

A Systematic Overview of Urban Agriculture in Developing Countries

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1. Introduction

Urbanisation: growing cities and agglomerations Demographic growth and increase in urbanisation are some of the challenges of the next decade. In 1994, 45% of the world's population lived in cities, and by 2025 this figure will have risen to 65% (UN, 1994, cited from Nugent, R.A., 1997). Even more remarkable is the trend towards large metropolitan areas. Almost 90% of the urban growth is about to take place in developing countries (Drechsel, et al., 1999).

Increase in urban poverty The rural-urban income gap narrowed in the 1970s and 1980s. By 1980, "new urban poor" seemed to have developed in many African cities (Jamal and Weeks, 1993, cited from Binns, et al., 1998). According to the World Resources Institute, in 1988 about 25% of the absolute poor in the developing world lived in urban areas. In 2000, this figure is estimated to total approx. 56%, WRI, 1997. Local administrations generally find it difficult to handle the growing pressure on public infrastructure, living conditions, labour, food, and are also facing environmental and sanitary problems. An uneven development with respect to geography and time (tendencies of spatial fragmentation) and social fractionating identified on all scales are the consequences of these trends (Sassen, 1996; Dittrich, et al., 2000).

Why urban agriculture? Urban agriculture could contribute to mitigating the two most intractable problems facing Third World cities - poverty and waste management. Urban agriculture is one of several food security options for households; similarly, it is one of several tools for making productive use of urban open spaces, treating urban waste, saving or generating income and employment, and managing freshwater resources more effectively (Bakker, et al., 2000).

The main objectives, processes and products of urban agriculture are illustrated in Fig. 1.

