Wastewater Irrigation, Farmers' Perceptions Of Health Risks And Institutional Perspectives: A Case Study In Maili Saba, Nairobi.

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EXECUTIVE SUMMARY

Key words: Urban Agriculture, wastewater use, health risks, Nairobi, perceptions, livelihoods.

Growing urban agriculture (UA) in many cities in developing countries has resulted in increased demand for resources such as land and water. In the context of access to water for irrigation, urban farmers have tapped into wastewater, which is a readily available resource in cities. Using wastewater for irrigation is enhancing the livelihood capacities of a large number of urban farmers. Farmers in urban and peri-urban areas are using wastewater to irrigate various crops, thus meeting substantial food demands within their households and for the market in cities.

Rapid urbanization in developing countries' cities has resulted in generation of huge volumes of municipal and industrial wastewater requiring treatment and safe disposal. Using treated wastewater for UA, provides a means through which wastewater can safely be reused and managed. The potential for wastewater use for irrigation can best be realized in an enabling environment that ensures adequate wastewater treatment and management, however, in most developing countries cities, wastewater used for farming is largely not treated raising public health concerns. Untreated wastewater poses potential health risks due to microbiological, and in other instances chemical contamination due industrial wastewater. These potential health risks are a major constraint of current wastewater use practices, and can possibly limit its long-term sustainability. The use of wastewater for UA is an important livelihood strategy especially for poor urban farmers, who are utilizing this resource, on the other hand its use, can result in an increased health risk for farmers and consumers if not well managed. To ensure sustainable and safe wastewater use for food production in urban and peri-urban areas, there is need to explore safe wastewater use and management options. The best approach will need to balance both farmers' livelihood needs, and public health concerns.

Building on previous studies, this report looks at the on-going challenges of wastewater use for irrigation in Nairobi, particularly highlighting the health concerns. The report presents a case study of wastewater use in a farming community in Maili Saba, Nairobi. The findings of the case study illustrate that wastewater use is a critical aspect of urban farmers' livelihoods, despite the potential associated health risks, and its practice will likely persist. It is imperative to acknowledge this practice and explore options for safe wastewater use. It is argued that searching for appropriate and realistic options for wastewater use in UA should look at how best to exploit the productive potential of this resource, while minimizing associated health risks. These options will be a combination of technological development, social interventions and institutional support.

The report is divided into two parts: Part I is a limited literature review, highlighting ongoing discussions on UA and wastewater use and relating them to sub-Sahara African experiences. The particular issues examined include the context in which use of wastewater for irrigation in urban areas occur, the complexity of the patterns of

wastewater use, health issues of wastewater use and the livelihood implications of wastewater use for farmers. This section also provides a framework for discussions of the second part of the report.

Part II of the report presents results and discussions of the case study of wastewater use for informal irrigation in Maili Saba, examining patterns of irrigation in the community, potential health risks and perceptions of these risks by farmers. In addition, the study also includes an exploration of institutional perspectives regarding UA and wastewater use for irrigation in Nairobi. In particular, the institutional perspectives sought were those of the Nairobi City Council (NCC) and Ministry of Agriculture, which are the two main government authorities, under whose mandate urban agriculture activities in Nairobi fall.

The report concludes that a comprehensive understanding of the context in which wastewater use for irrigation occurs in Nairobi is imperative for devising suitable wastewater use options. This includes looking at the livelihood strategies of farmers, analyzing the health risks of current practices, looking at farmers perceptions and awareness of health risks and understanding the broader constraints faced by farmers and the technical constraints of using wastewater for irrigation in Nairobi. Such a comprehensive understanding should form the basis for policy guidelines and institutional support for sustainable UA practices. It is hoped that the findings of this report will contribute to the wider discussions, and inform some of the policy deliberations of UA in Nairobi.

ACRONYMS.

UA- Urban Agriculture
NCC- Nairobi City Council
MOA- Ministry of Agriculture
PDA- Provincial Directorate of Agriculture
STW- Sewage Treatment Works
WHO- World Health Organization
IDRC- International Development Research Center
SSA- sub-Saharan Africa

PART 1: LITERATURE REVIEW

1.0 INTRODUCTION: URBAN AGRICULTURE IN SUB-SAHARAN AFRICA

Urban agriculture (UA) [1] is rapidly growing into an important economic sector in many cities globally. Urban farming has tremendous potential to improve the livelihoods of the urban poor and to make an important contribution to local food security. The increasing importance and magnitude of UA is timely in the context of developing countries, where hunger, malnutrition and environmental management problems are becoming largely urban problems. The above-mentioned problems are magnified by rapid urbanization in these countries. In 1990, the world's urban population stood at 2.4 billion and is projected to reach 5.5 billion by 2025. This growth will occur mainly in developing countries, which will be home to 80% of the urban population by 2025, compared to 63% in 1990, as result of both natural increase in populations and rural-urban migration (Smit et al, 1996). On one hand, UA is seen as a means of increasing employment opportunities, incomes, and food self-reliance, and on the other hand it is considered a tool for developing cities into healthier, greener, more liveable and sustainable urban landscapes (Sawio et al, 2001).

In the sub-Saharan African (SSA) context, urban agriculture has recently attracted more attention in research and development institutions as an alternative and viable urban food security strategy. With rapid urbanization in SSA, food insecurity is increasingly becoming an urban problem (Maxwell, 1999; Mougeot, 1994, Sawio et al, 2001, Lee-Smith and Memon, 1993). Economic crises and structural adjustment policies introduced in SSA countries over the years have had a disproportionately negative impact on the urban poor, as they resulted in rising food prices, persisting unemployment, declining purchasing power of local currencies and reduced public expenditure on social services and infrastructure mainly in urban centres (Mbiba, 1995; Maxwell, 1999; Mougeot 1994). Many urban dwellers responded to these challenges by adopting various strategies that diversified their income and food sources. One of the strategies identified by many urban residents, especially in response to food security was to engage in UA. Although there are differences between African cities with regard to UA practices and outlook, the common trend is that UA is not transitional, but will continue to be a permanent feature of these cites. This is because the aforementioned factors that have contributed to its growth are not ephemeral but are rather multiplying and irreversible (Mbiba, 1995; Mougeot, 1994). Thus, UA has potential to make food more accessible to many urban households in African cities.

In addition to the key role of improving food security, UA also offers alternatives for environmental management for African cities. The management of wastes, such as solid wastes and wastewater, constitutes one of the most intractable environmental problems

[1] Urban Agriculture is defined as the growing of food crops and non-food crops and the raising of livestock, which are consumed locally within urban and peri-urban boundaries. There is lack of a common working definition of what entails "urban" and "peri-urban". In the context of this report, the concept of Urban Agriculture is used to refer interchangeably to both urban and peri-urban agriculture.

facing African cities. Unlike rural organic waste, which is recycled, the nutrient rich content of urban waste is usually lost and contributes to pollution in cities with little return of nutrients to production areas. Urban agriculture offers an opportunity to manage environmental problems in urban areas through recovering and reusing oraganic wastes. (Drechsel and Kunze, 2001; Asomani- Boateng and Haight, 1999; Rose, 1999).

1.1 Wastewater use for UA in SSA.

A notable characteristic of UA in many developing countries cities is the use of wastewater[2] for crop production. In many developing countries, wastewater produced by rapidly urbanizing cities has been identified as an important and readily available resource for irrigation[3] in urban and peri-urban areas. Although the use of wastewater for irrigation has a long history (see Mara and Cairncross, 1989; Shuval, 1990), it is now more significant given the increasing scarcity of fresh water, especially in many developing countries. There are no comprehensive figures of the extent of wastewater used for irrigation, but available estimates indicate that about 900,000 hectares of farmland in developing countries are irrigated using wastewater (Raschid-Sally and Abayawardana cited in Inocencio, et al 2003). Municipal sewage, when properly managed, can be an alternative source of irrigation water for UA (Khouri et al, 1994; Strauss, 2000). There are many benefits of using urban wastewater for irrigation including water conservation, nutrient recycling and enabling year round access to a reliable source of water. For local governments, using treated wastewater for irrigation can be beneficial, as an economically feasible and environmentally sound method of disposing municipal wastewater (van der Hoek et al, 2002).

The extent and magnitude of wastewater use in SSA cities has recently increased in the context of rapid urbanization in the region, accompanied by a growth in urban agriculture (Armar-Klemesu, 2000, Drechsel et al, 2001). In water scarce regions such as SSA, access to water resources is precarious, especially with an increase in competing water demands for domestic, industrial and institutional use resulting from urbanization. Since UA is not fully recognized as a legitimate sector in most African cities, the demand for fresh water by these other sectors take precedence over UA demands (Armar-Klemesu, 2000; Mensah et al, 2001). The growing practice of UA in African cities has therefore resulted in a new demand for water. Agriculture requires water, which may be obtained directly from rainfall or indirectly from a variety of sources such as rivers, streams and wells, but because these water sources are not adequate, urban farmers have resorted to using alternative sources such as wastewater. In addition, other motivation for using wastewater for UA is it is readily available and rich in organic nutrients. Increased urbanization for most African cities has resulted in increased volumes of domestic and

[2] Wastewater is a broad term that is defined mainly by the composition of the water (see section 3.0). In the context of this report, as a working definition, wastewater refers to the liquid discharged from homes or commercial premises to individual systems or municipal sewers. It is a mixture of domestic sewage- grey and black water and municipal wastewater. It may or may not contain substantive quantities of industrial effluent. (Cornish et al, 1999). In many developing countries, due to limited amount of separate collectors, most wastewater is discharged in mixed collection systems.

[3] Wastewater has also been used for aquaculture, this has been an ancient practice especially in Asia (Mara and Cairncross, 1989), but this report is limited to wastewater use for crop production only.

industrial wastewater being produced and consequently a demand for suitable disposal options (Bruins, 1997; Mensah, et al, 2001). When properly treated[4] and managed, wastewater use in UA offers a viable alternative through which a substantial volume of wastewater can be safely be reused. As Rose (1999) notes, by facilitating organic waste nutrient cycles between points of generation to point of productions, UA can redirect waste streams of most cities toward production of food and fibre in a sustainable manner.

Acceptable and appropriate use of wastewater for irrigation can be enhanced when the infrastructure for wastewater treatment is put in place. Conventional approaches to wastewater treatment include centralized, highly mechanical and capital intensive conveyance and treatment systems, which are more typical in developed countries. But in many developing countries, these centralized systems have had limited success mainly due to the huge amounts of initial investments required and the accompanying high costs of operations and maintenance (Bradford et al, 2002; Drechsel, 2002; Rose, 1999). In the context of wastewater use, centralized treatment systems are also limited in that they do not consider the value of recovering organic waste resources in the wastewater, and are designed to dispose rather than recycle these nutrient resources (Rose, 1999). This indicates the unsustainability of centralized treatment systems, considering that effluence from municipal wastewater sources, when appropriately treated, can safely supply most of the water needed for urban irrigation that is rich in organic nutrients.

For most SSA cities, the lack of adequate and inappropriate infrastructure and facilities for wastewater treatment has been a major constraint for safe wastewater use. This inadequacy is made more challenging by limited institutional and legislative frameworks and enforcement mechanisms for pollution control. Most SSA cities have adopted centralized wastewater treatments systems within their urban plans, but the reality is that majority of the urban populations in SSA have no connection to any sewage facilities. For example, in Dar es Salaam, only 5% of the residents are connected to a sewerage system (Kiango & Amend, 2001, p.122). In Kumasi, a maximum of 8% of the population has access to piped sewerage systems (Keriata et al, 2002, p.11). In addition to lack of adequate facilities, the available facilities have limited function due to break down of equipment and expensive maintenance costs (Brock, 1999, Odurukwe, 2002, Drechsel, 2002). These factors result in untreated wastewater being discharged into natural water bodies such as rivers and streams, polluting these water bodies with microbiological contaminants, and in instances where there is industrial discharge, toxic contaminants. The situation is even more precarious as these rivers and streams are main water sources for crop production by urban and peri-urban farmers[5]. In other instances, farmers break directly to sewer lines or block manholes and divert raw sewage into their plots (Faruqui et al, forthcoming; Hide et al, 2001b, Dennery, 1995). In this context, the use of wastewater for crop production is in most cases totally unregulated, and poses potential health risks for both farmers and consumers. For most urban farmers in developing

[4] Treatment of water refers to a natural or artificial purification process to improve its physical, chemical or bacteriological quality before discharge. The degree of treatment can vary greatly (Cornish et al, 1999)
[5] Another concern is that this water is in many cases used for domestic purposes by households downstream. This issue is not discussed within the scope of this study.

countries, wastewater accessed directly or indirectly through natural surface waters bodies and sewers has become an inexpensive and nutrient rich resource.

2.0 WASTEWATER IRRIGATION: LIVELIHOOD STRATEGIES AND PERCEPTIONS OF HEALTH RISKS

In the rapidly growing cities in developing countries, access to water, especially for the poor, extends beyond water for domestic needs. For most urban poor, sustainable livelihoods can be built on access to water for productive purposes, and this can be clearly illustrated in the context of urban and peri-urban agriculture. The growth of wastewater use for UA in developing countries is related to increasing vulnerability of many urban households due to declining opportunities in the formal economy. In many African cities, for instance, wastewater irrigation has become an integral part of the informal economy, as urban dwellers take up farming not only for subsistence, but also for income generation through market gardening. Market gardening has evolved into a vibrant economic sector in Kumasi and Dakar, among other African cities (Keriata et al 2002; Faruqui et al forthcoming; Niang et al, 2002; Danso et al). For example, market gardening accounts for more than 60% of the vegetables consumed within Dakar (Faruqui, et al forthcoming). In Kumasi, farmers practicing year round irrigation earn annual incomes of between US$ 400- US$800, which is double what they could earn as rural farmers (Danso et al. 2002)

The use of wastewater for irrigation represents a significant monetary benefit for urban farmers (Cornish et al; 1999; Danso et al 2002; Faruqui, et al forthcoming; Hide et al, 2002a). Access to water as a resource is therefore important for urban farmers, as they have taken up informal irrigation to enhance their production capacities. Wastewater remains a cheap and reliable source of water and nutrients for these farmers (Van der Hoek et al, 2002). Access to wastewater has resulted in a shift in farming patterns from seasonal cultivation to year round farming, thus enabling farmers to have more harvests per year, which adds a significant amount of cash to their income. The availability of wastewater has also enabled farmers to produce high-value and high-demand crops such as vegetables, which require a constant supply of water, thus boosting their profit margins. In addition, the nutrient rich content wastewater is especially important for farmers since in most cases it decreases or eliminates the need for fertilizers. Considering fertilizers are a costly input for farmers, using wastewater can greatly reduce farmers' production costs. Further to producing significant quantities of fresh produce for urban and peri-urban markets through irrigation, it is widely acknowledged that these farms provide direct and indirect employment to a large number of people (Feenstra et al 2002; Van der Hoek et al, 2002).

