that favour the rich
- Support progressive block tariffs as they can effectively incorporate principles of social equity into pricing.
- Capitalize on the demonstrated interest in semi-collective and household wastewater treatment and reuse systems.
- Support water borne, conventional sewerage only where it is cost-effective
- Adopt simplified sewerage and treatment criteria to limit cost and one that is suitable for some irrigation.

Rents from the increased rates could be applied to wastewater treatment and use systems; systems that have shown to be cost effective when compared to the development of new water supplies. The cost of secondary-level treatment for domestic wastewater in MENA, an average of $US 0.5/ m^3, is much cheaper, than the development of new supplies in the region (WB, 2000). This is especially so when the costs associated with the future provision of a dwindling resource are factored in.

Thus, to ensure some equity and capability of funding appropriate WATSAN infrastructure, a three-pronged strategy should be put in place. First, use lifeline tariffs and increasing block rates to cover costs and keep water and sanitation services reasonable for the poor. Second, allow for targeted subsidies for the improvement of urban services in poor communities. Such subsidies could be directed to fostering effective locally operated WATSAN projects and appropriate planning for such projects. Finally, pass the burden of wastewater treatment costs onto polluters.

The key in the success of all of these arrangements is a favourable institutional and political environment, with appropriate enforcement capability.

4. 2 Building markets for wastewater

There is conclusive evidence that wastewater is valued by farmers. In Dakar, IDRC supported research has found that $0.25 USD per m^3 could be charged for wastewater (ENDA-IFAN, 2002a: 23). Tunisia and Jordan both sell treated wastewater to farmers. Other compelling evidence focuses on costs saved from wastewater reuse. In Cyprus, a study of greywater use found that there was a 36% reduction in water bills when household greywater was using a simple system (WHO, 1999). IDRC supported work on greywater use in Jordan found that the value of greywater used amounted to 27% of the average water bill (Faruqui and Al-Jayoussi, 2002). In the same case study, the average benefit-cost ratio of using greywater was measured to be 5. This figure was based on benefits from reduced water bills and increased urban agriculture yields and costs such as the installation of the systems.

Perhaps wastewater's greatest economic contribution is through the improved quantity and value of agriculture. The high nutrient content in domestic wastewater favours the growth of high-value crops such as vegetables. A comparative study of five crops (wheat, mung beans, rice, potatoes and cotton) irrigated with raw wastewater found that when raw wastewater was applied, there was a 36% increase in yield compared to a control group grown with fresh water and chemical fertilizer (Shende, 1985). Similar increases in yields were found for those crops irrigated with treated wastewater. In Dakar, farmers reported a 37% increase in overall yields of lettuce, tomatoes, eggplant and onion from the use of raw wastewater.

In Mendoza, Argentina, the provincial government has supported widespread irrigation of certain crops using wastewater. An analysis of crop yields has shown a steady increase that has partially resulted from the fertilizer in the wastewater used (CEPIS, 2001). In Jordan, household wastewater treatment systems tested by the IDRC have allowed greywater to be used safely on urban agriculture. Among the households reusing their water, an average annual benefit $376 USD was reported. This increase is accounted for by increased produce yields, as well as reduced water and fertilizer costs (Faruqui, et. Al, 2001: 5-6).

Identifying the benefits of wastewater is one thing, but as of yet, the development of markets for wastewater is still young. Are farmers willing to pay for treated wastewater as opposed to using free, raw wastewater – and thus be exposed to health risks? Based on the benefits of high quality wastewater, some research has proposed that farmers would be wiling to pay for the resource (Bahri, 1999; Pescod, 1992). This is, of course, based on whether farmers are aware of the household benefits and constraints of wastewater use. In a literature review of existing information on wastewater pricing, Mastenbroek (2001) notes that many studies have not explored willingness to pay for wastewater in enough depth. Instead conclusions are based on their perception of benefits as opposed to sound evidence. Nevertheless, arguments incorporating payment for wastewater have received abundant attention and water management is moving towards incorporating wastewater pricing.

Wastewater is used for different reasons and often not simply because there is no other adequate source of water. Most farmers understand the value of wastewater use, and use it because it is a cheap, reliable source of water. This is even true in Muslim countries where water use has not always been accepted. In Palestine, a survey of farmers found that 53% were willing to pay up to 0.24$ USD per m^3 for wastewater if it were suitable for irrigation (Faruqui, Biswas and Bino, 2001: 82). Three-quarters responded that they would pay for the fertilizer sludge that results from the treatment process. In Jordan, where wastewater is considered a legitimate resource, current policy suggests a cost of 15 cents/m^3 for treated wastewater (WDMF, 2002).

The value of wastewater amongst urban farmers is clear from other evidence as well. For instance, in Pakistan, van der Hoek and Hassan (2002), found that due to an uncertain water supply from canals and the ample available supply of wastewater, urban farmers using wastewater grew five times more vegetables than those using potable water. This higher cropping intensity is reflected in land prices where those plots irrigated with wastewater are, on average, 3.5 times more valuable than areas that are not irrigated with wastewater (van der Hoek et al, 2002)..

In Tunisia, national policy allows for controlled wastewater use on certain crops. Their national water plan dictates quality standards (they are moving more and more towards WHO standards) as well as directing how much wastewater is used by different economic sectors. Bahri and Brissaud (1996) have noted that the success of their policy is largely influenced by the links between national water planning and agricultural strategies. They also found that price and payment for the resource did not seem to play a large dissuasive role in wastewater use.

Willingness of farmers to pay for a) treated wastewater and b) household and collective systems to evacuate and treat wastewater are the basis for building markets where small scale WATSAN projects can improve their cost effectiveness. While many diverse methods exist to encourage sustainable treatment and reuse projects, a basic blueprint model is a useful starting point. The following questions are central:

1. How can wastewater treatment and reuse be encouraged amongst farmers?
2. What methods would be used to collect tariffs from farmers and determine price for the wastewater?
3. Who would distribute the wastewater?
4. What treatment options should be considered?

The following sections of this report examine water and wastewater management systems in some detail and look at possible options for consideration.

5. WATER AND WASTEWATER MANAGEMENT

Due to the importance of water to all sectors of society and the economy it is an extremely complicated resource to properly manage. This is especially true in poorer water scarce countries where pressure to increase incomes in the short term often leads to long-term mismanagement of the resource.

5.1 Water Demand Management

In order to be effective, urban water management must consider the links between population growth, urban development and its supporting infrastructure (Faruqui, 1997). Moreover, a strong water management framework must include water conservation and demand management principles as well as a strategy for water treatment and use (Wegelin-Schuringa, 2003; Brooks, 2002). Water is a resource that must be managed appropriately from its extraction, through its use to its disposal or use. The use of wastewater is an integral component of a water demand management strategy by reducing the need to increase supply.

The challenge to do this, however, is enormous. Perhaps the greatest difficulty will be in changing the attitudes of people towards a stronger conservation ethic. In a widespread survey of UA practitioners in Amman, 86% of respondents saw the solution to water scarcity as being an increase in supply. Only 2% saw conservation or demand management, as the appropriate response to water needs. The survey also demonstrated a key problem facing water management: the desire for increased levels of infrastructure without the accompanying willingness to pay for them. However, it is important to note that the reluctance to pay results from poor, inconsistent service. If service levels were of high quality, residents would be more inclined to pay (Mycoo, 1996). Not only would increasing water supply need massive investment, but so too would simple maintenance of the status-quo infrastructure. Of the 13500 respondents, 93% wanted to see a *reduction* in water prices as the solution to the economic problem of providing water. Only 0.7% believed practicing conservation was more important in reducing household water price[8].

Despite these statistics, there are signs of hope. Water conservation is practiced for the basic reason that money is saved by those who conserve. The same survey indicated that 40% of households use greywater to supplement their water supply. Evidence from other IDRC projects in Palestine and Jordan looking at household greywater treatment systems indicates that once people are aware of the benefits, there is a strong desire to use the systems. Lack of education surrounding water conservation, treatment and use could also be important factors preventing the uptake of strong water management.

5.2 Water Policy, Decision-Making and Decentralisation

While the decentralization of power to the local level has been occurring for years, "Local Agenda 21", a proposal that came out of the Rio conference on sustainable development in

[8] An IDRC supported project in Jordan (click here: **003740**) helped the Department of Statistics develop its urban agriculture database. The data is available from the project web-site.