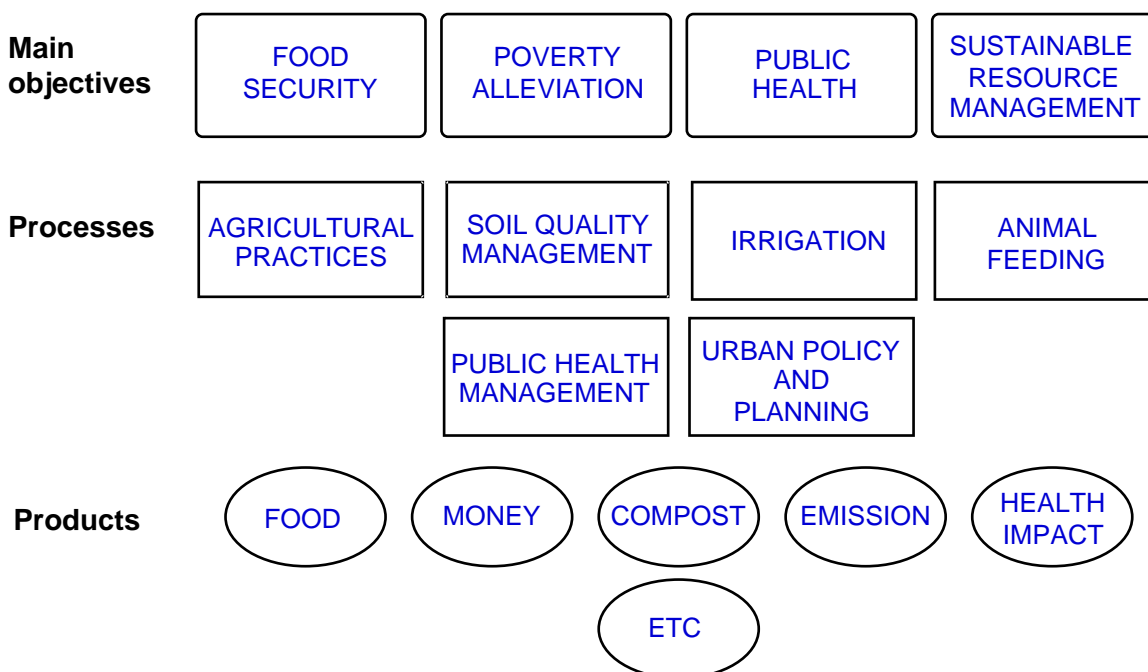


Figure 1. Main objectives, processes and products of urban agriculture

<i>Main objectives</i>	The main objectives, which include food security, poverty alleviation, public health, and sustainable resource management, are strongly linked to the problems of urbanisation and managerial skills of the cities to solving them.
<i>To what extent can urban agriculture contribute to food security in cities</i>	The main driving forces for farmers to become engaged in urban agriculture are food security and income generation. According to the Urban Agriculture Network (TUAN), of the roughly 800 million people currently involved in urban agriculture worldwide, 200 million produce for the market and 150 million are full-time employees. The literature has different views on the potential of urban agriculture. Between 1993 and 2005, urban agriculture could increase its share of world food production from 15% to 33%, its share of vegetables, meat, fish, and dairy products consumed in cities from 33% to 50%, and the number of urban farmers producing for the market from 200 to 400 million (Smit, 1996, Mougeot, L., et al., 1998). However, Nugent takes a more cautious view: urban agriculture is potentially viable and productive but not a panacea to solve the most severe problems of food security in cities (Nugent, R.A., 1997). The prevalent question is to what extent can urban agriculture contribute to the challenges of urban development. It has to be taken into account that the poor are not the only local food producers, but they are more dependent on it for income and nutrition.
<i>Aims: public health and sustainable resource management</i>	Apart from food security and poverty alleviation, urban agriculture is important for public health and sustainable resource management. The direct impacts are improved health conditions amongst urban farmers thanks to a richer vitamin and protein diet. Furthermore, more appropriate waste management practices lead to a decrease in health risks. Sustainable resource management implies a more efficient use of resources, including a reduction and reuse of waste flows whenever possible. Closing the nutrient loop in the urban environment by reusing the so-called waste as fertilisers in urban agriculture is an option to the prevalent open-loop and linear urban systems (Nelson, 1996, Smit, 1996).
<i>Processes of urban agriculture</i>	The processes of urban agriculture (Fig. 1) include: <ol style="list-style-type: none"> 1. Agricultural practices 2. Soil quality management 3. Irrigation 4. Animal feeding 5. Public health management 6. Urban planning and policy
<i>Products of urban agriculture</i>	The products of urban agriculture are manifold and include fresher, cheaper and more diverse food for the poor, more green space in the cities (recreational value, well-being, air quality), better sanitation and improved health conditions. The obvious additional income and household food supply are among the most important benefits.
<i>Objectives of the present report</i>	The aim of the present literature review is to gain an overview of urban agricultural practices and identify gaps in knowledge. The cross-cutting issues especially between environmental sanitation and urban agriculture are of key importance.

2. Definition of Urban Agriculture

Importance of a definition

A definition of urban agriculture is necessary to compare the different articles on the said subject. It is important to clearly define the studies for purposes of differentiation and clarification. Furthermore, definitions are mental tools to enhance understanding and describe the complex reality.

Various definitions of urban agriculture have been offered in the growing literature on urban agriculture (Aldington, 1997; FAO, 1999b; Mougeot, L.J.A., 1999; Nugent, R.A., 1997; Quon, 1999; Smit, 1996). In this work, urban agriculture is defined as follows:

Short definition

Urban agriculture comprises the production, processing and distribution of a diversity of foods, including vegetables and animal products within (intra-urban) or at the fringe (peri-urban) of an urban area. Its main motivation is food production (for personal consumption or sale) and/or higher income.

This definition only includes the questions pertaining to the where, what and why, and aims at distinguishing between rural and urban agriculture and agricultural activities conducted for recreational purposes.

A comprehensive view can be gained by enumerating the factors influencing urban agriculture:

- Location & scale (Where)
- Activities & stage (What)
- Stakeholders (Who)
- Motivation (Why)

2.1 Location & Scale (Where)

How can the boundary be defined?

Why differentiate between inter-urban and peri-urban areas?

The location is by far the most common element in the reviewed definitions. Most authors assign urban agriculture to the agricultural activities within and around urban areas. Definition of the outer boundary (peri-urban area) is, however, the main issue of contention. In this context, the question to be raised is whether this distinction (between “urban” and “peri-urban”) is suitable for any level (planning, intervention or production) and for any stakeholder. Mougeot states that “many authors recognise the need to differentiate peri-UA from intra-UA but the criteria used vary widely” (Mougeot, L.J.A., 1999). Binns and Lynch state that the significance of the distinctions between urban and peri-urban agriculture is itself unclear, since the motivation of the producers is often similar, the market is usually the same, and the issues of production and marketing are similar (Binns, et al., 1998). Consequently, some authors select a process and food-system-based definition instead of a location-based definition (Binns, et al., 1998); (Sumberg, 1996, cited from Adam, 1999). The problem could be that urban agriculture does not equate simply neither to one type of production system nor to a fixed geographical area around a city (Drechsel, et al., 1999). The literature contains several criteria influencing the size and shape of the peri-urban area, such as the urban influences, official city boundaries, travel time or distance to the centre (Bakker, et al., 2000; Adam, 1999; Binns, et al., 1998; Drechsel, et al., 1999; Mougeot, L.J.A., 1999).