On the other hand, access to untreated wastewater for agricultural purpose can also result in farmers' vulnerability. As previously noted, the use of untreated wastewater has accompanying health risks. For most urban farmers, perceptions of risks and benefits of using wastewater are centrally tied to their livelihoods. Understanding risk perceptions is an important variable in public health studies. Risk perception in public health and social science research has mainly been defined within an individualistic and psychometric paradigm. In this paradigm the focus has been on factors such as individual knowledge of risk, social trust and perceived control over risk (Frewer et al, 1998; Sommerfeld et al, 2002). Increasingly, there has been a refocus from individual approaches of understanding risk, to an inclusion of the broader macro-structural factors such as socio-economic contexts that influence risk (Sommerfeld et al, 2002; WHO 2002). Perceptions of risk related to use of wastewater could therefore be understood within these broader contexts, in which urban farmers make choices and decisions in order to attain food and livelihood security, and the institutional contexts in which these choices occur.

3.0 WASTEWATER USE IN UA: OPTIONS FOR ENVIRONMENTAL MANAGEMENT.

In the context of environmental management, properly designed, adequately implemented wastewater use can be a form of environmental protection. Safely recovering and reusing human waste in wastewater through UA reduces the amount of effluent that is discharged into receiving water bodies (Khouri et al 1994; Rose, 1999). Wastewater use is also a valuable strategy for water demand management as it can free large amounts of fresh water used for irrigation, and make this resource available to meet the growing needs for fresh water of cities in developing countries. A study in Haroonabad, Pakistan indicated that wastewater irrigation freed up three to four times the amount of fresh water for use elsewhere (Hassan et al, 2002). In addition, wastewater use decreases the need for additional inputs such as chemical fertilizers for crop production. The nutrient rich wastewater not only enhances their production but also enables urban farmers to practice environmental sound ecological farming.

The main constraint of wastewater use is the threat to public health related to insufficiently treated wastewater. Microbiological and (chemical) contaminants can cause diseases if wastewater is not well treated, and used to produce food crops. The main obstacle for wastewater treatment, as previously noted, is the dismal performance of conventional wastewater treatment systems in many developing countries. But there are on going efforts in search of low-cost[6], decentralized and potentially appropriate systems for low-income countries, which will also enable reuse of wastewater in agriculture production (Brooks, 2002; Rose, 1999). A more prudent approach to wastewater use has been through the use of treated grey water[7]. An IDRC supported research project[8] in Jordan has developed household grey water treatment systems that have successfully enabled households to reuse grey water for UA (CFP Project #100880). Grey water use in UA is associated with fewer health risks, as grey water does not contain pathogens present in black water. Results of the Jordan project show that households were able to irrigate certain food crops, which enabled them to offset food purchases and even generate income by selling surplus production (Faruqui, 2002).

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[6] Rose (1999) provides an extensive review of low-cost community based options for domestic wastewater treatment and reuse options. IDRC has also supported a project in Latin America, through CEPIS that extensively looked into integrated systems for treatment and recycling of wastewater (see CFP# 100123).
[7] The various distinctions of wastewater are expounded in the next section
[8] The treatment systems consist of a minor plumbing modification that diverts water from showers and kitchens through small scale, natural filters that enables the water to be used in home gardens.

Exploring options for better and safe wastewater use is in many ways, challenging conventional wastewater treatment and disposal approaches. Intertwining UA and decentralized approaches to wastewater management can contribute to ecologically sustainable urbanization in developing countries cities through resource recycling, food production and job creation. Wastewater use for UA has potential to contribute to urban economies and ecosystems, and if well supported through policies, it would encourage initiatives to enhance efficient and safe urban agricultural production.

4.0 TYPOLOGY OF WASTEWATER USE FOR UA.

In SSA, like in many developing countries, wastewater use varies from place to place (Cornish et al, 1999; Hide et al, 2001a, Faruqui et al, forthcoming). As previously mentioned, wastewater use for urban irrigation can be a formal and controlled practice or an informal practice. Tunisia provides a good example of formal wastewater use. Wastewater use is an essential component of the national water strategy in Tunisia. Given the limited renewable water resources of Tunisia, treated wastewater has been identified as an alternative and vital means of accessing water resources. A national reuse policy has been developed and implemented for crop irrigation and irrigation of recreational facilities. The local Agriculture Development Authorities distribute wastewater to farmers, and collect revenue. The authorities forbid irrigation of crops eaten raw and legally enforce this restriction. Tunisia uses 14% of its treated wastewater (Chenini, F et al, 2003)

But in most cities in developing countries, wastewater irrigation is an informal and unregulated activity, making it difficult to define the pattern and extent to which it is practiced. In the context of informal irrigation, wastewater is accessed directly or indirectly. Indirect use occurs when domestic wastewater, and in some instances, industrial wastewater is discharged directly into watercourses within the urban areas with no treatment. In Pakistan for example, the sewage disposal system entails discharging wastewater into surface water bodies, which are often irrigation canals. In this case there is no control over the subsequent use of the water for crop production (van der Hoek, 2002). Direct use occurs mainly when farmers deliberately break into sewer lines or block manholes to access wastewater (Hide et al, 2001a, 2001b; Dennery, 1995). Thus, under conditions of water scarcity and weak enforcement, wastewater irrigation has thrived as an unplanned and spontaneous activity.

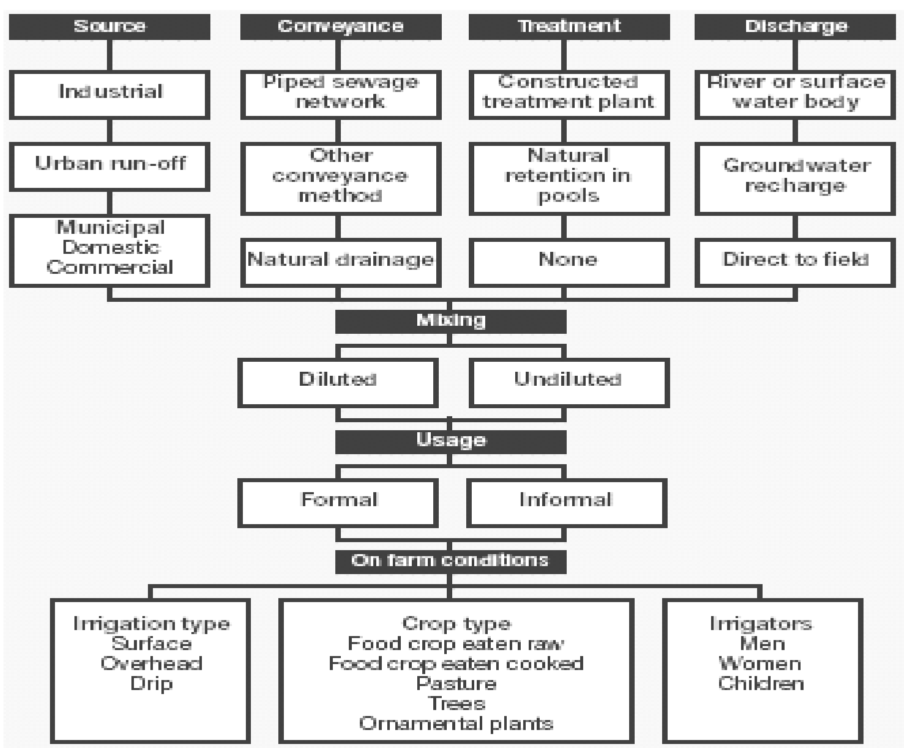
Comprehensive studies on wastewater use in SSA are sparse and scattered. In Dakar, Senegal, a project supported by IDRC has documented extensively the nature of wastewater irrigation (CFP project# 04367). The city of Dakar generates 180,000m^3 of wastewater daily. About 40% of this water is collected by a sewage network system, and of this volume, only 6% receives primary treatment before discharge. The rest of the wastewater is discharged untreated and is a main source of water for market gardeners (Niang, 1999; Faruqui, et al, forthcoming). Within Dakar, the pattern of wastewater use is varied according to the type and source of the wastewater. The main sources of irrigation water are *ceane*s (shallow hand-dug wells) and untreated wastewater (Niang, 1999; Faruqui, et al, forthcoming). In another comprehensive study conducted in Kumasi it was found that the main sources of water for the urban and peri-urban farmers were perennial rivers, ephemeral streams which form a series of pools or groundwater from shallow hand-dug wells (Cornish, et al 1999). A study of informal irrigation in Nairobi found that the main sources of water used for urban and peri-urban farming were rivers and abstractions from sewers (Hide et al, 2001b). In these studies, untreated domestic wastewater and in other instances, industrial wastewater was discharged into surface water bodies, which form the primary source of water for agricultural production. Thus, the composition of the wastewater varies according to the regime of the watercourse, the volume and the composition of the effluent that drains into it.

Wastewater is categorized according to its origin. The categories include:

1. Grey water – composed of domestic water without urine and faeces
2. Black water- composed of domestic water that is mixed with faeces and urine.
3. Industrial wastewater- composed of water from industrial processes, which may contain varying concentration of heavy metals.

In many developing urban centres, wastewater is generally a mixture of the three different categories and its use is mainly informal. The uncontrolled and varied nature of sources of wastewater used for irrigation makes it difficult to define, monitor and control the practice. A typology has been developed that reflects the complexity of wastewater sources and uses in developing countries (Cornish et al in Buechler et al 2002).

Figure 1: Typology of wastewater irrigation



Source: Cornish forthcoming in Buechler et al: UA Magazine No. 8 2002

The typology is designed to help standardize categories in wastewater use definitions. Such standard categories can be useful when assessing the extent of wastewater irrigation especially in urban areas

5.0 HEALTH RISKS ASSOCIATED WITH THE USE OF WASTEWATER.

In spite of a growing awareness of the potential benefits of wastewater use for UA in SSA, most municipal and state officials frown upon the practice (Smit et al, 1996; Drechsel, 2002). A key point of contention is the potential health risks associated with the use of inadequately treated wastewater for food production, which includes microbiological contamination and potentially toxic contamination from trace elements and heavy metals (Smit et al, 1996; WHO, 1999 Asomani-Boateng and Haight, 1999). In order to realize the full potential of UA, it is important that issues such as health risks and other deterrents associated with wastewater use be addressed. Although most public health risks associated with UA are tied to and even intensified by urban environmental factors, UA practices can also introduce new risks. For instance, in the case of wastewater use for UA, there are public health concerns for producers, handlers, consumers and communities around the production areas. There are also misgivings about risks introduced by poor agricultural practices such as inappropriate handling of agrochemicals and application of insufficiently treated solid wastes (Birley and Lock, 1999; Mougeot 2000). These are some of the reasons why local authorities have been reluctant and even resistant to supporting UA. These legitimate concerns point out to the fact that addressing health risks of UA will not only make it safe for farmers, their families and consumers, but it will also encourage more institutional support from municipalities and other government officials, in the light that these problems have reinforced socio-cultural biases against UA (Smit et al, 1996; Flynn, 1999; Mougeot, 2000).

5.1. Microbiological contamination of wastewater and related health risks.

As previously noted, in many developing countries, most wastewater is seldom treated, and correspondingly, contains high levels of pathogenic organisms. These pathogenic organisms include bacteria, viruses, protozoa and helminth (Table 1), and can potentially cause enteric diseases (Mara and Cairncross, 1989; Shuval, 1990).

Table 1: Pathogenic organisms related to wastewater

Group	*Agent*
Bacteria	*Vibrio cholera, Shingella spp, Salmonella spp*
Virus	Rotaviruses, hepatitis virus
Protozoa	*Entamoaeba histolytica, Giardia sp,*
Helmiths	*Ascaris lumbricodes, Trichuris trichiura, Nector americanus, Taenia saginata*

Source Mara and Cairncross, 1989; Shuval, 1990

Public health risks related to microbiological contaminants in wastewater used for agriculture concern three broad population categories

1. Consumers of the crops grown with improperly treated wastewater.

2. Agricultural workers (farmers) who are directly exposed to wastewater in the fields.
3. Populations living near the wastewater use farming schemes.

Recent studies have found negative health effects related to the practice of wastewater irrigation. Farmers who predominantly used untreated wastewater in Dakar were found to have a higher rate of infection with intestinal parasites compared to farmers who mixed wastewater and groundwater (Faruqui et al, forthcoming). A study by Armar- Klemesu et al (1998) in Accra indicated high levels of contamination of vegetables grown using wastewater. Although the study cautions the need to consider other contamination routes especially during distribution and marketing of food produce, it concurs that the use of wastewater for food production increases the risk of negative public health effects for both the farmers and the consumers. A study in Haroonabad, Pakistan, found higher incidences of diarrhoeal diseases in families irrigating with wastewater as compared to non-irrigating families. These farmers also had a high prevalence of hookworms and roundworms. (Feenstra et al, 2000).

Health risks of wastewater use for agricultural production are closely linked to the type of irrigation practice, and the extent to which the wastewater is treated. Wastewater irrigation can either be unrestricted or restricted. Unrestricted irrigation refers to the use of wastewater to grow certain food crops, especially vegetable crops eaten raw, and also for watering grass (sports fields, lawns, parks). If insufficiently treated wastewater is used for unrestricted irrigation, then consumers, farmers (workers) and the general public are at risk of exposure to pathogens. Restricted irrigation refers to the use of wastewater to grow certain crops such as cereals, industrial crops, fodder and pastures. In this case, it is mainly the farmers who are at risk of exposure to pathogens (Mara and Cairncross, 1989). Wastewater treatment is recommended when considering using wastewater for irrigation. Pathogens found in wastewater can be removed to a certain degree through primary and secondary treatments[9]. Such treatment can protect the farmers who irrigate using wastewater and consumers of food crops grown using wastewater (Rose, 1999).