1992, popularized the concept. Agenda 21 outlines the need to shift governance and responsibility from national to the local level where possible. With support from international donors, many countries in the South are decentralizing their economic, political and administrative structures. The idea is predicated on the concept that poverty and basic human needs are often better served by local administrations (Rabinovitsch, 1999; Van Dijk, 2000).

Regardless of the increasingly popular move to decentralize urban services, the fact is that in most developing countries, the institutions that currently have the capacity to manage water are at the national level. Local authorities, municipal governments and community-based organizations are often still lacking the capacity to manage the resource properly and efficiently. Still, decentralized service provision has significant advantages in terms of information, being responsive to local needs, and likely better able to increase participation in cost recovery and financial management of water.

In the WATSAN sector, a strong national policy combined with mechanisms for local decision-making and citizen participation are perhaps the best methods for the efficient provision of services. Water rights, allocation, budgeting and overall administration of national resources comes under the national law, while operation, maintenance, and public involvement in decision making would occur at the local level. Where decentralization is done well, the likelihood that innovative small-scale sanitation technologies are employed is higher (see box 3).

An important factor in determining the success of decentralization, is that local administrations have had their managerial capacity developed sufficiently to tackle the responsibility. As Yepes (2001) points out, the devolution of responsibilities to the local level has often been rapid and without the concurrent time needed to train and raise the capacity of the local authority. Moreover, when it comes to questions of water and sanitation services, it is vital to have a clear separation between the service provider and the regulating authority. Rodriguez (1997) found that increased responsibility for local governments has not meant increased funding for capacity building at these levels. Since decentralization is a relatively new phenomenon there are still a lack of effective models for its implementation[9]. Current thinking around governance suggests decentralization should not only confer responsibility, but also nurture capacity at a local level.

While most countries are still early in the their progress towards decentralising water and sanitation services, a number have already reported success in their programs. Argentina and Chile have had qualified successes by delegating some operations and management to user associations and the private sector. In Mexico, irrigation systems managed by user associations have increased cost recovery from 30% to 80% (Litvack and Seddon, 1999). Even in countries with lower capacity, decentralisation is laying the groundwork of effective water and wastewater management systems. In Ghana, the Community Water and Sanitation Project allows communities to own and operate their own water and sanitation systems.

[9] A notable exception is Rosenweig, Fred (ed.) 2001. Case studies on decentralization of water supply and sanitation services in Latin America. Strategic Paper no.1, USAID.
Also on-line is a World Bank supported course on decentralization (2003): www1.worldbank.org/publicsector/decentralization/

According to the agency responsible for the project, 78% of the target groups respond that their water services have improved (Agodzo and Huibers, 2002). To date, most decentralisation in the water and sanitation sector has occurred in rural areas since centralised management in rural areas is more complex then in urban areas.

Despite the promise of a properly implemented decentralization policy, water supply and sanitation need to also include some involvement of the national authorities. Policy direction is given at this level as well as health standards. In terms of wastewater use in irrigation, it is the national authority that needs to set guidelines that are appropriately geared towards respecting the WHO guidelines, as well as local capacity to actually achieve these targets.

Thus, a balance must be struck between centralized regulation and flexibility at the local level to implement cost-effective and appropriate solutions for wastewater treatment. Researchers attempting to influence policy in this regard can tackle the issue from two perspectives. First, by lobbying national governments to legitimize appropriate sanitation technologies and options as well as to accept wastewater use as a reality. Second, to encourage national governments to decentralize water and wastewater management *where appropriate*.

Decentralization is not a panacea. In some cases, especially in highly centralized governments, the mandate to provide services has been given to local governments while the authority to finance and control funding has not yet been granted. Responsibility without capacity plague many developing countries trying to decentralize governance and management of the water and sanitation sector.

Box 3: Decentralisation of the Water and Sanitation Sector: Some examples

Uganda

Since 1993, Uganda has delegated its water and sanitation services to local governments. For the largest urban areas, the National Water and Sewerage Company (a government owned utility) is in charge of provision. In the 66 other smaller urban areas, water and sanitation services have been devolved to local governments. Unfortunately, this was done without commensurate technical and financial resources and results have been mixed.

The government is in the midst of reforming the sector with the goal of a) creating an independent economic regulator; b) strengthening inter-ministerial coordination at the national level regarding health, urban planning and local governance; c) encouraging a 10-year lease contract for the urban water sector While policy and legislation at the national level is quite clear, the problems that the sector has experienced lie in low capacity, insufficient autonomy of service providers from government and an inability to recover more then operating costs allowing for increased investment. Nevertheless, considering the relatively strong national legislation, reform in Uganda`s water and sanitation sector has a relatively high chance of succeeding.

The Orangi Pilot Project – Karachi, Pakistan

The Orangi Pilot Project (OPP) was begun in the early 1980's as response to severe urban poverty in the Orangi peri-urban settlement adjacent to Karachi. The project focused on cheap technological solutions and cost recovery for basic sanitation infrastructure. By encouraging households to pay for their own sewerage connection, the OPP was able to persuade a sense of control and ownership that would carry on in future operation and maintenance of the system. Women were heavily involved from the beginning because of the recognized links between children's health and sanitation.

The results have been impressive. First, people were found to be willing to pay most of the costs for infrastructure upgrades if they were confident it would make a difference. This was helped by cutting out the middlemen and government and by focusing on very low costs technologies. Second, the OPP group limited their role to facilitating the development process through training and capacity building. As a result, a sense of ownership was instilled to those actually using the services. Finally, through what they call the "Research and Extension Approach" – essentially research results being disseminated and developed into clear action plans – the up scaling of successful initiatives was effective.

Under the OPP, a small-bore sewerage collection system has been put in place. The OPP has provided basic sanitation services for 20% the estimated cost that the Karachi Development Authority would have spent. By 1995, 80,503 sanitary latrines had been installed in the area along with an extensive sewerage network. The financing, maintenance and operation of the system rests largely with the community members. It was noted that while foreign donors can have a financial impact in the initial stages, there is no way that they can support the conventional long term costs associated with sanitation projects, and so the importance of community involvement in all stages of the project was inimical to its success.

Sources:

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6. Management Options for Wastewater Treatment and Use

The previous section discussed some of the shortcomings of traditional approaches to wastewater disposal. Community level wastewater treatment has had more focus placed on it in recent years due to the failure of large-scale infrastructure projects (Brooks, 2002; Niang, 2002). Many of the weaknesses of centralized treatment (high costs, excessive water needs, technical complexity etc.) can be dealt with directly when infrastructure is developed at the local level, however, for community level wastewater management to be successful, there is a need to have a concurrent devolution of decision-making, financial and policy-making power to the local level.

In urban areas, municipalities are considered the local authority of note, however, municipalities are often weak or non-existent. A serious problem manifests itself in low capacity for enforcement and implementation of WATSAN projects. Some municipalities barely have the capacity to resolve local land-use issues let alone the construction and maintenance of infrastructure. Often when there is a deficit of capacity, NGO's will fill this need. Indeed, many of the lessons learned in low-cost wastewater treatment are the result of the work of NGOs in partnership with donor organizations. Meanwhile, many national governments are unwilling to support "experimental" work related to wastewater treatment out of fear of negative health consequences. The absence of good data is a prohibiting factor that is preventing the scaling up of appropriate technological solutions for wastewater recycling.

While municipalities are often in charge of most basic urban services and play an operational role, water often falls under the jurisdiction of the state or national government. Often, a national water authority (or ministry) will administer the resource while other government departments such as health (for wastewater), energy, agriculture and industry will play a role in policy making related to water. Therefore, policy options for changes at the national level are needed if local solutions are to be implemented.

Models of management vary from country to country. In certain small countries and island states (Trinidad and Tobago, Costa Rica), the national agency responsible for water will also be responsible for development and maintenance of infrastructure. In others, administrative functions are devolved to para-municipal corporations who manage and operate infrastructure on behalf of the government. These organizations are usually linked with the municipal government to ensure that land-use planning and infrastructure planning are done in a complementary way.