Features of the peri-urban area

The striking features of the so-called peri-urban area can be summarised as follows: The peri-urban area contains both rural and urban elements, but the resulting peri-urban systems may have distinctive characteristics of their own (Drechsel, et al., 1999, Adam, 1999, Birley, M., et al., 1999). It is characterised by strong urban influences and demands, easy access to markets, services and other inputs, but a relative shortage of land, pollution risks and urban growth (Adam, 1999, Drechsel, et al., 1999). Therefore, the reasons to differentiate between urban and peri-urban could be the fragmented nature of the institutional landscape, its unplanned conditions, fast growth, extremely fast changes (social, economic, environmental) and increase in serious use conflicts. The peri-urban area is a zone of transition.

Availability of land and its access

Availability of land is very often the crucial element for people to become engaged in urban agriculture, but even more so is its access. This implies both manner of land use and legal aspects, as well as a near and secure access. The second aspect may be important in cases where women are the urban farmers and have to travel to the plot with their children at different times of the day.

2.2 Activities & Stage (What)

Activities and stages of urban agriculture

Urban agriculture may comprise different activities and stages: (1) acquisition and utilisation of the necessary resources, inputs and services; (2) production of goods; (3) “post-production”, including processing, packaging, distribution, marketing, and recycling; (4) consumption, Smit, 1996. Except for consumption, all these activities have to be included in the definition. Furthermore, all activities like home gardening, horticulture of food and non-food products (ornamental plants), aquaculture, livestock, and forestry form part of urban agricultural. If the entire agribusiness with suppliers of seeds, fertilisers and pesticides, as well as banks and credit agencies providing financial support are included, the number of people engaged in urban agriculture is much higher than if only the urban farmers are counted.

2.3 Stakeholders (Who)

Various actors are involved in urban agriculture; they are the suppliers of resources, inputs and services, the producers, the transporters, the processors, the retailers, the consumers, the promoters, and the managers. These actors belong to the public and private sector, the formal and informal economy.

2.3.1 Urban Farmer

Urban farmers mainly belong to low-income groups

In most developing countries, the urban farmers belong to low income groups (Nugent, R.A., 1997, Smit, 1996, Mougeot, L., et al., 1998). They are relatively long-term city residents, moderately poor, and frequently females. They exist in all regions of the world, but face vastly different conditions and opportunities. Urban farmers are marginally better off than the absolute poor. They have dwelt in the city long enough to have acquired access to some land and other resources (Nugent, R.A., 1997). A case study on Nairobi established in 1994 that about 44% of the urban farmers belonged to the very low income group, and about 16% to the low income bracket. About 85% of these urban farmers had been residing in the city for more than 14 years (Mwangi, 1995, cited from Foeken, et al., 2000).

The role of women

Little attention has been paid to the women who tend to predominate in urban agriculture which relates well with their care-taking and house-holding roles in most countries (Mougeot, L.J.A., 1999, Hovorka, 1998). Women perform numerous vital roles directly related to urban agriculture, and actively participate especially in urban gardening for home production, but also in food processing and marketing. In small-scale urban agriculture, women can perform the gender roles for which they are primarily responsible, namely provision of food, general household well-being and child-care duties. On a larger urban agricultural scale, the men take over food production and management of the plots. Furthermore, since women are still disadvantaged in the formal sector of urban economy, they get involved in small-scale production (Mougeot, L.J.A., 1999).

Diversity of urban farmers

Urban farmers can be classified in various categories depending on the region of the world, city zone, site location, tenure modality, time allocation, producer's socio-economic status, production system and scale, and product destination (Mougeot, L.J.A., 1999). Diversity is the one characteristic urban farmers have in common.

2.3.2 Consumer

The consumer is both the subsistence farmer consuming his own food, as well as the customer on local markets and consumer of food purchased from street-vendors. Consumers are rarely mentioned in publications on urban agriculture. They are mentioned mainly in articles focusing on health risks emerging from urban inadequate agricultural activities.

2.3.3 Supplier

People providing inputs and services

This group of stakeholders includes all those who provide inputs and services required by the process of production in urban agriculture. Producers of agribusiness inputs (such as seeds, feeds, fertilisers, herbicides, pesticides, and tools) belong to a well-organised economic sector, in contrast to the relatively unorganised, disparate and small-scale producers. A further characteristic of the agribusiness sector is that it manufactures for the rural market. The entire logistics, including its trade channels, are designed for the rural area and are not adapted to the needs and opportunities of the small and scattered group of urban producer. Additionally, credit providers, including banks, credit unions and farmer associations are essential because farmers are forced to invest always before the harvest.