Theoretical analysis suggests that a number of epidemiological factors determine whether various groups of pathogens will cause infections to humans through wastewater (Mara & Cairncross, 1989; Shuval 1990). Diseases related to wastewater are transmitted when an infected person excretes pathogenic organisms to the environment; the pathogenic organisms are then transported by a suitable agent (e.g. food or water) and ingested by a susceptible human host. In general, most wastewater carries several of these pathogens, which have been excreted by infected individuals (Shuval, 1990). The epidemiological factors that determine potential for infection include:

> a) That either an infective dose of an excreted pathogen reaches the field or pond or the pathogen multiplies in the field or pond to form an infective dose, (b) that this infective dose reaches a human host;(c) that this host becomes infected; and (d) that this infection causes disease or further transmission. The first three, (a), (b) and (c) constitute the risk factor and (d) the disease prevalence. If (d) does not occur, the risks to public health remains potential only.

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[9] Rose (1999) provides a comprehensive review of treatment methods and systems.

In relation to these theoretical factors, the different pathogens have been ranked (Mara & Cairncross, 1989; Shuval, 1990) according to their potential for transmitting disease through wastewater irrigation.

1. High Risk	Helminths
2. Medium Risk	Bacterial infections and Protozoan infections
3. Low Risk	Viral infections.

These factors should therefore guide interventions for safe wastewater use. The WHO has developed guidelines that propose permissible levels of these pathogens in wastewater used for irrigation (see section 6.0).

5.2. Health risks of trace elements and heavy metals and wastewater use.

Wastewater used in irrigation containing high levels of trace elements and heavy metals is likely to be toxic to plants, and also pose risk to human health. The issue of trace elements and heavy metals in wastewater for most developing countries is mainly related to the mixing of domestic and industrial wastewater in the same sewage system. This problem is further exacerbated by dumping of untreated industrial wastewater into water bodies, enabled by lax pollution control mechanisms. Examples of potentially toxic trace elements include mercury, lead, arsenic, copper, cadmium, manganese among others. Urban farmers use wastewater containing these industrial contaminants for irrigation, mainly due to lack of options. Cornish et al (1999) point out that since trace element and heavy metals in wastewater are likely to be toxic to plants at levels below that at which they pose significant risk to human health, it could result in some level of natural protection. The argument is that crops will not thrive well when irrigated with highly toxic water and farmers will abandon farming in the area before exposing themselves to significant health risks through the crops. But as Nabulo (2002) notes, heavy metal uptake varies according to plant species and at different parts of the plant. Leafy vegetables tend to accumulate more heavy metals, while in other instances monocot plants such as rice accumulate higher concentration of heavy metals in their roots. Carr et al (forthcoming) points out studies in China, Japan and Taiwan, where rice accumulated high concentrations of cadmium (and other heavy metals) when it was grown in soils contaminated with irrigation water containing substantial industrial discharges. These examples indicate that certain food crops have a higher possibility of transferring heavy metals to humans. Heavy metals and trace elements therefore remain of concern especially in instances where industrial effluent is an important factor. In addition, health risks of heavy metals can be looked at from an occupational hazard point of view where chemical pollutants in wastewater can cause harm to farmers as a result of direct contact with water during farming (Flynn, 1999). The WHO is currently designing[10] guideline values for a selection of harmful chemicals related to wastewater, which could be harmful in the context of wastewater use for agriculture (Carr et al, forthcoming).

[10] There are currently no guidelines for permissible levels of trace elements and heavy metals in wastewater used for irrigation, which relate to the potential risk to human health as a consequence of crop uptake and bio-accumulation. Most authors cite refer to the WHO drinking water guidelines (cited in Hide et al, 2001a).

6.0 GUIDELINES FOR SAFE WASTEWATER USE

The WHO developed guidelines to ensure safe wastewater use for agricultural purposes (Mara and Cairncross, 1989). These guidelines recommend permissible levels of microbiological contamination in wastewater used for irrigation and were developed using two approaches. One approach was to extensively review microbiological studies measuring faecal indicator organisms in wastewater, which indicate potential risks of wastewater use to human health. The second approach was based on epidemiological studies of incidences of enteric diseases. The premise of the second approach is that there should be no measurable excess illness attributable to wastewater use (Mara and Cairncross, 1989). These guidelines (Table 2) were to guide engineers and planners in the choice of wastewater treatment technologies and water management options that would ensure a safety level of effluent used for irrigation (Mara and Cairncross, 1990). In addition to guidelines, other protection measures such as crop restriction, choice of appropriate irrigation technologies and human exposure control were suggested as complimentary management options. Such guidelines for wastewater use are based on direct reuse systems where regulations and control can be applied. However, for countries in sub-Saharan Africa and other resource-poor nations, these guidelines have not been adopted, and in instances where they have been adopted, their implementation has been difficult (Drechsel et al; 2001; Carr et al forthcoming).

Table 2: Recommended Microbiological Quality Guidelines for Wastewater Use in Agriculture[a]

Category	Reuse conditions	Exposed group	Intestinal nematode[b] (arithmetic mean no. egg per litre[c])	Faecal coliforms (geometric mean no. per l00ml[c])	Wastewater treatment expected to achieve the required microbiological guideline
A Unrestricted	Irrigation of crops likely to be eaten uncooked, sports fields, public parks [d]	Workers, consumers, public	< 1	$< 10^3$ [d]	A series of stabilization ponds designed to achieve the microbiological quality indicated or equivalent treatment
B Restricted	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees. [e]	Workers	< 1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C Localized	Localized irrigation of crops in category B if exposure to workers and the public does not occur	None	Not applicable	Not applicable	Pre-treatment as required by irrigation technology, but not less than primary sedimentation

a. In specific cases, local epidemiological, social-cultural and environmental factors should be taken into account and the guidelines modified accordingly.
b. Ascaris and Trichuris species and hookworms.
c. During irrigation period.
d. A stringent guideline (< 200 faecal coliforms per 100ml) is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact.
e. In the case of fruit trees, irrigation should cease two weeks before the fruit is picked and no fruit should be picked off the ground. Sprinkler irrigation should not be used

Source: WHO (1989) cited in Blumenthal et al (2002).

Blumenthal et al (2002) have made recommendations for the revision of these guidelines, which allow more flexibility, especially in the context of resource constraints in developing countries (Table 3). In addition to looking at microbiological and epidemiological studies, the recommended revised guidelines include risk assessment as another approach for devising guidelines. By using risk assessment, the revised guidelines allow for defining a tolerable risk of wastewater use within a society (Blumenthal et al 2002). The recommended revised guidelines are therefore more responsive and take into account the different contexts in which wastewater use occurs, and situations where insufficient resources cannot allow for a "zero risk approach" (Carr et al, forthcoming).

Table 3:Recommended revised microbiological guidelines for treated wastewater use in agriculture [a]

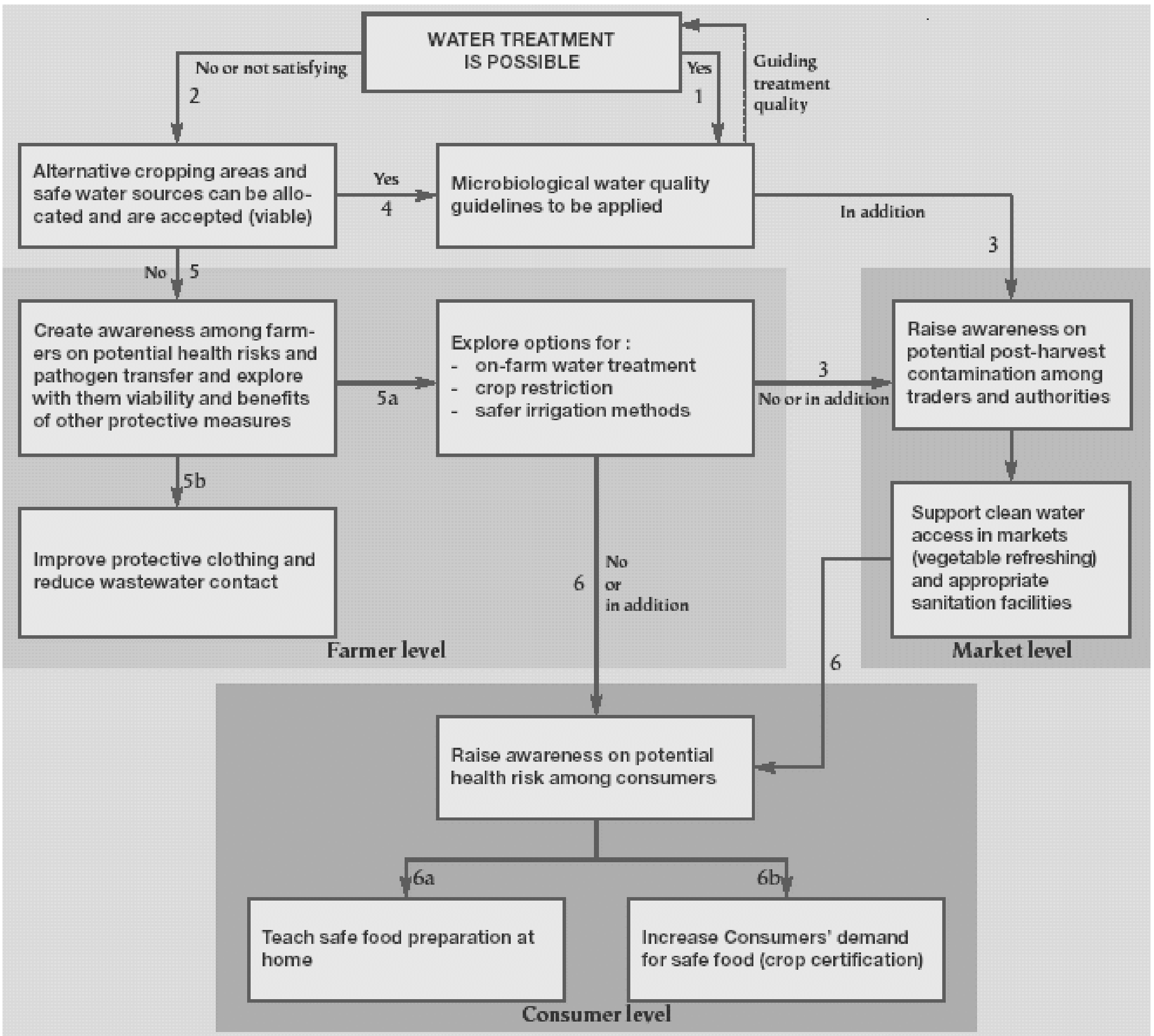
Category	Reuse Conditions	Exposed group	Irrigation technique	Intestinal nematodes[b] (arithmetic mean no of eggs per litre[c])	Faecal coliforms (geometric mean no per 100ml[d])	Wastewater treatment expected to achieve required microbiological quality
A	Unrestricted irrigation- Vegetable and salad crops eaten uncooked, sports fields, public parks[e]	Workers, consumers, public	Any	< 0.1[f]	$< 10^3$	Well designed series of waste stabilization ponds (WSP), sequential batch-fed wastewater storage and treatment reservoirs (WSTR) or equivalent treatment (e.g. conventional secondary treatment supplemented by either polishing ponds or filtration and disinfection)
B	Restricted irrigation- Cereal crops, industrial crops, fodder crops, pasture and trees[g]	B1 Workers (but no children <15 years), nearby communities	(a) Spray/sprinkler	<1	$< 10^5$	Retention in WSP series inc. one maturation pond or in sequential WSTR or equivalent treatment (e.g. conventional secondary treatment supplemented by either polishing ponds or filtration)
		B2 As B1	(b) Flood/furrow	< 1	$< 10^3$	As for Category A
		B3 Workers including children < 15 years, nearby communities	Any	< 0.1	$<10^3$	As for Category A
C	Localised irrigation of crops in category B if exposure of workers and the public does not occur	None	Trickle, drip or bubbler	Not applicable	Not applicable	Pre-treatment as required by the irrigation technology, but not less than primary sedimentation

a In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account and the guidelines modified accordingly.
b Ascaris and Trichuris species and hookworms; the guideline is also intended to protect against risks from parasitic protozoa.
c During the irrigation season (if the wastewater is treated in WSP or WSTR which have been designed to achieve these egg numbers, then routine effluent quality monitoring is not required).
d During the irrigation season (faecal coliform counts should preferably be done weekly, but at least monthly).
e A more stringent guideline (< 200 faecal coliforms per 100 ml) is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact.
f This guideline can be increased to <1 egg per litre if (i) conditions are hot and dry and surface irrigation is not used, or (ii) if wastewater treatment is supplemented with anthelmintic chemotherapy campaigns in areas of wastewater re-use.
g In the case of fruit trees, irrigation should cease two weeks before fruit is picked and no fruit should be picked off the ground. Spray/sprinkler irrigation should not be used.

Source: Blumenthal et al (2002)

Treating wastewater to ensure removal of pathogens is the most recommended method for mitigating public health risks for both farmers and consumers. Yet studies have indicated that in most developing country cities most of the wastewater is not treated and this untreated wastewater of varying qualities remains an easily accessible and cheap source of water for many urban farmers. There is a need to explore risk mitigation methods that take into account such contexts. The flow diagram (Figure 2) shows how context-responsive decisions can be made for risk mitigation using wastewater for irrigation.

Figure 2: Flow diagram of a decision making process on locally appropriate health - protection measures



Source: Drechsel et al (2002) in UA Magazine No. 8 2002

This framework indicates the need for exploring ways in which wastewater use for irrigation can be supported through treatment and also demonstrates the need to adopt alternative strategies for risk mitigation when using untreated wastewater. It should be emphasized that the main goal for treatment of wastewater to be used for irrigation must be removal of pathogenic microorganisms, but not removal of organic material that contains the highly valuable agricultural nutrients. There is a need to develop low cost, micro technologies that can enable such treatment of wastewater, and in addition, incorporating other non-treatment options can also enhance safe use of wastewater for urban farming (Rose, 1999).

7.0 CONCLUSION.

In many developing country cities, current trends indicate that urban farming will continue to increase in both magnitude and impact. This growth in UA will also be accompanied by an increasing demand for access to resources such as land and water. This calls for innovative and practical approaches that will seek to address these new demands. Harnessing treated wastewater clearly is one way through which water can be made available to urban farmers. The reality is that in many developing urban centres; urban farmers are already using mainly untreated wastewater for crop production. This practice comes with its own challenges, including potential health risks. At the backdrop of what is an increase in wastewater use for UA in many developing countries cities is, scarce and unreliable water, improper and expensive treatment systems that have failed, and a willingness by farmers to use this resource. Farmers are willing to take risks with wastewater, as it is a resource that presents an opportunity to benefit them economically (Buechler, forthcoming; Dreschel et al, 2002; Rose, 1999)

But there is a clear need to look at options that will enable safe and sustainable wastewater use practices. These options need to be a balance between technical solutions and political and social interventions. Considering the complex physical, institutional and social nature of urban agriculture, any strategies to promote and support the practice would need to engage with a range of stakeholder groups, so as to identify opportunities to enhance livelihoods, which are mutually acceptable to all. Sustainable UA practices must be looked at from a multidisciplinary and multi-sectoral angle and must be site-specific, adapted to the local socio-economic conditions.