Such top-down approaches to water and wastewater management have both advantages and disadvantages. Potential advantages include the assurance of consistency in norms (eg. health), policy making and water rights legislation at a national level. Disadvantages are also clear. Local water management is difficult to achieve when there are uniform, national standards that do not take into account local contexts, and administrative capacity. For example, many dry countries do not have uniform water supply problems – some areas may have abundance while others, scarcity - and so certain aspects of policy are more effective at the river basin level (Schiffler, 2002).

The interface between UA and wastewater use creates an interesting challenge to researchers trying to influence policy. Many questions related to UA (land use and tenure, commercial support, micro-credit) happen at the municipal level and so it is necessary to influence policy at this level. When wastewater is involved, however, it will need to involve national level institutions, as this is where water legislation is concentrated. Ministries of water, natural resources and health all should be targets for influence in order to increase the likelihood that wastewater use becomes an adopted practice. Researchers and those attempting to influence policy related to wastewater use will need to consider this fact closely in designing future projects.

6.1 Community Based Wastewater Management

The emphasis on large-scale projects that need a great deal of capital has distracted from innovation in lower-cost, smaller scale community and household wastewater treatment systems. Where treatment of wastewater is not possible, policy and resources should always support the development of decentralized wastewater treatment as even some treatment is preferable to none. Proponents (Bakir, 2001 is a good overview; Brooks, 2002) argue that wastewater treatment is best done at the local level for the following reasons.

1. It is best suited to identifying local needs and pursuing solutions that meet those needs. These include implementing demand management strategies and the reduction of environmental hazards.
2. Permits incremental improvements
3. Increases use opportunities
4. Improves cost-effectiveness
5. Reduces the risk of failure (i.e. failure in a centralized system shuts whole system down
6. Allows for the development of space confined treatment systems.

While it would be ideal if water and sanitation were in public control, it should also be recognized that the private sector (small scale local entrepreneurs to larger scale firms) already plays an important role in both water provision and sanitation. Truck borne water is frequently sold at elevated prices in neighbourhoods where service is lacking. Meanwhile, in sanitation, households and individuals invest in basic pit latrines, wastewater disposal and even, where it can be afforded, septic tanks. Small companies will often provide these services and the materials to build them. These entrepreneurs could play a very important role in developing small treatment and use systems, however, they could also impede the development of effective sanitation if their livelihoods are threatened.

In order to avoid conflict, and to ensure a successful project implementation, it is essential that public participation be a central component of any project. Moreover, it is equally essential that as many actors as possible be represented. Local governments can take a lead role in facilitating such participation. Monitoring and evaluating participation in order to strengthen it should also be a role absorbed by local government. In wastewater management, the following categories are useful to assess the level of community participation (and thus the level of success) in a project:

- Frequent maintenance of the household waste system to ensure the smooth functioning of the collective system
- Payment of service charges and user fees
- Participation in a committee that manages area programs gets involved in local programs, and monitors the operation of municipal and private wastewater management initiatives
- Involvement of actors in decision making processes

Ownership is a very important concept related to the development of small-scale infrastructure. When people develop the infrastructure themselves and play a direct role in its operation and management, while also being the primary beneficiaries, the likelihood of success is higher.

On the other hand, some detractors of decentralization also note that decentralized systems can be costly first to develop and second, to operate and maintain (Bakir, 2001). Moreover, they argue that some local operators simply would not have the technical capacity to maintain infrastructure even when it is basic. Still, if one considers water-recycling opportunities, there is enough economic benefit to encourage further study and investment in their development.

More research is needed to focus on assessing decentralized collection and treatment systems not only from a health perspective but as well as from a cost perspective. The combination of cost and health evidence will have a significant impact on how health and water authorities view such systems. Decentralized control can work, however, there needs to be some capacity to administer and manage the business and provision of infrastructure services, a willingness to invest on the part of the public (through sweat equity or direct financial contribution) and an ability to maintain and operate the physical infrastructure. These questions are all being considered by a number of IDRC supported projects.

6.2 Policy considerations for wastewater use in developing countries

As noted, in some areas, particularly those places where urban agriculture is common, the development of treatment and non-treatment options for wastewater use should be delegated to local authorities, provided they have the capacity. The question remains as to how this can be done without compromising on standards and quality.

The first task is to win over skeptical decision makers and public, and to convince them that wastewater is a valuable resource. Efforts to change the perception of wastewater are on-going[10], however, many more need convincing. The consolidation of existing research continues and a balanced effort to communicate such results in the public and private sphere is a continuing effort. As noted above, the WHO guidelines continue to be the benchmark target for decision makers in developing the wastewater recycling sector, however, as demonstrated, goals need to be in line with the capabilities of the country in question. Considering the needs

[10] See the Hyderabad Declaration (Annex I), Faruqui, et. al. (2001) Water Management in Islam, and the Water Demand Management Forum (www.idrc.ca/waterdemand) for examples of some IDRC supported efforts to link research and policy.

to first raise local capacity to an appropriate level, moving slowly towards achieving the WHO standards (when wastewater is treated) or minimize health risks (when treatment is deemed unlikely), governments should develop a **progressive** approach. Such an approach would allow countries to design targets in line with their ability to meet them. A further advantage of such an approach would be the gradual acceptance of wastewater use by the public.

A second policy consideration should recognize that the prohibition of wastewater use is ineffective because it is very difficult to enforce. Governments need to lay out a **strategy that legitimizes and recognizes wastewater use as almost inevitable** both when treatment exists, and when it does not. Such recognition creates a strong basis from which to promote better practices and support initiatives to minimize risks. Such a directive needs to come from the national government as guidelines for all agencies (national and municipal) responsible for urban agriculture and water. Guidelines can then be interpreted and adjusted by local authorities responsible for wastewater UA to create locally appropriate systems.

Third, within guidelines, there needs to be **flexibility**. Generally, acceptable risk levels in wastewater policy are more stringent than is financially feasible. Moreover, as shown in developing countries, such standards ignore the reality of the many who use wastewater for its benefits while ignoring (or being unaware of) its risks. Health guidelines must be strong where capacity exists, but in cases where it is unfeasible, governments should not avoid supporting projects that *reduce* health risk. At the moment, the WHO is in the process of revising the WHO guidelines.

An important consideration for both municipal governments and national authorities is obviously safety. Most policy makers are unwilling to support wastewater treatment projects that do not meet the WHO guidelines for the safe use of wastewater (WHO, 1989). In fact, following a minimal risk policy - one with very stringent standards - is far more common in developing countries than is necessary. The WHO guidelines, which are lower than most standards used in the North, are still unrealistic for many developing countries.

Fourth, since it is clear that most policy regarding wastewater occurs at the national level, it is important to **concentrate efforts at the national level**. While infrastructure is often operated and maintained at the local level, decision-making occurs at the national level. Changing national policy about the acceptance of wastewater use and low-cost treatment systems could alter what kinds of systems are put into place by municipalities and basic service providers.

A further challenge is in changing the perceived equation between “low-cost” and “poor performing”. Low-cost wastewater treatment infrastructure is a viable alternative to large conventional system and needs to be seen as such. Naturally, policy makers wish to see evidence of the success of low-cost systems before acting, however, in the absence of such evidence, even partial treatment is better than none. Only through the continuous exploration of treatment options will successful methods be found.

Treatment, however, is not always possible. For this reason, researchers are taking into account non-treatment options (Dreschel et. Al, 2002). Guidelines are useful where there is an adequate supply of water or where water is treated to a reasonable degree for use. Where this is not possible, alternative strategies at the farmer level, market level and consumer level that mitigate negative health risks are necessary.

The next section discusses in more detail some of the existing technological options for municipalities.

6.3 National vs. Local Policy

Efforts to boost the acceptance of wastewater use in urban agriculture have been employed at different levels of governance. At the national level, health, agriculture, water, urban development and environmental ministries are all connected to water planning. Moreover, as noted above, water planning and legislation is highly centralized in nature. This highlights the need for a national level intervention to legitimize and establish the safe development of wastewater use in urban agriculture. The benefits of wastewater will only be valuable if it is possible to reduce or eliminate costs such as health risks and assure that wastewater is equitably distributed. To do this, a national wastewater policy that is effective and realistic will be needed. Management of the resource and security for urban farmers using wastewater will be important aspects of this policy.