2.3.4 Processor, Vendor

Processors and vendors are very heterogeneous

The group of processors and vendors is very heterogeneous. Poor women selling a small amount of cooked food on the street are one extreme. Companies processing, distributing and selling large quantities of processed and unprocessed products are the other extreme.

In contrast to large-scale farmers in rural areas with direct contacts to supermarkets or restaurants, small-scale farmers in urban and peri-urban areas cannot easily find a market for their products which they sell on small local markets. Furthermore, small-scale farmers carry out their own cleaning, processing and possibly packaging activities, whereas large-scale farmers leave this work to food processing facilities. Some products require special processing, such as for example slaughtering should be conducted in professional facilities for reasons of hygiene and associated risks (Smit, 1996).

2.3.5 Public Sector

Government organisations, institutions

The public sector has a strong influence on urban agriculture. In cities where urban agriculture is illegal or neglected by governments, performance of urban agriculture is low. There is little government support and training for the urban farmers. In the event of a prohibitive legislation on urban agriculture, only few organisations and institutions plan activities in this field.

2.4 Motivation (Why)

Main motivation is food security and income generation

Urban agriculture is very often believed to be a response to urban crises, a survival strategy of the migrants who come from the rural part of the country, and after being disappointed at not finding work in the city they become part of the growing population of the urban poor. Streiffeler claims that it is not true that the migrants from the village to the city are “attracted by the lights of the town”. In fact the migrants hope that by coming to the towns they can increase the number of different activities which, in various combinations, can guarantee their survival (Streiffeler, 2000). Swindell also emphasises the diversification possibility of maximising the advantages of combining farming and non-farming work (Swindell, cited from Binns, et al., 1998). It must be emphasised that, in most cases, decision to migrate to the city is not taken by the individual alone, but rather on a family or household level to spread the risk over different regions, activities and persons (Tacoli, 1998).

3. Main Objectives

3.1 Food Security

<i>Definition of food security</i>	<p>The most influential and widely accepted definition of food security is the one of the Food and Agriculture Organisation of the United Nations: "access by all people at all times to enough food for an active and healthy life" (FAO, 1999a). This definition encompasses many issues, but above all the following key components.</p> <ul style="list-style-type: none"> • Availability is achieved when both safe and nutritious as well as sufficient quantities of food are consistently available to all individuals within a country. • Access is ensured when all persons within a household have adequate resources to obtain appropriate foods for a nutritious diet. • Adequacy in terms of quality, quantity, safety, cultural acceptability, and food preferences.
<i>Food security in the urban context</i>	<p>Specific aspects of food security in the urban context are, on the one hand, the necessity to purchase most of the food required by the household and, on the other, a greater dependence on the market system and on commercially processed food. Employment and income are, therefore, the main prerequisites for attaining food security.</p>
<i>Malnutrition results from poverty</i>	<p>Pronounced food insecurity arising from poverty results in malnutrition. Owing to the massive urbanisation process currently prevailing in the developing world, food insecurity and malnutrition have become urban as well as rural problems.</p>
<i>Food quantity</i>	<p>In the literature on urban agriculture, much attention is given to the extent urban agricultural practices can contribute to increasing food security. An especially important aspect is the issue of food quantity for the urban low-income residents. Surveys have shown that urban farming provides for 30% of vegetable consumption in Kathmandu (Wade, 1987), 45% in Hong Kong (Wade, 1982), 50% in Karachi (Yeung, 1988), 60-85% in Shanghai (Skinner, 1981), 70% in Dakar, 90% in Dar es Salaam, 10% in Jakarta, and 30% in La Paz (cited from Nugent, R.A., 1997 and Nugent, R., 2000). Case studies generally support the hypothesis that urban agriculture does improve the food security of vulnerable groups (Armar-Klimesu, 2000).</p>
<i>Food quality</i>	<p>Mwangi compares farming and non-farming households in low-income neighbourhoods in Nairobi (Mwangi (1995) cited from Armar-Klimesu, 2000). He notes that, while mean consumption is well below estimated requirements in all cases, farming households are better off in terms of both energy and protein consumption. Furthermore, farmers participating in an organised urban agricultural support programme are significantly better off in both categories. The Cagayan de Oro study shows that people in farming households generally eat more vegetables than those in non-farming households of the same wealth class, and also more than consumers from a higher wealth-class who consume more meat (Armar-Klimesu, 2000). However, these figures have to be interpreted with caution. Since the studies do not work with identical terms and definitions, it is very difficult to undertake studies on the nutritional status of persons.</p>