The perspectives drawn from this first part of the report, will guide discussions on the findings of a case study in the following section. In Nairobi, Kenya, wastewater use for UA is practiced at a fairly large scale. Hide et al (2001a, 2001b) conducted an extensive study of informal irrigation in Nairobi and provide useful insights into the extent and nature of wastewater use for irrigation. Building on the findings of Hide et al (2001a, 2001b), a case study was conducted in Maili Saba, Nairobi, to further explore patterns of wastewater use in UA, emphasizing farmers perspectives on the use of wastewater and their perceptions of related health risks. In addition institutional perspectives on the use of wastewater for UA in Nairobi was also explored.

SECTION B: FIELD RESEARCH

Wastewater irrigation, farmers' perceptions of health risks and institutional perspectives- a case of Maili Saba, Nairobi

1.0 INTRODUCTION:

Farming in Nairobi is ubiquitous. Agricultural activities can be seen along roadsides, at roundabouts, along rivers and railway lines, under power lines and on people's backyards. Despite UA being ignored as an important component of the urban landscape by city authorities, it continues to thrive. Although UA in Nairobi[11] is practiced by all sectors of society, most of the farmers are low-income earners with majority being women (Lee-Smith and Memon, 1993, Foeken and Mwangi, 2000). For this section of the population, farming consists of subsistence crop cultivation on small public plots, and for some it also encompasses production for markets. Most of the farmers in Nairobi practice informal irrigation using wastewater (Hide et al 2000, 2001a, 2001b, Foken and Mwangi, 2000; Dennery, 1995). Access to wastewater is important, as it has enabled most farmers to engage in year round farming, which results in substantial economic gain.

1.1 Wastewater irrigation in Nairobi:

Although wastewater irrigation in Nairobi is mainly an informal activity its extent is significant. In an extensive study on informal irrigation in Nairobi, Hide et al (2000, 2001a, 2001b) identified more than 2,200 ha of informal irrigated land within a radius of 20km from the city centre of Nairobi. Official figures of irrigated land identified only 1,500 ha of urban irrigation for the whole country; therefore it appears that the extent of urban irrigation is under-reported in official statistics. The study estimated that vegetables[12], which are, the main crops grown within Nairobi's urban irrigated area generated an annual revenue of US$ 3.9 million. This is an indication that the economic value of wastewater irrigation is significant especially for low-income farmers.

Main sources of wastewater used for irrigation farming in Nairobi are rivers that flow through the city. As Hide et al (2001b) noted, large quantities of raw sewage and domestic wastes from houses and informal settlements drain directly into these rivers, and at some points along the rivers there is no observable difference in the quality of water in the rivers and raw sewage. Further downstream of the city's industries, untreated industrial wastewater is also dumped into the rivers. In addition to river water, a number of farmers divert raw sewage flowing through the city's sewerage network to irrigate their farming plots. The quality of this water raises concern over its suitability for crop production. Hide et al (2001a) conducted an assessment of water quality at five selected sites, where irrigation is practiced including, Thiboro, Mau Mau Bridge, Kimathi, Njiru Bridge and Maili Saba. Results indicated high levels of feacal coliform for all sites that

[11] UPA in Nairobi distinguishes between on plot and off plot practices. Most urban poor practice off-plot farming because they reside in densely populated neighbourhoods with little space available for farming (see Lee-Smith and Memon, 1993; Foeken and Mwangi, 2000). Wastewater irrigation is practiced mainly by off-plot farmers.

[12] This included a variety of indigenous and exotic. The estimate is based on estimates of yields during the study period.

exceeded the WHO recommended levels of 10^3 per 100ml for unrestricted irrigation. At Maili Saba site where raw sewage was being used, the levels exceeded the recommended levels by up to four magnitudes, at 10^7 (Hide, et al, 2001a). In addition to microbiological contamination, untreated industrial wastewater drains into the rivers and the sewage network resulting in concentrations of heavy metals that could be toxic to plants when used for irrigation. Hide et al (2001a) in their assessment of wastewater quality noted that the concentrations of manganese and some other heavy metals could be toxic to plants and may pose an indirect threat to human health. Thus, using untreated wastewater with such high levels of contamination can expose farmers, and ultimately consumers, to risk of enteric diseases and toxic contaminants[13].

Hide et al (2001a) recommend stringent restrictions of the practice, including its prohibition where farmers use raw sewage. However, they are also cognizant of the fact that this approach may not be feasible with respect to implementation and policing of wastewater use. Wastewater remains a readily available and nutrient rich source of water for most farmers. Unduly restricting the practice would affect the livelihoods of already marginalized poor urban farmers. An alternative approach should be based on efforts to balance sound public health practices and sustaining the livelihoods of poor urban farmers. This balance can be achieved through identifying adequate standards of water quality and exploring localized low-cost treatment and non-treatment management options (Blumenthal, 2002). It will also require a comprehensive understanding of farmers' level of awareness, livelihood patterns, perceptions and general constraints related to wastewater use.

This section of the report describes a field study conducted in the farming community of Maili Saba, one of the sites in Nairobi where irrigation using raw sewage is practiced. The research was conducted as part of a one-year IDRC-CFP internship. The research intended to build on previous studies of wastewater use for irrigation in Nairobi, with a focus on the health issues, highlighting farmers' experiences. The objectives of the study were:

1. To explore wastewater irrigation practices and farmers' perceptions related to health risks associated with the use of wastewater.
2. To inquire into institutional perspectives of wastewater use within the context of UA in Nairobi.

It is intended that findings of this research will contribute to a better understanding of UA practices within Nairobi in on going efforts to facilitate its recognition and integration within city plans by authorities and raise attention to the need for exploring better wastewater use options, in particular.

[13] Because of the large volume of untreated industrial wastewater discharged into rivers and the sewage network in Nairobi the risks of heavy metal and toxic contamination are high. The importance of this issue notwithstanding, this study focuses more on microbiological contamination. But emphasises that there is need for more comprehensive research that addresses this issue within the context of UA in Nairobi.

2.0 BACKGROUND OF STUDY AREA

Maili Saba is an informal settlement in the peri-urban area of Nairobi located about 15km east of the City Centre, bordering Dandora area, 5km to the East and Saika estate to the south (see map below). The only road to the area forms the western boundary. The settlement consists of three 3 villages namely:

1. Muoroto
2. Mwengenye
3. Silanga

Figure 3: Cross-sectional view of off-plot farming in Maili Saba

The area used to be part of a sisal plantation, which was transformed into farming land, and the former plantation workers settled in the area (Ministry of Agriculture, n.d). These workers started practicing farming and were later joined by scores of rural migrants. In the early 1980s the area had a population of about 10,000 with around 68% practicing farming. Recently, the farming in Maili Saba has become precarious as real estate developers have rapidly taken over parts of the farming area and constructed housing units (Gathuru and Kariuki, 2001).

Many households in Maili Saba engage in crop and livestock farming, keeping livestock such as pigs, goats, chickens, ducks as well as cattle. The farming plots are in the nearby valley and farmers use sewage water to grow an assortment of crops. The sewage water used for farming is illegally obtained by puncturing the sewer lines, or by blocking the manholes. Unofficial estimates indicate that there are over 1,000 farmers who practice irrigation using the sewage water in Maili Saba. Although most of the farmers produce for subsistence, some of their produce is sold at the local markets. (Ministry of Agriculture, n.d)

3.0 METHODS

Field research was conducted between June and August 2003. The research methods used included a questionnaire, informal discussions, direct observation and a focus group meeting, which explored wastewater irrigation practices and farmers' perceptions of health risks related to wastewater irrigation. In addition to the study of Maili Saba, key informants from the Nairobi City and Ministry of Agriculture were interviewed so as to provide institutional perspectives regarding wastewater use for UA in Nairobi. More institutional insights were gathered from accessing official documents such as annual reports and the Nairobi City Master Plan report (see Appendix I for list of documents).

Sampling

Due to lack of base line information about the number of farmers in the community, sampling for the survey was done by convenience. Farmers were approached at their farming plots, where the purpose of the research was explained, and based on the farmer's consent and availability, participated in the survey. Thus, only farmers who were at their plots at the time of the survey were sampled. The instances in which such a sampling strategy could potentially bias our results are properly acknowledged. Although the farmer was the unit of analysis, he or she was not disconnected from the household. The farmer was able to provide information about other household members, their role in farming and knowledge on wastewater related health issues that affected the whole household.

Data Collection Methods

Questionnaire

A semi-structured questionnaire was used to gather personal and household information, plot characteristics, cropping patterns, marketing channels and farmers perceptions and levels of awareness of health risks using wastewater. The questionnaire was administered with the assistance of three agriculture extension officers and one community member. A total number of 139 farmers were surveyed in the three divisions of Maili Saba. The total included 70 women (50%.) and 69 men (50%). The questionnaires were not equally distributed among the three divisions because some of the divisions had more farming activities than others. The distribution breakdown included 55 farmers in Mwengenye (Kirima), 34 in Silanga and 50 in Muoroto. The questionnaire is presented in appendix II.

Focus groups

Upon completion of the survey, one focus group discussion was arranged with the farmers with the aim of deepening the discussions on issues affecting them. During the survey administration the farmers were informed of plans to conduct a focus group meeting. The community member[14] who assisted with the survey went back to remind the farmers three days before the focus group meeting. There were 11 farmers who attended the meeting, including seven men and four women. The focus group discussion was held

[14] He went to individual farmers, and to identified leaders who were asked to remind others of the meeting by word of mouth.

at the Embakasi division agriculture office, which is located close to Maili Saba community. The meeting also gave farmers the opportunity to connect with the agriculture extension office. The focus group discussion provided insights into farmers' perspectives of wastewater use including the knowledge levels of farmers regarding health risks of using untreated wastewater such as the diseases associated with its use. The group session was also used to provide information on health risks related to wastewater to the farmers, and to explore localized mitigation strategies by engaging in discussions with farmers. The focus group discussions also explored other general constraints and challenges faced by farmers in Maili Saba.

Direct observation and informal discussions

These methods were not limited to time spent with informants, and during administration of the survey but covered the whole period of the fieldwork starting with the initial visit to the community. Direct observation was useful in gathering information on the patterns of irrigation and the crops grown. It was also a useful method of seeing first hand some of the practices or behaviors that would put farmers at risk such as consumption of unwashed food at the plots. The observations complemented some of the information gathered with the questionnaire and focus group discussions, and provided fresh insights that were not gathered using other data collection methods.

Interviews and discussions with key informants

With regard to the second main objective of the study, semi-structured interviews were used to explore local authorities' views, capacities and interventions related to wastewater use in urban agriculture. An interview was conducted with the extension coordinator of the Embakasi division, Ministry of Agriculture (MOA). Another interview was conducted with an officer from the water and sewage department of the Nairobi City Council (NCC). In addition, informal discussions were held with other officers from the department of environment of the NCC and other staff working at the MOA, who provided more insight into perceptions and institutional perspectives regarding wastewater use for agricultural production. The information from municipal authorities was used to explore potential opportunities for institutional intervention strategies for safe wastewater use in UA. At this point, relevant documents such as annual reports and Master Plan reports produced by respective institutions were collected to complement the information collected during discussions/interviews.

4.0 RESULTS

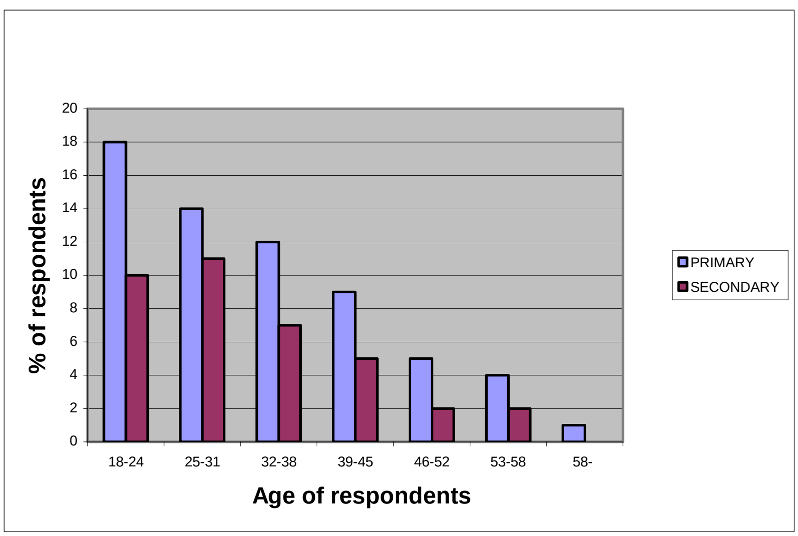
The following section presents the research findings of the case study of wastewater use in Maili Saba. Section 4.1 presents the results from the questionnaire administered and focus group discussion. The results are divided into section headings used in the questionnaire, and incorporate findings from the survey and discussions with the farmers. Section 4.2 presents research results on institutional perspectives regarding wastewater use and UA.

4.1: Results from Maili Saba

4.1.1 Characterization of respondents

Farming is an important activity in Maili Saba community. Because of the informal nature of the practice there is no data available on the exact number of people engaged in farming. A questionnaire was administered to 139 farmers to collect data on practices of wastewater use for irrigation in the community. Although there were 139 respondents, in terms of households, information was collected from a total of 292 adults[15]. All respondents played the central role of farming within the household. The other adult members and in other cases younger family members, too, provided support at the farm. In total there were 158 (54%) female and 134 (46%) male adults in the sampled households. On average, each household had 3 children under 18, ranging from zero to five. The respondents' ages ranged from a minimum of 18 to a maximum of 85 years. The highest education attained within the sampled household adult members was secondary level. About 63% of the respondents had some level of primary education while 37% had secondary level education. As figure 4 indicates the observable pattern with regard to age and education was that for all age groups, more people had primary education than secondary education. This could probably be related to the general poverty of the community.

Figure 4: Education by age



[15] This includes individuals 18 years and older which is the age cut off for those considered adults in Kenya.

When education levels were cross-tabulated with gender, the results indicate significant differences between men and women. More women, about 70% had attained only primary education while the remaining 30% had attained some secondary education. In contrast, among the men, 54% had a primary education and 46% had some secondary education.