Municipalities should be able to support the development of options for wastewater. It is this level of government that is most often best positioned to organize local groups of producers, support safe reuse options as well as dialogue between the different stakeholders. These actions can easily feed into national government initiatives, however, considering the politics of decentralization discussed above, it is unlikely that most will be able to in the short and medium term.

With such a variety of interests at stake, coherent policy making in the WATSAN sector is difficult. Consistently, it is the Ministry of Health that demonstrates the most reluctance to press for change or more flexible policy on wastewater. Despite the enormous evidence that wastewater use is commonly employed, this is still the case. The result is a policy framework completely detached from the reality on the ground. Considering the varied impact of the use of wastewater, a responsible policy needs to come from coordination between different ministries. There are a number of different departments that play roles related to the interface between urban agriculture and wastewater use. Figure 8 outlines ministries that play an important role in decision making related to wastewater.

Ministry	Function and role
Water	• Develop a water budget that includes the potential for the use of wastewater in agriculture, urban, peri-urban and rural. • Develop pilot programs of low-cost treatment systems partnered with local research organizations, other ministries and international donors • Create clear national guidelines for wastewater treatment and use based on results from pilot projects. • Decentralize urban water provision to an appropriate level
Environment	• Develop guidelines for environmental standards and assessment for wastewater conveyance and treatment projects.
Agriculture	• Develop technical support for urban and peri-urban agriculture • Concentrated efforts on decreasing water usage for irrigation

	instead of allowing increases
Health	• Set guidelines for the use of wastewater based on international standards while progressively phasing in treatment using incremental targets • Develop guidelines/enforcement mechanisms for municipalities on appropriate risk management options for wastewater use • Collect evidence from existing low-cost treatment methods and use this evidence to set appropriate health guidelines for low-cost treatment systems • Provide clear guidelines and sound scientific research on treatment technologies and health impacts is needed to impact on health policy.
Urban Development and Municipal Planning	• To provide clear direction to municipalities as to their role in urban service provision • Ensure appropriate land tenure legislation is in place and that informal urban areas are absorbed into municipalities • Develop land use guidelines for municipalities that includes urban agriculture in areas where wastewater is available • Set standards for participation in infrastructure development

Figure 6: Functions and roles of national ministries related to wastewater management.

7. ALTERNATIVE TECHNOLOGICAL OPTIONS FOR WASTEWATER TREATMENT AND USE

The WHO guidelines have been debated vigorously in recent years. Many say that for some countries it is nearly impossible to meet these guidelines and so, in order to be relevant, the guidelines need to be adapted to the region where they apply. On the other side, the argument is made that strict standards must be a precondition before wastewater is used to avoid any health problems.

A meeting of experts in 2002 in Hyderabad, India concluded that research and policy makers need to concentrate on:

cost-effective and appropriate treatment suited to the end use of wastewater, supplemented by guidelines and their application.

and that,

health, agriculture and environmental quality guidelines are linked and implemented in a step-wise approach.

These conclusions are embodied in the Hyderabad Declaration on Wastewater Use (see annex I), a document that was signed by forty experts as a model for future research on the interface between wastewater and its use in urban and peri-urban agriculture.

Efforts to develop systems that can meet the criteria outlined in the Hyderabad declaration are on-going. There are many options for low-cost conveyance and treatment where the effluent can be used safely afterwards. IDRC and its project partners have been researching a number of different low-cost treatment methods with the aim of consolidating methods in support of wastewater use for UA. What follow is a brief review of some conveyance and treatment options and technologies for municipalities to support and implement. The basis for these suggestions are: a) they are comparatively cheap; b) on-going research is showing their benefits while also helping governments and NGO's strategize on how to increase their use; c) they are well-suited to the use of certain waste products (nutrient filled water or fodder) that can be employed in support of agriculture; and d) are appropriate for municipal consideration and implementation.

Figure 7 outlines options that will be discussed in this section.

Conveyance and Treatment	Non-treatment Management	Support and financing
• Small-bore/simplified conveyance	• Drip irrigation	Macro Level Options
• Upflow anaerobic filters (household level)	• Timing of irrigation	• Water Demand Management
• Constructed wetlands	• Protective clothing	• Public-Private Partnerships
• Floating aquatic macrophytes ▪ Duckweed	• Crop restriction	Micro Level Options

▪ Water Hyacinth (water lettuce) • Waste Stabilization ponds • On-site ponds	• Health care	• Public participation • Urban extension • Micro-credit

Figure 7: Options in support of local wastewater management and reuse

7.1 Conveyance and Treatment

Small-bore and simplified sewerage

In low-density, unconnected neighborhoods, small-bore sewerage provides the possibility of evacuating waste at 20-50% of the cost of traditional infrastructure (Sanitation Connection, 2002). It also has the additional benefit of not needing as much water to function as conventional systems. Small bore sewerage functions by using 10cm wide plastic tubing to collect household waste and can collect as much as 80 litres per household per day which is adequate in dry, poorer neighbourhoods. Small-bore sewerage is an adaptation of simplified systems that includes a septic tank that pre-treats the wastewater and acts to separate solids from liquids.

Simplified sewerage collection can also be easily adapted to low-cost cost treatment systems and technologies. In Dakar, Senegal, IDRC has supported the Institute de l'Afrique Noire in the construction of a simplified sewerage system to transport wastewater to a biological treatment system. The advantage of such systems is that they are low-cost (in terms of both labour and necessary financial resources), use simple, locally available materials and can easily be used to retrofit all kinds of informal settlements. Their relatively simple maintenance makes their potential for use by local authorities desirable.

Figure 8: Example of small-bore sewerage connection.

Household Greywater Treatment (using upflow anaerobic treatment)

While the treatment of black water (toilet water) is complex and should be closely regulated, greywater treatment can be done using relatively simple technologies. Many of these systems can be employed at the household level and are inexpensive to install and maintain.

In Jordan, the Inter-Islamic Network on Water Resources Development (INWRDAM) has pioneered the use of low-cost household greywater treatment kits based on an upflow anaerobic treatment design. These kits cost little and treat the water to a level where it is suitable for restricted irrigation (i.e fruit trees and cooked vegetables). With the resident time of 1 to 3 days in the treatment kit the influent greywater is expected to undergo a treatment level equivalent to something between primary and secondary treatment. The effluent is then pumped through a drip irrigation system to distribute water to home gardens.

When applied to urban agriculture, the benefit-cost ratio is 5 to 1 meaning that for every dollar spent on the treatment system, five dollars is made from agricultural yields and reduced water and fertilizer costs. With such a high cost-benefit ratio, demand for the units is high as is the willingness to contribute for installation. In Palestine, similar household anaerobic treatment systems have achieved a recovery rate of 55% of all greywater.

Due to their low-cost and easy maintenance, such systems are good options for municipalities. Greywater treatment is also much easier to manage since it does not involve the same health risks as blackwater – and thus do not need the same kinds of preventative health strategies. The key components of such a project for a municipality to consider are that the chosen system is selected with public input, that they are willing to make a contribution (financial or through sweat equity) and that they are well installed and maintained.

In Jordan, the relative success of the project was dependent on the significant interest by homeowners to install such systems, as the benefits are quite clear. In Jordan, INWRDAM trained plumbers and the public in the maintenance of the systems. Since then, the popularity of the greywater system has been high with many people soliciting the system.

Figure 9: Four-Barrel Upflow Gravel Filter.

More information on INWRDAM's work on this is available from www.idrc.ca/cfp following the link to project 100880.

Constructed Wetlands

Constructed wetlands are an effective method of treating greywater and using the water as an irrigation supplement. A wetland is composed of a small pond in which water plants are grown. The plants use a combination of anaerobic and aerobic processes in order to break down organic matter. Constructed wetlands have a very good removal rate of Biological Oxygen Demand (BOD), Total Suspended Solids (TSS) and nitrogen. There are a number of different types and sizes of constructed wetlands depending on its purpose, however, in urban areas, perhaps the most appropriate are *sub-surface wetlands.* The principle behind a sub-surface wetland is to have water drain into rocks and soil that are then treated by the roots of a series of plants. Such systems are appropriate for a small household and relatively simple to construct. A constructed sub-surface wetland (including food produce) of about 10X10 feet would be adequate to treat the greywater of a household of 5 people.