In general, most of the respondents (61%) were married, but this statistic skewed the differences between men and women with regard to marital status. When gender was cross-tabulated with marital status, 51% of the women indicated they were single, with most of them being heads of households. The other 49% of women were married. On the other hand, 71% of the men were married, with only 29% indicating to be single.

With regards to occupation, 94% of the respondents indicated that they exclusively engaged in farming. The remaining 6% engaged in additional occupations including doing business, working as casual labourers at the industrial area or working in trades such as mechanics, plumbers and masons. However, the sampling strategy may have inflated these numbers. Farmers who engaged in other activities might have had lower probability of being sampled due to their absence from the area during the interviews.

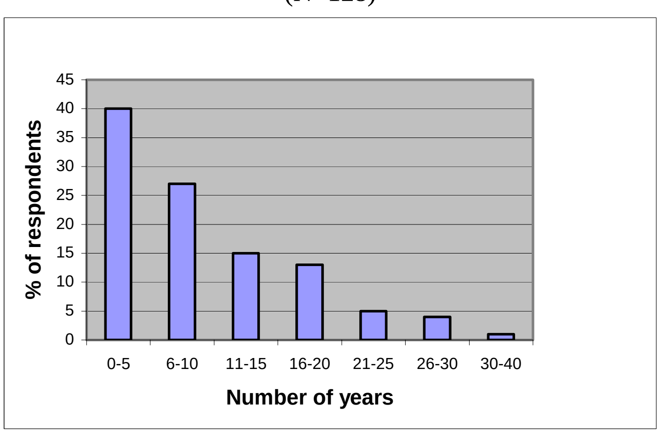
4.1.2 Farming activities and other social and economic patterns

Farming patterns: Farm size and access to land

Farming in Maili Saba has been practiced over a long period as indicated by figure 5. The average number of farming years in the area was 11 years. A significant portion of farmers had entered into farming during the 1990s, as up to 66% of the farmers indicated that they had started farming within the last 10 years. The period of economic structural adjustments in Kenya had a negative impact on the formal employment sector, forcing most urban dwellers to resort to livelihood strategies based on informal activities such as UA. However, even this has become tenuous, as farmers noted that recently agricultural land was being lost to housing development in the area.

Figure 5: Distribution of farming years

(N=128)



Farmers in Maili Saba use diverse modes of tenure and usufruct arrangement to gain access to land. But for the majority of the farmers, access to land is tenuous as they are squatters on the land. Some of the land in Maili Saba belongs to the municipal government, while wealthy individuals who do not reside in Maili Saba privately own other portions.

Table 4: Mode of farmland access (N=136)

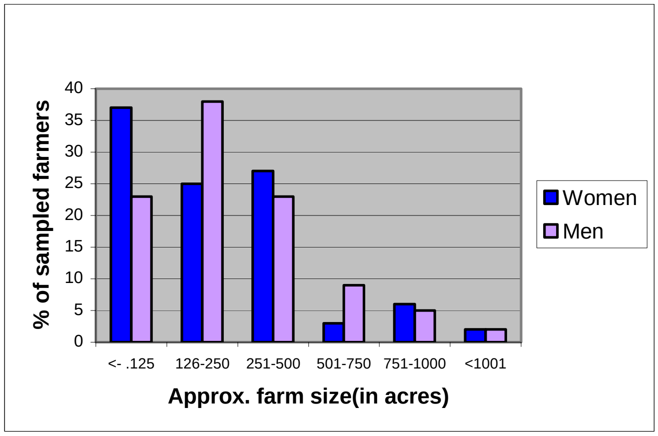
Mode of land access	Respondents (%)
Squatting	67
Buying	13
Renting	11
Other[a]	7
Lease	2

a. Other modes of land access that were expressed by the farmers included inheritance, informal arrangements of access between family members, friends or neighbours

The precarious nature of access to land is reflected in the size of farming plots. The average farming plots[16] size was .035 acre and ranged from .025 to 1.5 acre. In general, farming plots are quite small with 61% of the farmers cultivating on a quarter of an acre of land or less. According to most farmers, several members of the household assist in the farm at some point. Because farming plots are quite small, there are no clearly defined or gender differentiated activities during farming. Tasks such as weeding, irrigating and harvesting are shared among the different family members. About 17% of the farmers cultivated in more than one plot in the same or other area. Cultivating in several plots was a strategy used by farmers to enhance access to land. During discussions, farmers raised the issue of cultivating on small plots as being a major constraint to their farming practices, restricting their production to mainly subsistence farming. Farmers also noted that lack of land tenure exacerbates the situation, because it discourages making investment that could lead to better farming practices. Even for farmers with relative land security, such as those with rental arrangements, the landowner maintains control over what can be planted. As one farmer noted during the focus group, the idea of investing in practices such as agro forestry was not an option in most cases as most land owners would not approve of farmers planting trees on their plots. There were important differences between men and women in relation to plot size. When farm size was cross-tabulated with gender, it was observed that 37% of women were farming on an eighth or less of an acre, compared to 23% of men (Figure 6).

[16] Actual plot measurements were not taken. Farmers were asked to estimate the size of their plots.

Figure 6: Farm size distribution by gender



Crop production patterns

According to the survey, a variety of 29 different crops are grown in Maili Saba. Common crops included maize grown by 93% of the respondents, kale[17] (88%), spinach (64%), beans (60%) and cowpeas (58%). Other crops included bananas, amaranthus, carrots, capsicum, onion, black nightshade, cabbage, potatoes, eggplant, papaya, oranges, lemons, green beans, tomatoes, passion fruits, parsley, pumpkins and sorghum.

Photograph by Catherine Kilelu

Figure 7: Kale growing in one of the farming plots

All the farmers surveyed indicated that they farm year round, and generally practice inter-cropping. Clearly, access to wastewater is an important factor for enabling farmers to farm all year round. The farmers noted that cropping choices was partially determined by

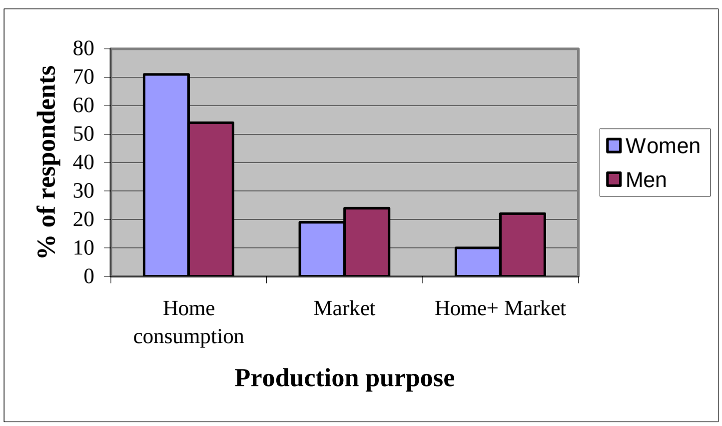
[17] Most of the leafy vegetable including kale, spinach, amaranthus, black nightshade, and cabbage are cooked before consumption.

season. During discussions, the farmers noted that they sometimes plant certain crops during the season when it is less available on the market so as to fetch higher prices at the market. For the majority of the farmers surveyed (77%), farming is a key method of accessing food consumed within their households. Other modes of procuring food include the local market, which was the primary source of food for 7% of the households surveyed. A quarter of the respondents gave equal weight to the market and farming as primary source of food in their households. UA remains an important strategy for increasing food security for farming households

Marketing

Although subsistence is the main objective of production as indicated by 62% of the surveyed farmers, production for the market is also of considerable importance. Approximately 21% of the respondents indicated that production for the market is their main objective while 17% gave equal importance to production for home and market. There was a variance with regards to gender and production, (figure 8) where more women than men produce primarily for subsistence. This could be correlated to farm size, as previously noted, since more women than men cultivate on smaller plots of land, which limits their production capacities.

Figure 8: Production purpose by gender
(N=139, female 70, male 69)

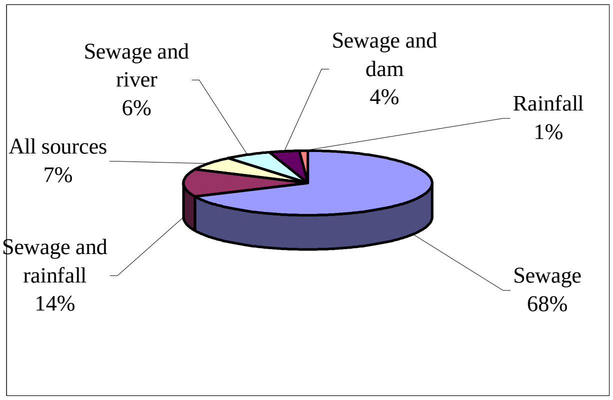


Almost half of the farmers who produce for the market sold their produce through a market retailer. In such instances, the market retailer visits the plot and buys produce directly from the farmers. For 38% of the respondents, marketing is carried out through a combination of direct sales to neighbours, retailing at the local market and selling to market retailers. Others rely only on selling directly to the neighbour (7%) or retailing at the local market (6%).

4.1. 3 Wastewater irrigation patterns and constraints

Access to water is central to the farming practices in Maili Saba. Farmers accessed water for their crops from several sources, but by far, untreated sewage water is the primary source for most (Figure 9)

Figure 9: Main sources of water for irrigation
(N= 139)



The wastewater is diverted from sewers lines that carry both domestic and industrial wastewater to the Nairobi sewage treatment facility located in Ruai, east of the city. Figure 10 shows a blocked manhole and a section of the sewer line. The wastewater is diverted to farming plots through canals.

Figure 10: Blocked manhole and a sewer line crossing through Maili Saba.

Farmers in Maili Saba have constructed a hand-dug canal system and the main conveyance method of water to the field is by gravity. The Farmers are fairly well organized with regard to sharing of water. The farming area has been divided into zones and the farmers have designed a rotating schedule through which wastewater is shared throughout the week. They use sand bags at different points along the waterway to divert the water to different zones on specific days of the week. Figure 11 shows an example of the hand-dug canal and how the farmers divert the water using sand bags

Figure 11: Hand dug canal and water diversion system using sand bags

Although this model could imply an equal distribution and access to water among the farmers, discussions with the farmers revealed that there is a lot of contention related to how the resource is accessed. For instance not all the farmers in the area are part of the scheme. For these farmers, water for irrigation can only be accessed at night or on Sundays, which is the only day that the water is freely available for anyone. In addition, farmers who belong to the organized scheme note that wastewater is not always enough for all, and conflicts do occur during distribution, and some farmers assert themselves more than others in controlling the resource. Although these conflict impact on all the farmers, gender is particularly a factor in this regard, as women are affected more by these inequalities. For instance, women noted that those who were not part of the scheme, and had to irrigate at night faced higher risk of physical harm. In addition, when conflicts arise over use of the water, the women's rights to access the resource are infringed by threats of violence against some of them. It is important to remember that most of women farmers in the area were single heads of households.

From discussions with farmers, it was revealed that there were two farmers' groups in the area[18]. These are registered self–help groups formed with the aim of looking into the welfare of farmers in the area. A striking feature of the two farmers' groups identified in the area was that men held all leadership positions. Discussions with the women revealed that although women were members of these groups, they were not actively involved in the groups operations. Some women noted that they felt that these groups did not

[18] The names of these two groups were Silanga Mwengenye Self help group and Silanga ya Ng'ombe Self help group. Discussions with some of the leaders revealed that membership was voluntary and open to any interested farmer in the community. The organization and operations of these groups were not investigated in detail in this study. Research on urban farmers organizations is very limited and there is need for in-depth studies that to look into the dynamics of such organizations.

represent their interests. This would probably include their safety concerns related to irrigating during the night.

Water is channeled into individual farms mainly by digging furrows or flooding the plots, which is practiced by 64% of the farmers surveyed. The remaining 36% combined furrows or flooding with the use of buckets especially for those farmers whose plots are on a slope, and water is not able to flow to all sections of the plot. With regards to motivations for using sewage water for farming, 70% noted that they used it because it was the only reliable source of water year round. In addition 64% of the respondents also pointed out that they opted to use sewage water because of its rich nutrients. The fact that the wastewater is available for free, albeit illegally was also an important factor for 58% of the respondents. Half of the respondents noted that easy access to the resource was a motivating factor.

The importance of wastewater's high nutrient content and its year round availability was reiterated during the focus group discussions. Because of the nutrient rich wastewater, 78% of the farmers indicate that they do not apply any chemical fertilizers or organic manures to their crops. This is significant for the farmers as it translates to lower farming costs. During discussions, farmers noted that the nutrient-rich water also resulted in shorter growing periods and more harvest sessions. More harvest sessions meant more produce for subsistence and for sale, which significantly impacts on the farmers' incomes. Another observation made by some farmers (45%) was that irrigating with wastewater also resulted in better-textured vegetables, which made them more appealing at the market.

On the other hand, 65% of the farmers indicated that they use pesticide on their crops, which represents an additional input cost for the farmer[19]. In addition, 49% of the farmers also noted that sewage water sometimes scorched their vegetables. This may be attributed to the chemical content in the wastewater, considering that industrial water is in many cases discharged in the sewage network without treatment.

4.1.4: Health risks and perceptions of wastewater use and sanitation.

Wastewater use and health in Maili Saba.

Irrigating with sewage poses a public health risk, as untreated wastewater is a major source of pathogens that may cause enteric diseases and may contain harmful chemical toxics from industrial wastewater. The health concerns are related to both consuming crops grown using wastewater and by exposure to contaminants during farming. Although the mode of application of wastewater to the farms is through furrows or flooding of the farming plots, most farmers still had direct contact with the wastewater or the soil. In some instances farmers, wade through the canals so as to remove solids that block the flow of water into their farms, resulting in exposure to occupational hazards

[19] Other studies on the use of untreated wastewater for irrigation have indicated that one of the major drawbacks of this practice is that it increases the level of weeds and insect pest on the crops (Bradford, 2002; Cornish, 1999; Faruqui et al forthcoming).

such as broken bottles and other sharp objects. In addition the use of buckets by some farmers also results in direct contact with the wastewater.