Reed beds are the best plants for use in wetlands as they are simple to maintain, however, certain types of vegetables and produce can be easily planted if the wastewater being used is greywater and not blackwater.

More information on constructed wetlands can be obtained from:
www.epa.gov/owow/wetlands/watersheds/cwetlands.html
Also, CFP Research Report 27 "Community Based Technologies for Domestic Wastewater Treatment", available at www.idrc.ca/cfp

Aquatic Macrophytes[11]

The use of aquatic plants to treat water is increasingly popular. Semi-collective treatment systems using water hyacinth, duckweed and water lettuce (amongst other plants) are effective in reducing BOD and TSS as well as absorption of nutrients. The systems function by having effluent flow through a number of ponds that allow for sedimentation and exposure to the plant that removes pathogens, bacteria and nutrients through biological and chemical processes. The plants act as living substrates on which microbial activity occurs. There are two types of macrophytes used in wastewater treatment. *Floating* macrophytes (duckweed, water hyacinth) settle on the surface of the wastewater while *emergent* macrophytes (*typha,* bullrushes) grow out of soil on the bottom of the pond.

Using the famed model of duckweed aquaculture applied in Bangladesh by PRISM, the Water Environment and Development Organisation (WEDO) of Palestine have created a treatment system using duckweed as both the treatment medium for wastewater and also as fodder for livestock. Using duckweed as their treatment medium, WEDO have built a semi-collective wastewater treatment system. The duckweed as fodder is then used to feed animals and sold to farmers. WEDO have partnered with the Arab Development Society (ADS), a local cooperative business that works closely with farmers. Their results have been impressive: the effluent from treatment using duckweed meets the standard for *restricted* irrigation of crops while the duckweed fodder has increased the weight and quality (and thus, the value) of the chickens the ADS sell. In addition, a 15% reduction on the cost of fodder for farmers has made the duckweed a popular product as feed for chickens and livestock. The experience has also benefited from a high degree of participation from farmers proving that with the right economic incentive and a strategy respectful of local needs, there is a great deal of interest in investing in decentralized wastewater treatment.

In Senegal aquatic plants have been tested, with support from the national sanitation authority, to see if they can adequately treat wastewater to be sold and used in market gardens. The daily disposal of 100,000 m^3/d of wastewater – a potential resource – spurned on two NGO's, ENDA-Tiers Monde and the Institut Fondamental de l'Afrique Noire (IFAN) to develop two aquatic plant treatment systems. The community, through local farmers' organizations, has been an integral actor in the O&M of wastewater collection and treatment infrastructure. Each system involves a grease trap, septic tanks and then collection through small-bore sewerage piping. The effluent is taken to a sedimentation basin where most of the sludge is retained. The effluent then moves on progressively through four aerobic treatment ponds using typha (water reed) plants as the treatment medium. The effluent quality progressively increases to the point where by the end, there have been significant reductions in BOD, COD and suspended solids levels.

The model is based on the premise that the use of donor funds can support the initial development of the system followed by a step-by-step transfer of financial responsibility onto users. The project team are also assessing if there is any economic potential in terms of selling the wastewater and aquatic plant waste (for animal fodder) to farmers. The project has been acknowledged by the national sewerage authority (ONAS) who are seeking an evidence base to go forward with the development of 160 similar systems.

[11] Macrophytes are simply plants large enough to be seen with the eye.

More information on WEDO and ENDA-IFAN work on this is available from www.idrc.ca/cfp following the link to projects 100219 (WEDO) and 04367 (ENDA-IFAN).

Waste Stabilization Ponds

In addition to floating aquatic macrophyte systems, a more commonly employed option are waste stabilization ponds (WSP). These have received a fair amount of attention in the literature on wastewater (Mara and Pearson, 1998; WHO 1987). The main advantage of WSPs is their cost effectiveness and suitability for creating an immediate supply of wastewater for irrigation (Rose, 1999). They work through employing natural influences (wind, sun, gravity and biological processes) that serve to provide primary and secondary treatment over a period of days. Well-designed WSP can achieve very high BOD, nitrogen and phosphorous removal rates (Mara and Pearson, 1998). Unfortunately, despite these advantages, WSPs are faced with the problem of requiring large spaces and thus, are not particularly suitable for urban environments. Where land prices are high, they are not economically feasible. This discounts their use from most central urban areas, however, in peri-urban area WSP's are financially feasible and provide a ready source of irrigation water.

Despite the relative disadvantages of WSP in terms of space needs and the length of time needed for treatment, municipalities should still consider these foremost amongst their options for treatment for several reasons. First, the cost of treatment using waste stabilization ponds is significantly cheaper than mechanical treatment. In Jordan, the average cost of treatment for WSP is 0.07 JD per m^3 while mechanical treatment costs averaged 0.22 JD per m^3 (WHO, 1999). Second, municipalities may be reluctant to purchase the land necessary for WSPs, however, if a proper economic analysis were conducted internalizing costs associated with not collecting wastewater, the overall impact of the land purchase would be negligible.

On-Site Wastewater Ponds

Where formal treatment is not feasible, the option of encouraging very rudimentary treatment is a possibility. Small ponds dug on farm land, and exposed to the elements, provide better treatment than nothing. Exposure to natural processes will lead to a dying away of viruses and bacteria due to natural processes such as ultraviolet radiation from sunlight, the settling of solids and absorption. In short, the longer wastewater sits, the fewer health risks present. Groundwater can be mixed in to reduce the salinity of the wastewater and improve its quality as an irrigation supplement. Asano and Sakaji (1990) found that after two weeks, there was a %99.99 reductions in viruses in wastewater in ponds under regular field conditions.

This is a very simple form of containment and irrigation, with at least some natural "treatment" occurring through the effluents' exposure to natural processes. As of yet, no government is willing to legitimize this form of wastewater storage and use, however, it is popular and there is potential to at least reduce health risks – even if not achieving current WHO guidelines – and so consideration should be given to its use.

7.2 Non-Treatment Management Options

In communities where poverty is extreme and governance capacity is low, there must be some consideration given to non-treatment management options as treatment may be unfeasible. These options are needed because it has been shown consistently that urban farmers will use wastewater regardless of whether it is treated or not. There are many non-treatment management possibilities, however, as Faruqui et. al (2002) have pointed out, the problem remains how to convince farmers that they are important to follow.

One key issue with untreated wastewater use is the fact that often farmers do not link illnesses and working with domestic wastewater (IWMI-RUAF, 2002). Without making the link between their work and health risks (bacteria/parasites that are not visible), farmers are unlikely to change their behaviour without a significant amount of convincing and a well thought out strategy. Social marketing (see box 4) can provide one way to creatively convince farmers of the danger. Simple workshops and education programs targeted towards farmers would be another solution. Finally, the importance of tailoring results into a format that is accessible to farmers needs to increase in prominence when conducting applied research. Pamphlets, posters, pictures, handouts and workshops that synthesize more complex research are important.

Irrigation options

The type of irrigation system employed can significantly impact both the quantity of water being used and the degree of contact between farmer and wastewater. Often irrigation is done with watering cans that expose much of the plant to pathogens. Drip irrigation directs the water into the ground and roots, thus avoiding contact with the leafy part of the plant. This is especially important when dealing with salad crops and other crops eaten raw. Drip irrigation reduces water use when compared to conventional irrigation leading to a reduction in evaporation and reduced soil salinization. Drip irrigators also save 30% to 60% of water compared to standard irrigation techniques. Second, as the water does not come into contact with foliage, and instead irrigates the roots of the crop, there is a reduced health risk for crops eaten raw. One major drawback is cost. At $1,000 to $2,500 per hectare, drip irrigation is considered too expensive for poor farmers; however, the costs are coming down with the production of cheaper drip irrigators (FAO, 2002).

Harvesting soon after irrigation can increase the risk of exposure to health risks. The sooner a crop is harvested after it is irrigated with wastewater, the greater the health risk. Waiting for a period of days or, ideally weeks, between the application of wastewater and harvest can significantly reduce the health risk as pathogens die off over time. A period of five days to two weeks is ideal depending on the crop.

Figure 11, 12: Untreated wastewater application using watering cans is a common practice that can lead to serious health problems.

Figure 13: Trickle irrigation reduces the amount of water needed for irrigation and also can reduce the exposure of farmers to harmful wastewater

Protective Clothing and Chemotherapy

An important source of wastewater related illness occurs not when the crops are eaten, but rather when the wastewater is applied by farmers. Many farmers wear little or no protective clothing and thus are exposed to pathogens. The obvious method in response is to encourage farmers to use protective clothing such as boots and gloves. In practice, however, this has proven extremely difficult due to the low level of awareness that illnesses are in fact caused by the domestic wastewater used in irrigation.

Anti-worm medication and chemotherapy could be considered as options in cases where risk is acute and other options are not feasible. Cleaning of crops with light bleaches, boiling and other cooking methods are also ways that harmful pathogens can be killed.

Crop Restrictions

Crop restriction has been attempted to limit exposure of certain crops (such as leafy salad crops which are often eaten raw) to wastewater, however, restrictions on crops have proven unsuccessful as farmers end up producing crops for the market (if they are in demand) regardless of any prohibitions. Often, it is the crops that yield the greatest profit (such as lettuce) that are excluded. Enforcement is another problem. Mara and Cairncross (1989) found that crop restrictions can work when used by a limited number of large producers as it would be much easier to monitor and enforce.

7.3 Support and Financing

Water Demand Management

Wastewater use as an irrigation supplement is considered an integral part of a water demand management strategy (WDMF, 2002). The principle behind water demand management is to reduce the need for dependence on increasing supply as a solution to water scarcity. Instead, options for reuse reduction and conservation are prioritized. Some methods used in WDM include water pricing structures, Integrated Water Resource Management and participatory irrigation management. Technologies used in promotion of WDM principles include many of those discussed in this report: drip/trickle irrigation, low cost treatment and use, small bore collection etc.

WDM is increasingly seen as a key principle in the sound management of water. It is likely to affect policy, and accordingly, impact the development of wastewater use.

Box 4: Social marketing

Social marketing is an important method increasingly being employed by community health professionals as a way to entice changes in behaviour. The premise is simply to "sell" ideas, attitudes and behaviours using the same types of marketing strategies that are used to sell products. It is a type of marketing that is focused on the consumer and attempts to prioritize their needs, situation and cultural context. Social marketing is responsive to user needs.

For domestic wastewater use, social marketing strategies employed by community health workers might provide some changes in behaviour that would ultimately reduce health risks. Budds et. al. (2002) caution that despite claims of success, there are not a huge amount of scientifically valid evidence of social marketing's effectiveness.

A good review of social marketing linked with urban sanitation is available at:

www.lboro.ac.uk/departments/cv/wedc/projects/sm/index.htm - Anchor-Project-37005

Public Private Partnerships

A well-designed PPP can offer private capital to support the development of the WATSAN sector. If appropriately regulated, this can be an effective way to improve management, and operational efficiency. There is also a need to recognize the fact that water must first and foremost remain a public good and thus, any partnership needs to retain social equity as a primary principle. Many models of private sector involvement exist along a spectrum from full public ownership and operation to complete divestiture to the private sector (Kessides, 1993 is a good overview of existing options). Most water managers and decision makers see PPP as an important area for research considering its recent popularity (WDMF, 2002). At the moment, there may not be enough incentive for private firms to focus on low-cost sanitation (and reuse) or marginal communities, however, if PPP contracts included equity as a contractual condition, it would likely spur investment into developing alternatives and expanding existing options.

Micro-credit financial arrangements

An important goal of community wastewater treatment is cost recovery. Municipalities are well positioned to support micro-credit and financing groups that can provide loans to pay for the installment of a collection and treatment system (at the household or community level) and then recuperate the loans at a favorable rate over a fixed period. Such a system is currently being employed in Yoff, a moderately poor neighbourhood in Dakar by FOCAUP (fonds communautaire pour l'assainisement des quartiers urbains pauvres), a local micro-credit organization. FOCAUP provide credit specifically for households to connect themselves to the sewerage network and septic treatment system. The debt is paid off at a favourable interest rate over a period of 30 months. One of the notable lessons from this project has been that success is linked with income. Where income allows, households demonstrate a willingness to invest sanitation. Moreover, higher income is connected with the capability to repay the loan. For these reasons, micro-credit may not work in the most abjectly poor neighborhoods, but rather, can be used in lower-middle class neighbourhoods.

Public participation and community education

On questions of urban farming using wastewater, it has been amply shown that there remains a large amount of ignorance on basic aspects related to its use. For example, farmers are often skeptical that there are health risks related to the application of wastewater simply because most health risks are not visible (IWMI-RUAF 2002). Both bacteria and heavy metals fall into this category and their risks are often mis-understood by farmers. Any risk mitigation or policy/enforcement change would need to be anchored in community education and participation.

Research has shown that in too many instances, the marketing of sanitation technologies is ignorant of the wants of the poor and thus unsustainable (Obika, et. al, 2003). For example, the use of health and illness prevention in education does not always work since for many, "invisible" illnesses are not tangible enough to change basic behaviours. The users themselves are the best positioned to say exactly what their needs are and what they see as viable sanitation infrastructure for their households. Health may not seem as immediately important to users as cost, smell and functionality. Promotion of low-cost wastewater treatment technology, particularly amongst urban farmers, needs to give this regard if the technology in question is to be successfully adopted. Social marketing (see box 4) is an increasingly popular method useful in preparing demand-driven responses to infrastructure needs.

Dreschel et. al (2002) provides three areas where educational interventions might occur: amongst farmers, at the market and amongst consumers. Amongst farmers, needs relate to understanding potential health risks and how to avoid direct contact with wastewater. Some options include wearing protective clothing (although in hot climates, rubber boots and gloves are not likely to be adopted) or building small bridges from which the wastewater can be accessed without wading into the ponds. Farmers can also be encouraged to grow crops that accumulate fewer heavy metals. In markets, awareness needs to be raised about post-harvest contamination and how it might be prevented through the provision of clean water to the markets. Consumers need to be aware of the potential health risks and be prepared for simple mitigation techniques such as safe food preparation or more complicated ones such as crop certification.

Urban Extension

Formal agricultural support in the South has traditionally focused on the development of the rural agricultural sector. In the eyes of development workers and theorists, it was believed that with a vibrant rural economic sector, a reduction in poverty would ease the rate of urbanisation. There was also a belief that food security could be achieved through having a viable rural agricultural sector. History has proven this perspective too limited as urbanisation - and the concentration of poverty in urban areas - has continued unabated and food security has become more tenuous. The field of development has not kept pace with reality. Support for rural agriculture is still far higher than urban agriculture in spite of the increasing acknowledgement of the importance of UA as an economic sector.

One widely practised method of support has been the adoption of agricultural “extension” programs. These programs were developed to disseminate methods, crop inputs, technology and training widely. Such programs were met with mixed success, but rarely tackled issues relating to urban agriculture. Currently, urban agricultural extension programs are almost non-existent (Cuba being a notable exception), or exist as a part of a larger extension agricultural strategy. National agricultural authorities would do well to develop urban agriculture extension programs including training and guidance for those reusing wastewater and developing treatment and conveyance systems. Municipalities would be suitably placed to administer such programs. One positive development has been the increased interest of National Agricultural Research centres (NARS) in developing UA research that will perhaps lead to more substantive program support.

7.4 Summary of Recommendations for Increased Adoption of Wastewater Recycling

The following table represents a summary of goals and recommendations discussed in this report. Each goal links with a recommended course of action and a number of tools that could be used to increase the likelihood of adoption of wastewater use policy options.