Farmers were asked to self-report[20] on the occurrence of enteric diseases within the family including diarrhea, stomachache and intestinal worms. About 26% of the respondents indicated that at least one of the family members had experienced diarrhea, while 36% indicated that at least one family member had experienced stomachache within the month prior to the day the questionnaire was administered. In addition, 37% of the respondents reported cases of intestinal worms in children in their households within a period of up to a year prior to the questionnaire administration. Due to a lack of a control group of farmers not using wastewater in the area, it is difficult to associate wastewater use and reported incidences of enteric diseases. Other confounding factors, which could be associated with the occurrence of enteric diseases in the community, are the general quality of potable water and sanitation in the area. Table 5 shows the various sources of water for domestic purposes of the surveyed farming households. Because Maili Saba is an informal settlement, most of the people have no access to water in their houses, and they buy water from vendors who have set up kiosks at various points within the community.

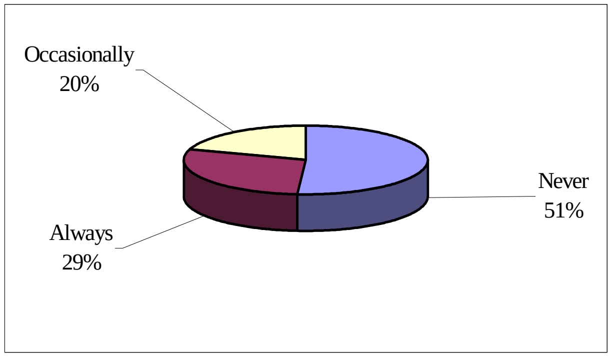
Table 5: Household water sources. (N=139)

Water source	Respondents(%)
Bought from vendor	56
Shared (compound) tap	42
Other	2

Because of limited access to water and the modes in which it is transported, especially that bought from vendors, the quality of potable water in Maili Saba is likely to be poor. In this context, practices to improve water quality within households were surveyed (Fig 12). In total, 71% of the farmers indicated that they either did not boil the water, or occasionally boiled it, thus for these farmers and their household members, potable water sources used in their homes could potentially expose them to pathogens that cause enteric diseases.

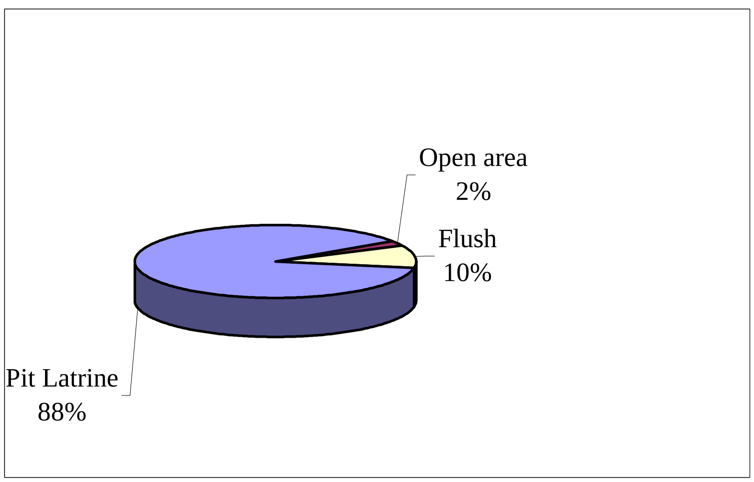
[20] Using self-reporting to assess incidences of enteric diseases is a limitation of the study as the reliability of the responses could be affected by inaccurate recall by the respondents.

Figure 12: Household water treatment practices
(N=138)



In addition to domestic water sources, sanitation facilities in Maili Saba were also surveyed. Figure 13 provides a summary of the types of toilet facilities found in the community. The majority of the community lacks proper sanitation facilities, which is not unusual for informal settlements in Nairobi.

Figure 13: Types of toilets in the community
(N=139)

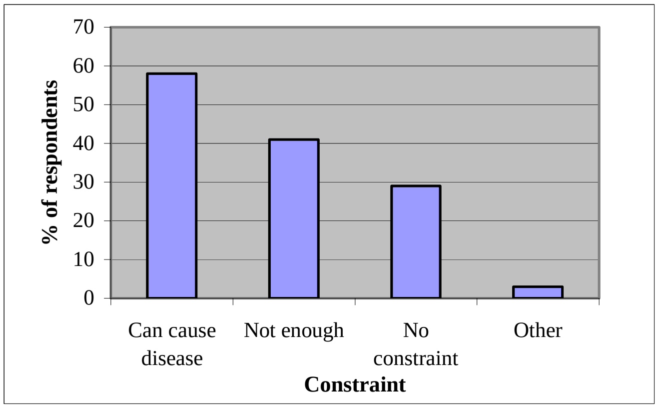


Poor sanitation and wastewater use are probable factors contributing to the incidence of enteric diseases and negatively impacting on the quality of life in general in Maili Saba. Further research is required to determine the significance of wastewater use on the prevalence of enteric diseases in the community.

Perceptions and constraints of wastewater use

Although wastewater is a valuable resource for farmers in Maili Saba, it can pose health risks to both farmers and consumers. In order to understand farmer's perceptions of health risks related to the use of wastewater, farmers were asked to identify the constraints that they face when using this resource (Figure 14). The findings show that farmers are concerned about the quality of the water and it's potential to cause disease.

Figure 14: Perceived constraints of wastewater use



Yet inquiry into specific diseases found that, rather than enteric diseases, the primary health concern for most farmers were skin irritation. The questionnaire revealed that 55% of respondents' linked wastewater to skin irritation problems, while only 20% linked wastewater to diarrhea, and 16% linked wastewater to stomachache.

Farmers' perceptions of the link between use of wastewater and enteric diseases were diverse. For example, some farmers rejected the possibility of negative health consequences due to handling of wastewater or through consuming crops grown with the wastewater. This perception is clear in the words of one farmer:

> "I have been farming for over 8 years - and if there is one person who farms using sewage it would be me- If there is someone with problems using sewage it would be me- If there is someone with problems with the water it would be me, I enter into the sewage lines – sometimes it even gets into your mouth and you go on… What I would say is that we should be honest- the water we use is clean" (focus group discussion)

But in the same discussions some of the farmers noted that they were aware of the risks of using the wastewater but continued to use it because of lack of options:

> "We have continued with this farming practice even knowing that the quality of water is not good- we do know that there are diseases that are related to wastewater- but because of problems we have continued to use this water"

The link between disease and consumption of crops was not explicit for some farmers. The farmers contend that if consuming the produce had negative health consequences, doctors in the area would have highlighted this problem. This point was clearly important for the farmers since 73% of the respondents noted that they usually visited a doctor whenever they fell ill. As one farmer noted:

> "[I]n terms of disease, in my house I have not seen a child being taken to hospital because of eating vegetable grown here, I have not seen maize causing any disease and in the maize that is sold around town- I have not heard anything- the doctor would have tested people and say that this disease is caused by the vegetables you ate"

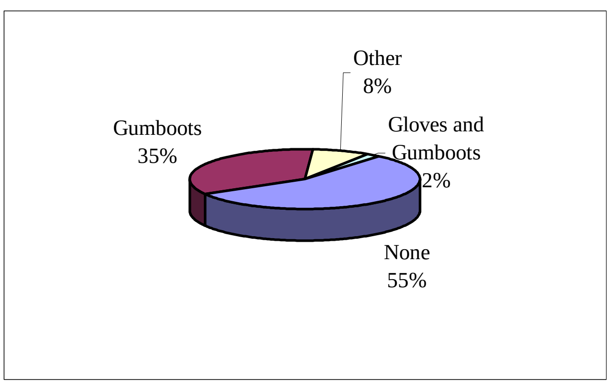
The farmers further argued that the crops they produced were usually cooked before being eaten, which in effect would have destroyed any microorganism that would be associated with enteric diseases. In addition, most farmers indicated that they usually washed their produce before consumption. But farmers were observed several times consuming produce in the field before cleaning. Another farmer's perspective is that because they had been farming using wastewater for a long time they had developed immunity to the diseases that are normally associated with poor water quality. The farmers' view of enteric disease was that the occurrence of enteric diseases was normal and not necessarily related to their farming practices using sewage water. It is significant that around 80% of the farmers surveyed do not perceive wastewater use as making them more vulnerable to enteric diseases. This indicates a need for awareness raising among the farmers on the link between wastewater and enteric diseases.

Risk mitigation strategies

Because of the risks of enteric diseases related to raw sewage and the concern of farmers regarding the quality of water, the questionnaire also sought to find whether the farmers used any risk mitigation measures. Figure 15 shows that 56% of the farmers used no protective measures during farming, which puts them at a high risk of negative health consequences related to using untreated wastewater, especially when they are directly in contact with the water.

Figure 15: Use of protective measures when irrigating

(N=139)



As previously noted, the farmers mentioned that most of the crops they grow are cooked before consumption. This is an important consideration, because crop selection has been identified as one of the risk mitigation strategies of using wastewater for irrigation, yet the decision to grow these crops was not necessarily dictated by attempts to reduce risks. Most crops produced by farmers in the area are generally staple food crops and vegetables. These crops are also in high-demand and have a ready market in the community. The farmers noted that they were willing to consider other non-food crops, but only if these alternative crops identified had a ready market and it was economically viable to grow them.

Farmers also mentioned their irrigation methods as a way of minimizing risks for crop contamination. The most common irrigation method in the area was through furrow and flooding irrigation. This method results in less contact between water and the edible parts of the plants, except for tubers and other crops that grow under the soil. Although this argument holds to a certain extent with regards to contamination of crops, there is still potential health risk for the farmer when they directly contact the water during irrigation. Discussions with farmers, mainly women, also revealed that farmers used de-worming medication especially for younger children. It was not explicit whether they used this strategy because of farming using wastewater or whether it was a general practice to prevent intestinal worms in their children.

Table 6: Gender and protection measures
(N= 139- Women, 70; Men 69)

Gender	(%) Protective measure			
	None	Gumboots	Gloves	Other[a]
Women	35	11	1	4
Men	21	23	1	4

a Other measures include wearing regular shoes that are not water proof

More men than women use protective measures when irrigating with wastewater (table 6). This could be due to several factors including economic. When asked whether they had considered using gumboots as a protective measure especially against helminth infection, farmers noted that it was too expensive to buy a pair of gumboots compared to their earnings. This is mainly due farmers' limited production capacities tied to limited access to land resources. Access to land resources has a gender dimension as more women cultivate on smaller plots, which limits their production to mainly subsistence farming. Thus, women have limited incomes and are unable to invest in protective gear such as gumboots.

In addition to problems of using wastewater, farmers also highlighted general constraints they face with regard to UA. More than half the farmers (58%) were concerned about the issue of land insecurity. They also noted lack of a credit schemes (41%) and lack of access to a reliable market (15%) as constraints. Other minor limitations mentioned included theft of produce and use of their plots as latrines. Interestingly, farmers tied the issue of lack of a reliable market to negative perceptions by consumers of crops grown using sewage water. Farmers noted that this negative perception by consumers affected them, as they felt shunned by the larger community. Some farmers had found creative ways to go around this problem. For example, some farmers smear their produce with soil of different color than that generally found in the area. Such a disguise is helpful as the consumers are not as weary of buying their produce as they assume that the produce is from rural areas. In other instances the farmers would lie to the consumers about the real origin of their produce.

Although the farmers in Maili Saba encountered multiple constraints with regard to UA, access to water (better quality) and land are of prime concern, as farmers perceived these resources to have the greatest impact on their farming potentials. In light of these two constraints, the farmers indicated that they would welcome any interventions that would address these issues. The farmers also expressed that they would like to see various services provided to them such as extension services and access to credit and farm inputs.

These results indicate the significance of wastewater irrigation for poor urban farmers in Nairobi. It also confirms that urban farming occurs in a contradictory environment that provides opportunities and constraints related to resources such as land and water, resulting in practices that are deemed risky. A broader understanding of urban farming should go beyond a microanalysis of farmers' experiences to look at the macro or institutional environment in which urban farming occurs. The next section will examine perspectives and responses to wastewater use in UA by two main institutional actors, who have a stake in UA in Nairobi.

4.2 Institutional Perspectives of Wastewater irrigation in Nairobi.

Although farming is widely practiced in Nairobi, there are no comprehensive policies that address urban agriculture. For instance, the issue of wastewater irrigation in Nairobi remains tenuous and is frowned upon by municipal government authorities. But there are no policies that have been drawn to systematically attempt to address the issue. It is this lack of clear policy directions and accompanying mechanisms to implement policies that have led urban practices such as UA to develop in an ad-hoc and unsafe manner. Within the policy arena, the two government authorities that are key players with regards to urban agriculture are the Nairobi City Council and the Provincial Directorate of Agriculture, Ministry of Agriculture[21]. The following section explores and highlights the institutional perspectives with regards to urban agriculture and wastewater irrigation of these two actors. The information presented here is based on interviews and discussions with officers from the two government authorities. In addition further insights were garnered from official documents accessed through the respective offices (see Appendix 1).

4.2.1 Institutional perspectives- Nairobi City Council.

The Nairobi City Council (NCC) is the local authority that is mandated to draw up policy directions of land use within the city of Nairobi. Through its policies the NCC can regulate development within each urban land use zone and provide controls on development through rules, regulations, zoning, by-laws etc. Urban agriculture has been

[21] Although these are the two key government institutions are highlighted, it should be noted that there are other government departments who can be drawn in as stakeholders in discussions around urban agriculture.

identified as one of the major land use types in Nairobi (Odongo, 1996), but paradoxically, the NCC has no specific policies to support and integrate agricultural activities within urban development plans. The City of Nairobi (General Nuisance) by-laws, describe the conditions for cultivating or keeping livestock. Although the by-law allows agricultural activities in permitted areas, UA is an unregulated practice and is generally viewed as a nuisance. Lack of clear policies regarding UA in Nairobi, has resulted in a *laissez faire* approach by the NCC. The NCC rarely enforces its by-laws regarding urban farming in Nairobi leading to uncontrolled, and often in some instances unsafe practices such as sewage irrigation.