Goal	Recommendation	Tool
Improve cost-recovery	• Adopt the "polluter pays" principle • Change behaviour to improve cost-recovery • Adopt water demand management principles	• Willingness to pay survey • Water/wastewater pricing • Social marketing
Develop wastewater-friendly policy	• To identify researchers who are well positioned and driven to have impact on policy. • To create a series of policy related materials and toolkits that are easily accessed by policy makers • Remove constraints to the use of wastewater	• Identify "Policy Entrepreneurs" • Policy briefs • Incorporation of policy makers into UA teams early in project development • Revise building codes to allow for adoption of household treatment systems
Involve water users	• Develop water users associations at the basin level. This can be done through trans-boundary administration so as to incorporate both urban and rural water users. • Find appropriate technology to employ for water and sanitation provision • To target the actual (as opposed to inferred) needs of the poor and ensure long-term viability of proposed solutions	• Participatory planning process • Social marketing • Make use of networks to access information about appropriate technologies
Decentralise wastewater management	• Decentralise management to an *appropriate level*, ensuring that the local government have capacity and tools. • Plan low-cost collection and treatment systems with wastewater use in mind	• Use donor community and governance networks to do decentralization training and policy development
Develop design guidelines for low-cost treatment systems in developing countries	• These need to take into account pollutants of concern because they differ from those that are a problem in the developed world (industrial vs. domestic)	• Guidelines with a realistic scale respecting relative differences in finance and capacity (regional, instead of global)

Land use planning	• Development of tools and methods for planning in support of UA • Protect land near water sources, (including wastewater) through agricultural zoning	• Zoning • Standardised methodology and process for municipalities • Geographical Information Systems • Land value analysis of areas near sources of wastewater
Financial support for farmers	• Improve access to credit and other financial services for the UA sector	• Micro-credit
Provide technical agricultural support	• Training and education on safe use of wastewater in irrigation based on national policy and administered by local authorities. • Development of urban extension programs by national governments and administered by municipalities	• Urban extension programmes • Market analysis for UA products • Business Development Services for small enterprises
Improved effluent management	• To reduce the use of industrial wastewater use and to better manage both waste streams	• Source separation of domestic and industrial wastewaters.
Community Health Programming	• Provide medical assistance and outreach to farmers • Examine medication (anti-worm) for protection against parasites and nematodes. • Employ disease control officers and facilitators for education programs on dangers associated with irrigation • Incorporate wastewater and health related risks into municipal health programming	• Develop `train the trainer` courses for education on untreated wastewater use • Find an appropriate use of ICT`s for health dissemination

8. CONCLUSIONS

This report has concentrated on highlighting links between urban agriculture and wastewater use. When used as an input into the income generating activities of UA, wastewater use has clear economic potential. Still, the policy environment remains fairly hostile to the concept out of concern for associated health risks. As this sector develops, the more it becomes clear that there are technologies and policy options that hold promise. In the right socio-economic and institutional setting, such options can work. Several things are clear: (1) in the absence of alternatives, farmers will use wastewater including raw wastewater; (2) if regulations are excessively strict and not enforced, they will be ignored for the most part; (3) when wastewater is used raw, any treatment and risk mitigation possibility even those that do not meet international health standard, are better than no treatment; and finally (4) for poor urban areas, low-cost conveyance and treatment is the preferable solution to the urban infrastructure dilemma.

There is some movement towards revising the WHO guidelines towards a more appropriate balance between WATSAN capacity, health risk and allowing for an incremental, "step by step" improvement in treatment. WHO assumes responsibility to assess current epidemiological evidence and revise guidelines based on this evidence. In response to criticism that the WHO guidelines are too strict and unattainable, the WHO has indicated that guidelines for wastewater use will become more flexible by using the *Stockholm Framework*. This framework examines health risks in the context of other potential risks (drinking water, poor hygiene practices, contaminated food) thus prioritising the greatest health risks foremost (Carr et. al., forthcoming). A phased approach to developing guidelines, updated every few years as technological and sanitation options are improved, may be recommended.

There is a need for a coordinated research effort towards new technological and policy options. Decision makers consistently cite the need for more information on the effectiveness and capability of low-cost methods to treat wastewaters to internationally recognised standards while retaining its reuse potential. At the moment, the WHO, IDRC, the International Water Management Institute (IWMI), and the Resource Centre on Urban Agriculture and Forestry (RUAF) represent some international institutions attempting to develop a unified global research agenda on the topic. The Hyderabad Declaration (Annex I) represents a benchmark containing key issues and research needs (Annex II).

At the national level, two key areas for policy consideration are to (1) develop technological options and encourage their implementation by local water authorities and (2) adapt water policy to incorporate strong demand management and cost-recovery elements. Demand management and cost-recovery are already being adopted, but more emphasis can be placed on wastewater use as an integral component of a WDM strategy. The evidence cited in this report also shows that it makes sound economic sense. There are many models whereby costs associated with inexpensive treatment can be recuperated. Systems at the household level can be supported through simple building code adjustments and design guidelines. Training programs, through agricultural extension services, could be developed focusing on decentralized wastewater treatment and wastewater use. Moreover, such extension should include the development of micro-credit facilities to allow farmers access to credit for basic sanitation and irrigation equipment as well as business development services. Extension would also help in the development of markets and an entrepreneurial sector interested in promoting the use of wastewater for urban agriculture.

Public participation, infrastructure planning and education should be the thrust of municipal level work. In places where municipalities are very weak (such as some parts of Africa), the national level government would be a more appropriate target since they often end up assuming responsibility for basic services.

Where municipal governments are relatively strong, planners would be an essential part of the solution. While planners need to consider technological needs, planning should be based on the principal that income constraints are probably easier to overcome than technological constraints. Therefore, linking community development with the installation of low-cost on-site and off-site water treatment technologies is a good approach. In places where treatment is unrealistic even in the medium term, some municipalities can adopt more drastic planning measures. The traditional area where municipalities can have an important impact on both UA and wastewater use is in land use planning. As noted above, ensuring land tenure and protecting agricultural areas (with access to various sources of water often resulting in higher land values) through zoning are one possibility.

Innovative work on low-cost wastewater treatment technologies at the community level also needs to be supported. NGO's, research and academic institutes are at the forefront of research into low-cost treatment. Since investment in such systems is so far minimal, donor organizations (along with governments) need to play a facilitating role in supporting the development of such research. Individual groups can be helped in designing projects, developing networking and dissemination activities for their work. CBOs and NGOs must be involved to some degree as they represent the best means to involve water users: a key principle needed to ensure success of local WATSAN work.

On a final note, I wish to highlight three basic concepts that are necessarily the starting point in order guide policy development in this area at both national and municipal levels. First, it is necessary for governments to accept that wastewater use for irrigation is a common reality and cannot be simply outlawed or ignored. Second, where health standards are adopted, the minimum health guidelines should be appropriate for the local context and not based on standards that are difficult, or too strict, to achieve. Otherwise, the gap between treatment options and WATSAN capacity will remain too large. Finally, the need to shift policy towards developing appropriate technologies – technologies that are not capital intensive and large-scale – is key. By focusing an increasing amount of attention on decentralized treatment, one is not ignoring centralized and extensive wastewater treatment, simply acknowledging that in the vast majority of developing country urban areas, large-scale systems are simply not viable. Adopting these three concepts would lay a solid basis for the development of reasonably attainable wastewater recycling options.

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ANNEX I : THE HYDERABAD DECLARATION

The Hyderabad Declaration on Wastewater Use in Agriculture
14 November 2002, Hyderabad, India

1. Rapid urbanization places immense pressure on the world's fragile and dwindling fresh water resources and over-burdened sanitation systems, leading to environmental degradation. We as water, health, environment, agriculture, and aquaculture researchers and practitioners from 27 international and national institutions, representing experiences in wastewater management from 18 countries, recognize that:
   1.1 Wastewater (raw, diluted or treated) is a resource of increasing global importance, particularly in urban and peri-urban agriculture
   1.2 With proper management, wastewater use contributes significantly to sustaining livelihoods, food security and the quality of the environment
   1.3 Without proper management, wastewater use poses serious risks to human health and the environment.

2. We declare that in order to enhance the positive outcomes while minimizing the risks of wastewater use, there exist feasible and sound measures that need to be applied. These measures include:

   2.1 Cost-effective and appropriate treatment suited to the end use of wastewater, supplemented by guidelines and their application
   2.2 Where wastewater is insufficiently treated, until treatment becomes feasible:
      (a) Development and application of guidelines for untreated wastewater use that safeguard livelihoods, public health and the environment
      (b) Application of appropriate irrigation, agricultural, post-harvest, and public health practices that limit risks to farming communities, vendors, and consumers
      (c) Education and awareness programs for all stakeholders, including the public at large, to disseminate these measures
   2.3 Health, agriculture and environmental quality guidelines that are linked and implemented in a step-wise approach
      Reduction of toxic contaminants in wastewater, at source and by improved management.