Cities develop sewage networks to facilitate safe wastewater disposal. Nairobi's Sewer and Drainage Master Plan was completed in 1974[22], which was to guide the development of the city's sewerage network system (Odongo, et al, 1998). The sewage network was developed to transport domestic and industrial wastewater generated within the city to sewage treatment works (STW) for treatment and safe disposal into receiving water bodies. The Nairobi sewage network covered 65% of the total area by 1995, but this has shrunk to about 55% because of the rapid development of the city. In terms of population, only about 25% of the population in the city is serviced by the sewerage network with the rest of the population either using septic tanks or having no sewage facilities at all (NCC water and sewage department officer, personal communication)

In general, the Ministry of Water and Resource Management and Development, The National Water Conservation and Pipeline Company and the local authorities are the main players in the water supply and sanitation sector in Kenya (Allen and Ngonga, 2003). Thus, in Nairobi, municipal wastewater falls under the responsibility of the NCC, through the Water and Sewage department[23]. The NCC is responsible for investing, collecting and disposal of wastewater in the city. According to the Master Plan report (Odongo et al, 1998) the NCC operates 5 treatment plants[24], which cover 90% of sewage network coverage area. In general most of these treatment plants are not performing well, producing poor quality effluent that by NCC standards should not be discharged into watercourses (Odongo et al, 1998 pp44- 57). The rivers that flow through Nairobi are the receiving bodies for effluent from the sewage treatment works. The Master Plan report's (Odongo et al, 1998) analysis of the river water quality indicated extreme pollution by physical, organic, chemical and microbiological contaminants. The report found that most industries in Nairobi did not treat their wastewater, discharging high levels of contaminants into the NCC sewerage network or directly into receiving bodies. Furthermore, a substantial part of the sewage generated within the network in Nairobi is presently not reaching the sewer treatment works as intended. This is mainly because most of the network is non-functional due to collapse, blockages, poor maintenance etc

[22] These Master Plans have not been updated since and consequently development of water-borne facilities has not kept pace with population growth resulting in poor environmental health conditions for most of the population (Odongo et al, 1998).

[23] Other municipalities have established autonomous companies that fall under the Ministry of Local government that operate and maintain water supply and sanitation (Allen and Ngonga, 2003). An officer at the water and sewage department of the NCC noted that there are on going discussions to establishing a similar autonomous company for the city of Nairobi.

[24] There are a total of 21 treatment plants, but most are small-scale private/institutional based systems.

(Odongo et al, 1998). Urban farmers have taken advantage of the poorly functioning sewage network by accessing the wastewater directly from the network for irrigation.

The main policy challenge of wastewater use is relates to public health and environmental concerns of using poor quality water. As such, the NCC has no provision of using wastewater for agriculture. From the municipal point of view, the production of vegetables using sewage water, which are later sold in the market, is an important public health concern (Odongo, 1998). But interestingly the survey of farmers in Maili Saba revealed that harassment by city authorities was not an issue in the area. This indicates that although officially wastewater use for agriculture is prohibited, the municipal authorities do not have any particular mechanism to respond to this issue. Although most farmers in Maili Saba are concerned with the quality of the untreated wastewater they use, they argue that this is partly due to lack of options, noting that even the rivers that flow through the area are just as polluted. This fact is corroborated by the findings of the Master Plan report, as noted above (Odongo et al, 1998).

As early as 1974, the City of Nairobi Master Plan has since 1974 recommended that a pilot scheme using effluent for irrigation be carried out (Odongo et al, 1998). This recommendation has not been implemented, although there has been an observable increase in sewage irrigation, which implies a demand for wastewater use. The Master Plan report notes that reuse options for wastewater should be integrated within the planning of the sewage network, but at an institutional level the NCC has not been able to systematically draw policies to formally integrate UA within the city Master Plan. This lack of integration makes it difficult to adopt some of the recommendations that have been put forth. According to an officer at the sewage department of the NCC, other recommendations made to the city have been to use the wastewater effluent to develop recreational facilities such as animal breeding and for recreational water sports (NCC water and sewage department officer, personal communication). Another officer suggested that the reason the city is not keen on using the wastewater for irrigation is that municipal authorities have not been able to conduct comprehensive analyses of the effluent discharged from the treatment plants and assess its suitability for irrigation purposes. Another constraint noted by the NCC officer for implementing the recommendation was limited financial resources.

Due to lack of policy on UA in general, there are no regulations or by–laws that address sewage irrigation and the health concerns that go with it. According to an officer at the department of environment at NCC, the Public health act indirectly covers issues of wastewater use, as the act can be invoked when an activity is viewed to be a public health hazard. Discussions with municipal authorities indicate an appreciation of the urban farming, especially with regards to its contribution to livelihoods of the urban poor, but institutionally UA is still perceived as a marginal activity within Nairobi's landscape. UA is still not considered a major socio-economic activity and is viewed as secondary with regard to other land use activities such as housing etc (NCC department of environment officer, personal communication).

Such a policy arena impedes rather than facilitates safer and sustainable UA practices.

From an institutional perspective, sewage irrigation in Nairobi can best be addressed only when the NCC comprehensively understands farming activities in Nairobi, give due recognition to the practice, and develop practical guidelines and policies to incorporate UA in city planning. In addition, in order to facilitate safe UA practices, there is need to develop institutional mechanisms and frameworks that will adequately address pollution of water bodies in the city, as these are important sources of water for most farmers.

4.2.2 Institutional perspectives- Ministry of Agriculture.

The Ministry of Agriculture recognises that farming does occur in Nairobi, and through the Provincial Directorate of Agriculture (PDA) provides services to farmers in the city. The directorate provides extension services in seven administrative divisions in Nairobi these include:

1. Kasarani
2. Dagoretti
3. Kibera
4. Westlands
5. Makadara
6. Embakasi
7. Central

The PDA offices within each division provide frontline extension services through farm visits, field days and demonstrations (MOA, 2000, 1999). The extension workers are in charge of identifying problems farmers face and link them with the needed services. In addition, the division offices also provide farmers with training on improved farming methods to improve their yields, and on soil and water conservation and management (MOA, 1999). Farming within the seven divisions is varied. In some divisions farming is mainly composed of small-scale horticultural production for supplying the city market, while in others, it is a mixture of both horticultural and livestock production. The extension services are meant to meet the diverse needs of the different farming communities (MOA, 1999; MOA, extension coordinator, Embakasi division, personal communication). In practice, however, this is not always done as in the case of Maili Saba within Embakasi Division.

Although farming is extensively practiced in Maili Saba, farmers do not receive any support from the Embakasi Division office. According to the extension officers, the contested nature of sewage irrigation, especially with regards to the Nairobi City Council, limits their ability to provide any services to the area. The Embakasi office has taken a hands-off approach to sewage irrigation in Maili Saba. This approach has been exacerbated mainly because of lack of coordination or linkage between the NCC and the PDA offices. Although the existence of PDA implies recognition of urban farming in Nairobi, the PDA's role and operations seem to be overlooked by municipal authorities. Discussion with an extension officer revealed that there were minimal channels of communication between the agriculture office and the NCC. For this reason the PDA has not been proactive in exploring options that would help address the problem of sewage farming in Embakasi Division. This problem is further exacerbated by the limited funds available for operation of the provincial agriculture office. (MOA, 2000)

But lately there have been attempts to address the issue of wastewater use for urban food production. According to the Embakasi extension coordinator, at a recent Central Agriculture Board (CAB) meeting, a recommendation was made to ban sewage irrigation. Representatives from the NCC, the Nairobi Provincial Commissioner's office and the Provincial Directorate of Agriculture attended this meeting. But the modalities of enforcing this ban have not been developed (MOA, extension coordinator, Embakasi division, personal communication). This standard approach of trying to address wastewater irrigation by banning the practice is ineffective, mainly because of lack of proper structures to implement and police the situation. The Provincial agriculture officer has suggested that a sub-committee[25] be established to look into long-term options taking into account the livelihoods of the farmers that would be affected by the ban (MOA, extension coordinator, Embakasi division, personal communication).

With lack of any clear direction regarding sewage irrigation at the municipal level, there are limited opportunities for the Ministry to Agriculture to intervene with regards to this farming practice. According to the extension officer, the issue of sewage irrigation is beyond their jurisdiction; hence the Ministry of Agriculture office cannot act on the issue. But their role in providing extension services offers potential for this office to make a positive impact with regard to wastewater irrigation. Extension services can be an important means for farmer education, especially with regards to the risks of using wastewater and ways to mitigate these risks. Discussions with farmers revealed that they saw a need to receive support in the form of expert advice on farming practices. This demand for extension service does open a window of opportunity for which better farming practices can be promoted. But this will require concerted and collaborative efforts by all stakeholders, and this has to be backed by clearly defined policies developed within a framework based on the political economy of UA.

[25] At the time of conducting this research the committee had not been set up yet.

5.0 DISCUSSIONS

The findings of this research reiterate the notion that UA is an important livelihood strategy for the urban poor in Nairobi. The contribution of farming to food security in Maili Saba is quite appreciable both in terms of subsistence and its provision of inexpensive food at the local market. Although the results indicate that the majority of the farmers produce for subsistence, their contribution to the urban food market cannot be underestimated. This is mainly because irrigation using wastewater has enabled year round farming, thus enabling farmers to supply cheap vegetables to the local markets, which is compounded by farmer's closeness and resultant lower transportation costs. Vegetable production in urban areas has been instrumental in curbing fluctuation of vegetable prices. As Mougeot (1994) notes, although UA receives little support, it already supplements a significant share of cities' needs for cheap and quality foods.

Because of lack of supportive policies on urban farming in Nairobi, UA development has been opportunistic in terms of access to resources such as land and water. But limited access to these resources has resulted in farmers resorting to unsafe practices (Mbiba, 1995; Drechsel and Kunze, 2001). The use of wastewater for irrigation in many developing countries cities clearly illustrates this. In Maili Saba, lack of alternative sources to safe and affordable water sources has resulted in the use of raw sewage for irrigation. But the farmers also see wastewater as a resource that boosts their production potential by enabling them to farm throughout the year.

Not surprisingly, the quality of untreated wastewater used by farmers in Maili Saba points to potential health risks (Hide et al, 2001a). Methods of irrigation used where farmers come in direct contact with wastewater, makes them vulnerable to enteric diseases and helminth infections. Although some farmers are aware of the potential risks, others do not necessarily see linkages between health conditions and their irrigation practices. Other studies have indicated similar perceptions by farmers (see Ouedraogo, 2002). This indicates that education and training are an important component of promoting safe wastewater use for UA. Although extension service officers have an important role in farmer education, in most cases, more effective initiatives will most likely involve interventions of community based or non-government organizations. This is in light of limited capacity in most municipalities to implement such an initiative; hence a gradual progress in self-regulation of risk is necessary especially through community-based organizations (Furedy, 2002).

But engaging in unsafe farming practices, such as using untreated wastewater goes beyond limited knowledge of the risks, especially in the context of poor farmers. Poverty and food insecurity results in most farmers adopting short-term strategies to ensure a livelihood despite associated risks. Understanding risk perceptions within a broader socio-economic context is critical when exploring risk mitigation strategies. Discussions with farmers confirm that daily threats such as lack of alternative income generating activities and food insecurity weigh heavily on their perceptions of health risks posed by using untreated wastewater. For most farmers the benefits of using wastewater for food production outweigh the potential health risks related to wastewater. In addition, farmers' choices are limited by constraints such as insecurity or lack of access to land and water resources (Buechler, forthcoming).

The findings also highlight important gender dimensions of the constraints and risks related to wastewater irrigation. Reviews of UA research indicates that there are considerable differences between men and women with regards to the challenges they face related to access to resources (Hovorka, 1998). This study finds that women tend to cultivate on smaller plots than men. More limited access to resources put more women than men at risk of exposure to hazards related to wastewater in their farming practices, as women have less resources to invest in protective gear such as gumboots for use during irrigation. A gender analysis points out to the need for paying special attention to gender when planning for UA. Such awareness will then inform interventions that will seek to attain an equitable level of access and control of resources needed for UA for all those involved.

In conclusion, a livelihoods approach enables a better analysis and understanding of the issues identified above, highlighting trade offs made by poor urban farmers in an effort to make a living. This should therefore provide a basis for identifying the kinds of interventions needed to improve farming practices while recognizing that households construct their livelihoods on the basis of the resources available to them and within the broader socio-economic context (Buechler, forthcoming; Rakodi, 2002). In addition, practices of urban farmers cannot be understood in isolation of institutional processes and practices encapsulated by policies, particularly at the municipal level, which determine the environment in which UA occurs. Research on UA and health risks should not only focus on the micro factors, which explain some of the motivating factors for engaging in unsafe practices, rather it should further explore the macro factors such as infrastructure and institutional or government support, which can provide an enabling environment for sustainable UA. Central to this issue is access to land. Land tenure is an essential factor with regards to reducing risks and to improving of UA practices. Farmers noted that land insecurity was one of the reasons why they were not keen on investing in safer UA practices. This suggests that a more systematic inclusion of UA into urban land use planning would respond to some of the underlying factors that lead to practices, such as use of sewage water for agriculture. The problem with land is not only physical availability, but also adequate access, as the informal, and sometimes, illegal access to land has made UA more precarious (Smit et al, 1996). Addressing land tenure and allowing more land security would enable farmers to focus on the long-term condition of the land and invest in safer and more efficient farming practices.

6.0 CONCLUSION: CHALLENGES AND OPPORTUNITIES

This research confirms that UA in Nairobi has become an integral part of the informal urban economy. The deteriorating urban economy resulting from structural adjustment policies among other factors have triggered the rapid growth UA without adequate institutional support. Although UA has thrived due to weak urban management regimes (Mbiba, 1995), this has also resulted in unsafe and unsustainable practices. The lack of proper guidelines, policies and support is attributed to a general negative attitude towards the concept of UA, based on several assumptions held by municipal authorities.

Wastewater irrigation highlights issues that need serious consideration. For the farmers wastewater is a valuable resource rich in nutrients and easily accessible to allow year round production. But for municipal authorities, use of wastewater for irrigation remains a contentious issue as municipal officers and planners are primarily concerned with public health and infrastructural implications of current wastewater irrigation practices, without necessarily considering the economic, social and environmental sustainability of this practice (Smit, et al, 1996). Addressing this impasse would first require a recognition and acceptance that urban farming is a reality in cities in SSA. This calls for a change in local authority attitudes, leading to well-defined policy and guidelines and changes in institutional regimes that govern cities, and a better appreciation of the intrinsic social and economic values upon which urban food production is anchored (Obudho and Kauti, 2002). Institutionalization of UA will in effect provide supportive frameworks for enabling safer and more sustainable practices, yet such a process requires active participation and deliberation of all key stakeholders.

6.1 Options for reducing risks

In exploring safe wastewater use options, there is need to consider both farmers' socio-economic well-being and public health concerns. Inevitably conflicts may arise and trade-offs will have to be made in trying to reach such a balance. But there is a need to search for appropriate and realistic options that look at how best to explore the productive potential of wastewater irrigation. These options will be a combination of technological development, social interventions and institutional support. The section below points out to some of these options.

The standard approach to safe wastewater use has been through wastewater treatment. The WHO developed guidelines on wastewater quality used for irrigation (Mara and Cairncross, 1989). Central to the WHO guidelines lies the assumption that wastewater generated and used for irrigation receive some level of treatment, but for most developing countries, wastewater used for irrigation seldom receives treatment (Carr, et al, forthcoming). Since most of these countries have not been able to invest in centralized and highly mechanical systems for wastewater treatment, and for those countries with such treatment systems, the challenge is to keep them in operation. The challenge is not limited to the initial capital costs of constructing sewage systems, but also the long term operation and maintenance cost of these systems (Rose, 1999; Dreschel et al, 2002; Carr et forthcoming).

In order to enable the use wastewater for UA, efforts should be directed towards promoting decentralized, but strategically located, treatment facilities to enable the treatment of wastewater and the recovery of these resources (Rose, 1999). Such a strategy reduces the distance of conveying wastewater to centralized treatment plants. In addition decentralized treatment systems are smaller in scale, easily maintained and operated, and make it more likely that the treated effluent is accessible to the farmers. An IDRC supported project in Dakar, Senegal has developed decentralized, small-scale biological wastewater treatment systems using water lettuce. The treatment systems are managed and run by the local community and the treated wastewater is then reused in market gardens (CFP project# 04367, Faruqui et al, forthcoming; Niang, 2002). Such low-cost technological options can enhance safe use of wastewater in urban farming.

To compliment decentralized treatment options, certain irrigation micro-technologies can reduce potential health risks of using wastewater for irrigation. Bradford et al (2002) highlight some simple technologies adopted by farmers in Hubli-Dharwad, India. These methods include various forms of sewage filtration including improvised gauze filters around the filter inlet. These filters are meant to filter out solid wastes present in the wastewater. Filtering these solid wastes prevents potentially hazardous materials such as glass bottles, plastics and other debris from being buried in the soils and ultimately posing an occupational hazard to the farmers.

Apart from technological approaches and interventions, non-treatment options, which entail relatively less elaborate interventions, have been proposed (Mara and Cairncross, 1989). Non-treatment options provide opportunities for immediate interventions, although in some cases these are mainly on a short term. These options include:

1. Reduced human exposure
2. Crop restriction.
3. Chemotherapy (Treatment)

Reduced Human Exposure

In most instances, farmers are exposed to enteric diseases and helminth infections because of their direct contact with wastewater during irrigation. To reduce this risk, a practical and immediate intervention is to reduce farmers’ exposure to the hazard. One measure to mitigate these risks is the use of protective wear. This includes wearing gumboots and gloves when irrigating so as to minimize direct contact with the water. Using gumboots is particularly useful for protection against worm infections. To this end farmers should be encouraged to invest in such protective wear. Although it was noted that cost was a prohibitive factor for many farmers, awareness of the long-term benefit of such investments would likely motivate more farmers take precautions. In order to overcome the limitation of cost, there is also a need for micro-credit options for farmers. Access to credit can allow farmers to access cash to improve their farming practices. Farmer education campaigns will also be useful in complementing the above strategy. There is a need to raise farmers’ awareness of the health risks associated with untreated wastewater.

Crop restriction

The WHO has classified crops in relation to health risks and wastewater irrigation (Mara and Cairncross, 1989). Vegetable crops, especially those eaten raw, pose a higher health risk when grown with wastewater. Thus a high microbiological quality is necessary for water used to grow these crops. On the other hand, crops that are cooked before consumption poses less risk of contamination when grown using wastewater hence the quality of the water to grow these crops could be lower standard. Crop selection is a health mitigation strategy that should be explored, keeping in mind economic considerations. Most urban farmers using wastewater are poor with limited livelihood opportunities, thus any intervention to improve on their practices should not jeopardize these opportunities. In many instances, farmers opt to grow vegetables mainly because they are high yielding with a high market demand and most profitable (Faruqui, et al; forthcoming).

Chamotherapy (Treatment)

Providing treatment has also been proposed as a management option for using wastewater for irrigation (Mara and Cairncross, 1989). This strategy entails using de-worming medicine for treating farmers and their families for helminth infections. It can also be used to control anaemia in both children and adults. But chemotherapy should be considered as a short-term strategy pending improvement in the water quality or adoption of other control measures (Carr et al, forthcoming).

6.2 Looking forward- Policy options and recommendations

The findings in this report indicate that UA, including other practices emanating from urban farming such as wastewater irrigation, are livelihood strategies for the urban poor. Therefore the sustainability of UA is dependent on providing better support for the farmers through broad based actions that include developing supportive UA policies and improving access to resources as a foundation for their livelihoods (such as land, water, access to credit, extension services etc). Experience has shown that meaningful engagement and dialogue among various stakeholders of UA in cities has led to success including drawing up of supportive policies and increased collaborative efforts in sustainable UA practices. Box 1 highlights such an example based on the experience of Dar es Salaam.

BOX 1: Urban Agriculture in Dar-es- Salaam

Dar es Salaam provides a good example of how systematic institutionalization of UA can maximize the potential of farming in the city. Through the Sustainable Dar es Salaam project (SDP) launched in 1992, UA was identified as one of the environmental management strategies of open spaces, recreational areas, green belts and hazardous land in the city.

Dar es Salaam has identified UA as an integral part of the urban mosaic and has been incorporated into the city's strategic urban development plan (SUDP). It has been recognized that UA in Dar es Salaam is an important input in the urban economy, in terms of employment generation, and food production. UA can also be used to create a green belt for the city, enabling the city to respond to its future demand for recreation areas.

Through a working group on UA, Dar es Salaam has collected comprehensive information about various agriculture activities within the city, initiated pilot project activities such as training farmers on adoptive technologies, conducted radio programs to publicize and disseminate information on UA, and worked with city officials to solve problems related to UA.

The working group also identified constraints to UA such as ambiguities in city by-laws, and in response proposed the need for revisions of such by-laws. In addition constraints related to public health risks due to unsafe practices such as irrigation using contaminated water were identified. Several strategies were identified to address this problem including exploring other sources of cleaner water such as groundwater from wells, using wastewater that has been treated (through decentralized biological treatment systems) and options for water harvesting.

Thus in Dar es Salaam the response to UA through policy formulation and projects has enabled it to become more integrated within the city's development plans. One successful program has been the Urban Vegetable Promotion Project implemented under the Ministry of Agriculture and Cooperatives which aims to improve vegetable production in Dar es Salaam

(Source: Sawio .C 1998. Managing Urban Agriculture in Dar es Salaam. CFP report no. 20 and Jacobi, P et al. 1999 Urban Agriculture in Dar es Salaam: Providing an indispensable part of the diet. In In Bakker, N et al. *Growing Cities, Growing Food: Urban Agriculture and the Policy Agenda. A Reader in Urban Agriculture*. DSE

Opportunities for interaction between regional municipalities should be promoted in order to foster practical exchanges of knowledge, technology, and best practices of UA in SSA. Regional networks can facilitate meaningful cooperation between countries and enhance the capacity of various UA actors through training and sharing experiences.

Incorporating UA through policy will provide directions for planning within the broader development of sustainable cities. In this regard, it is imperative to have an understanding of the political economy of UA and its contribution to the larger urban economy. It is recommended that more research be conducted in this regard, especially in understanding UA's contribution to the urban and national food supply systems. The issue of wastewater irrigation also calls for further research especially with regards to looking at more appropriate and feasible options for safe use of wastewater. There is a need to test out various options in relation to their viability, which should take into consideration the social, economic and cultural contexts of wastewater irrigation.

But highlighting lack of clear policy for UA is nothing new; this bottleneck has too often been mentioned as an obstacle to be overcome. What is now more important is to get through this impasse and achieve real political commitment to seriously recognize UA not only as a reality in cities in developing countries, but also to be more cognizant of the opportunity cost of not taking proactive measures to incorporate and support UA in local development plans. These costs not only include environmental and health risks, but also lost opportunities of increased food security and the general economic benefits related to farming in cities. Policies need to be developed to overcome major constraints of UA such as access to land and water resources, access to credit etc. But a first step towards addressing these constraints is to promote dialogue and collaboration among the various government authorities concerned at both national and local levels. Collaboration will allow for developing a broader vision that goes beyond each actor's mandate, which will ultimately enable the integration of UA in municipal development plans.

Research based evidence is clearly an important element in incorporating UA as part of sustainable urban development practices. Several recommendations for further research have been highlighted through the report, in summary they are as follows:

- Urban farmers are key stakeholders in the promotion of sustainable urban practices. The report's findings indicate that farmers are to a certain extent formally and informally organized in their bid to negotiate access to resources. But there is limited understanding of how the organization and dynamics of these organizations, thus action research in this area would ensure any interventions would match up to farmers needs.
- This report found that farmer and members of their households are at a high risk of infection by enteric diseases. But due to the complexity of other confounding factors within the farming community, the occurrence of enteric diseases cannot be attributed only to the use of wastewater for irrigation. More research could be conducted to determine the significance of wastewater use to occurrence of enteric diseases in the context of the sanitation conditions. There is also the need for more research on health risks due to heavy metal contaminations, especially because of significant industrial contamination of wastewater in Maili Saba.
- There is limited comprehensive evidence on the benefits of UA for households and its general contributions to urban food systems. More research in this area is needed to provide the evidence needed by local authorities to fully integrate UA within broader municipal development plans.
- Wastewater is an important resource that is still ignored and underutilized. In order to exploit this resource within a broader sustainable urban development framework, research should explore appropriate and feasible options for reusing wastewater especially in the context of UA.

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APPENDIX I

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APPENDIX II

Questionnaire

Section I- General Information:

1. Name:______________________________
2. Sex: ______________________________
3. Age: ______________________________
4. Level of Education: __________________
5. Marital status _________________________

Information of Household

	Name	Sex	Age	Education Level	Occupation	Role (assistance on farm)

Section II- Agricultural activities and other social and economic factors

6. How long have you been farming at this plot?

7. How did you acquire the land that you use for farming
   - ☐ Renting
   - ☐ Lease
   - ☐ Squatting
   - ☐ Buying
   - ☐ Other (specify)________________________

8. What is the approximate size of your farming plot (acres)_______________

9. Do you farm anywhere else in the city? (Note where else)

10. What crops do you grow?

☐Maize	☐ Amaranthus	☐ Cowpeas
☐Beans	☐ Tomatoes	☐ Pigeon peas
☐ Kale	☐ Arrow roots	☐ Carrots
☐ Spinach	☐ Sugar cane	☐ Other (list)
☐ Bananas	☐ Sweet potatoes	

11. Cropping Cycle

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crops												

b) How do you decide what crops to grow?
- ☐ Easily marketable
- ☐ Grows faster
- ☐ Consumption needs
- ☐ Other (specify) ___________________

12. The food/ vegetables that you consume is mostly from:
- ☐ Your farm
- ☐ From the market
- ☐ Gifts/ Exchanges from family and friends
- ☐ Other (specify)

13. What you produce is mainly for?
- ☐ Home consumption ☐ For market

14. (If they sell their produce) Which crops do you sell (list)

15. (If they answer Q12) Where do you sell your crops?
- ☐ Directly to neighbors
- ☐ Local market
- ☐ To market retailers
- ☐ Other Specify ___________________________

16. Do you add any inputs to your farm?
- ☐ Organic manure
- ☐ Artificial fertilizers
- ☐ Pesticides

17. How many bags of produce do you sell in the market for every harvest?

Section III- Wastewater use patterns, constrains and perceptions

18. What sources of water do you use for farming?
 - ☐ Raw sewage
 - ☐ River water
 - ☐ Rainfall

19. (Ask this question if farming is year round as indicated in the cropping cycle chart) Where do you get water during the dry season

20. Why did you decide to use wastewater for farming?

☐ Only source of water ☐ Rich in nutrients
☐ Free source of water ☐ Easily accessible ☐ Other (specify)

21. What are the methods you use to irrigate your farms

Irrigation patterns	Buckets/ Cans	Flooding	Pumps	Sub-surface irrigation	Other (specify)	

22. Do you have any problems using wastewater for farming?

☐ Not enough water all the time ☐ can cause disease ☐ Other (specify)
☐ Harassment by city council ☐ None

23. Does wastewater have an effect on your crops?

☐Better-looking produce ☐ scorches crop
☐ Provides manure ☐ Other (specify)-
____

Section IV – Health risk perceptions of wastewater use and sanitation of farming households.

24. What are the sources of water used in your household?
 - ☐ Tap water
 - ☐ Bought from water kiosk/vendor
 - ☐ From stream/river
 - ☐ Other__________________

25. Do you normally boil water before you drink?

☐ Yes, all the time ☐ No ☐ Sometime

26. What type of toilet do you use in your household?

□ Pit latrine □ Open areas □ Other (specify)___________________

27. What kind of health problems has any member of your household experienced within the last two weeks, month, and year?
□ Diarrhea □ Intestinal worms)
□ Skin irritation □ Other (list)
□ Stomachache

28. Has any person in this household had stomachaches within the last two weeks, one-month ?
□ Yes □ No
List who:

29. Has anyone in your household had diarrhea in the last two weeks, one month
□ Yes □ No
List who:

30. What kind of health assistance did you look for when you have fall sick with diseases mentioned above?
□ Buy medication from the shop □ Go to the dispensary/ health clinic
□ Did not take anything □ Herbal medicine
□ Other__________________

31. Have your children been had intestinal worms?
□ Yes □ No
32. If Q30 is yes, how long ago?
□ Two weeks ago or fewer □ One month ago □ One year ago

33. DO the children have following symptoms
□ Loss of appetite □Protruding stomach □Painful abdomen □Coughing
□Fever □Vomiting □Diarrhoea □Listlessness and generally feeling unwell

34. When you come home from the farm do you:
□ Eat food without washing your hands
□ Eat raw food from the farm without
□ Other (specify)

35. What kind of protective gear do you wear when irrigating with wastewater?
□ Gumboots
□ Gloves
□ None

□ Other (specify)________________________

36. Which of the common diseases that you have mentioned (recap the diseases listed in Q26.) can be caused by using wastewater to grow crops?
    □ Diarrhea □ Stomach ache □ other (list)
    □ Skin irritation □ intestinal worms

37. In which ways can someone avoid the health problems related to unclean water
    □ Not touching
    □ Not drinking
    □ Growing certain crops
    □ Other (specify)

38. Do you have any problems as farmers
    □Land insecurity □Lack of market □Lack of extension services
    □Not enough clean water □Lack of credit access □None □Other (specify)

39. What services would you like to get as farmers
    □ Training on health □Market access □Access to land □Access to land
    □Access to clean water □Credit programs □Other (specify)

40. Do you have any comments or questions with regard to this research?

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