3. We also declare that:
   - Knowledge needs should be addressed through research to support the measures outlined above and
   - Institutional coordination and integration together with increased financial allocations are required.

Therefore, we strongly urge policy-makers and authorities in the fields of water, agriculture, aquaculture, health, environment and urban planning, as well as donors and the private sector to: **Safeguard and strengthen livelihoods and food security, mitigate health and environmental risks and conserve water resources by confronting the realities of wastewater use in agriculture through the adoption of appropriate policies and the commitment of financial resources for policy implementation.**

ANNEX II: RECOMMENDATIONS FOR THE CFP WASTEWATER RESEARCH AGENDA

In the field of wastewater use, policy makers are waiting for factual evidence that low-cost treatment systems can work than at least well enough so that the benefits (financial and others) outweigh the costs (possible health impact). Policy impact can happen directly in a linear fashion, but more often in an indirect, interactive and networked way (Neilson, 2001). Policy makers are often making decisions without having all of the answers while research is always on-going and building on previous experience. Research involves a process of seeking answers and solutions support the evolution of policy and make it more responsive to needs. Good science can lead to sound policy decisions.

At the Hyderabad meeting in November, 2002, research needs on the question of wastewater use were discussed and a series of research gaps agreed upon to help inform future research.

Research Gaps (Hyderabad Meeting, 2002)

A. Livelihood issues:

A.1.	Study on wastewater-dependent livelihood activities
A.2.	Global assessment of (treated) wastewater use (diagnose and benefits)
A.3.	User perceptions of risks and benefits
A.4.	Human health issues related to (treated) wastewater use

B. Field- and farm management

B.1.	Appropriate irrigation techniques and water management (context specific)
B.2.	Development of context-specific guidelines
B.3.	Local water management strategies (related to quantity and quality)
B.4.	Long-term effects of (treated) wastewater use on soils and groundwater
B.5.	Nutrient management in relation to cropping practices
B.6.	Feasibility of non-treatment options

C. Communication and information

C.1.	Information systems that support farmers in decision making
C.2.	Knowledge networking and exchange

D. Integrated design and management

D.1.	Linking wastewater treatment techniques to beneficial use of the effluent (application of a conceptual design framework)
D.2.	Scale issues (centralised vs decentralised)
D.3.	On site low-cost wastewater treatment systems incl. household level greywater use

E. Policy and planning

E.1.	Institutional framework, legal arrangements and implementation strategies
E.2.	Economic assessment of wastewater use
E.3.	Privatization vs indigenous practices and water rights
E.4.	Linking wastewater with demand management strategies (pricing and cost

	recovery)
E.5.	Management of industrial wastewater

Source: IDRC-IWMI Workshop, November 2002.

Recommendations for CFP

For the CFP programme initiative, the following recommendations are made to help it adopt a strategic approach to research for wastewater use and urban agriculture. The recommendations have been divided up into three sections:

1. Organise existing data/research
2. Research design
3. Develop new programming

Organise existing data/research
Identify the comparative advantage of low-cost treatment and wastewater use In simple terms, low-cost treatment (to acceptable standards) and use is the best option for small-scale sanitation. However, small-scale sanitation is not always well suited in certain urban areas. The issue of at what scale and urban density would be ideal for use of low-cost treatment technologies and where they have a comparative advantage over large-scale systems is a research need.
Evaluate wastewater treatment technologies and develop guidelines Currently, there is a mixed bag of different low-cost domestic treatment technologies that are being developed by CFP partners. There is a need to disseminate not only their research, but also to disseminate their operational experiences for other practitioners. Based on these experiences, approximately 7 systems can be evaluated using a cost-benefit analysis.
Research Design
National authorities versus municipal/local authorities As this research report has demonstrated, in the absence of well functioning local governments, the most effective policy actors are at the national level. Decentralisation is an aim, but has not yet been achieved in most areas. As a result, action-research oriented at influencing policy should concentrate on national level policy makers.
Include government representatives in research process Wherever possible, at an early stage of the research cycle, representatives from national ministries and local governments should be brought on board to maximize the possibility that decisions will be made using the research results. For low-cost wastewater treatment, a special effort should be made to include representatives from sanitation authorities in project design.
Differentiate between MENA and Africa in terms of what is relevant research on wastewater use. In the MENA region, governments and individuals have a higher capacity to develop expensive treatment technology. While low-cost treatment systems have a high likelihood of success in MENA (due largely to individual households ability and willingness to pay for treatment), it will be more difficult to achieve in Africa.

Have all projects incorporate economic aspects of wastewater use and treatment technology into its study

Policy-makers often place a heavy weight on economics as a key determinant of policy change. It is not the only factor, but the most important question that a fiscally conscious policy maker is concerned with would be is the technology cost-effective. While there is a growing database on the economic benefits of both UA and wastewater use, project specific data would be useful for use by the researchers to influence local policy on the questions of both UA and wastewater use.

Develop New Programming

Comprehensive studies into models of decentralization in the water and sanitation sub-sector (Senegal, Ghana, Uganda, Tunisia).

The decentralization of the water and sanitation sector is currently occurring in a number of countries and is sure to continue. At the moment, little research has been done into the impact of decentralization on the uptake of low-cost treatment and the use of wastewater. Future projects supported by CFP should make a concerted effort to analyze the institutional environment in which they work. This would aid CFP understand the overall state of the water and sanitation sector and help define how projects can impact policy.

Social marketing of low-cost technologies

As noted in this report, wastewater use in UA is often seen in a negative light. Many users of wastewater are aware of the benefits, but not as aware of the associated risks. Social marketing by CFP partners to potential users of wastewater about both benefits and risks would likely increase responsible use (see page 46 for more information on social marketing). Social marketing strategies would be particularly useful to support the development of greywater treatment in the Middle-East since is has already been noted that there is a high demand for the systems when people are aware of their benefits.

Land Tenure and Urban Regularization

Another important research need is to fully explore different tenure regimes in different regional and local contexts, as well as within different systems of governance. Secure tenure is a precondition for investment and improvement of landholdings. Meanwhile, urban regularization can facilitate the provision of urban services (such as WATSAN). An understanding of how these can be better integrated into local and national governmental structures is important.

Progressive approaches to wastewater treatment with incremental targets

Based on the problems related with having WHO guidelines that are beyond what most countries can afford to achieve, it would be useful to support the development of a step by step approach with targets respective of the country context.

This goal is more of a strategic goal for CFP to promote at the international level and through its networks.

Knowledge networking

The development of networks of researchers looking at questions of wastewater use is timely. While certain international networks exist (RUAF, IWMI), a more formal network of researchers in the MENA region is warranted considering the scarcity of water and the potential for low-cost treatment. Some networks already exist and CFP should tap into them when developing its own initiatives.

Target research to policy makers

Action-research should do its best to integrate the members of different ministries into its fold to ensure that there is cooperation at the national level. Strengthening the links between the health ministry and those of water and urban development is particularly important. Low-cost treatment will only be supported if restraints to its use (by health authorities) are changed.
Multi-stakeholder meetings/workshops on wastewater Supporting multi-stakeholder meetings and processes will help ensure that solutions are comprehensive and inclusive. While it is often true that multi-stakeholder processes can be cumbersome and unwieldy, they form an essential basis for responsible decision-making. CFP needs to continue to support these types of meetings in order to develop an appropriate research agenda.

ANNEX III: OTHER RESEARCH INSTITUTIONS OF NOTE

Currently, there are a number of institutions that are actively exploring questions of the interface between wastewater and urban agriculture. The Resource Centre on Urban Agriculture and Forestry (www.ruaf.org) is an international network of organizations working on issues related to Urban Agriculture. A recent copy of their UA Magazine was focused on wastewater use in UA.

The International Water Management Institute (www.iwmi.org), an international research institute with a focus on water have also done much work on untreated wastewater. IWMI co-sponsored an experts meeting on wastewater use in India in November 2002. The meeting culminated in the Hyderabad Declaration in support of research into the problematique (see www.idrc.ca/cfp for more information).

The Resource Centre Network for Water, Sanitation and Environmental Health (WELL) provides a basin of research and reports on questions related to water and wastewater. The WELL site is located at www.lboro.ac.uk/well/