3.2 Poverty Alleviation

Real and fungible income

By growing their own food, people produce food for personal consumption or for sale. Consequently, “real” and “fungible” income is generated. Fungible income is defined as the substitution of goods or labour for money that would have had to be earned to acquire these or equivalent goods. In any case, they save money they would otherwise have spent to buy food. Studies show that savings from home consumption and income from sales are spent on other basic needs or invested in other businesses (Swindell, cited from Binns, et al., 1998; Nugent, R.A., 1997; Streiffeler, 2000). This is significant for poor women who must often juggle meagre household finances and face budgetary constraints which prompt them to increase their income-generating activities in addition to existing productive and reproductive tasks. Thus, urban agriculture can contribute significantly to municipal, regional and national efforts to deal with poverty.

Urban poverty

Structural unemployment, currency devaluation, inflation and elimination of subsidies for basic needs have all reduced the opportunity of the urban poor and middle-class to acquire healthy food. Food and fuel absorb already a large part of the poor household's income, and food insecurity is increasing. In 1990, households in nearly half of the largest urban areas in developing countries were spending 50-80% of their income on food. These percentages, which are higher for low-income households, are increasing (Nugent, R., 2000; Mougeot, L., et al., 1998).

Contribution of urban agriculture to overcome poverty

According to official data, urban agriculture does not make a substantial contribution towards urban employment or to the gross domestic product (Nugent, R., 2000). Urban agricultural activities generally form part of the informal economy and are usually not included in official statistics. Furthermore, it is very difficult to determine the urban agricultural contribution towards a city's overall economy as it is determined by the quantity and market value or price of the goods created by this subsector. However, prices cannot be easily determined, because much of the output from urban farming is not sold on markets. According to Maxwell, women in Kampala may not even let their husbands know the extent to which their gardening is relied upon in the household budget (Maxwell (1995) cited from Nugent, R.A., 1997).

3.3 Public Health

Aim

The aim of public health is to promote the well-being, prevent diseases and disabilities, and enhance the quality of life. These are the physical, mental and environmental health concerns of communities and populations.

Traditional and modern health hazards

The traditional health hazards are mainly associated with undernourishment. The people most vulnerable to these hazards are those who are least able to avoid them (Birley, M., et al., 1999, Dittrich, et al., 2000). Modern urban health hazards are typically diseases associated with pollution, stress and overnourishment, including injury and violence. On account of the rapidly changing conditions in urban areas, especially in the peri-urban zone of transition, diseases associated with the traditional as well as modern health hazards occur at the same time (Birley, M.H., et al., 1998; Birley, M., et al., 1999).

<i>Potentially positive impacts of urban agriculture on public health</i>	Urban agriculture has positive impacts on public health, mainly through increased food security and, consequently, improved health conditions of the individuals. Appropriate waste management leads also to a decrease in health risks. Furthermore, working in the home gardens may have a recreational value and improve the physical and mental health of the individuals (well-being). Due to improved air quality by increased greening of the cities, it also contributes to decreasing respiratory diseases.
<i>Negative impacts</i>	However, it is very important to bear in mind that urban agricultural activities may have both, positive and negative impacts on public health. The negative aspects will be elucidated in Chpt. 4.5.

3.4 Sustainable Resource Management

<i>Solid and liquid waste</i>	The urban environmental condition is deplorable in many cities of the developing world. The problems associated with providing environmental sanitation services are central to the urbanisation phenomena. Urban waste is considered one of the most serious and pressing urban environmental problems. Most cities focus on simply getting rid of their waste and fail to recognise its economic asset. A considerable potential of urban agriculture could consist in reusing urban solid and liquid waste and, thereby, helping to overcome the waste problem and saving resources.
<i>Water</i>	Growing food in cities requires additional water and could exacerbate already prevailing problems of adequate water supply for household and industrial use. Urban agricultural activities can improve water management for sustainable agricultural production, for example through wastewater reuse.
<i>Soil</i>	Impoverished urban soils is as much of concern as water scarcity and pollution. Soil quality, including fertility of most urban soils is bad. The soils can be overbuilt, poisoned by hazardous industrial chemical waste and illegal dumping of for example lead-contaminated waste from traffic or other heavy metals. One of the aims of urban agriculture is to close the nutrient loop through reuse of organic waste accumulating from urban activities. Waste reuse can prevent loss of soil nutrients and reduce fertiliser costs.
<i>Transport, fossil fuels</i>	Urban agriculture can decrease the daily flow of food into the cities, reduce traffic injuries and negative impacts on air quality, and save fossil fuel resources (Nelson, 1996.).

4. Processes and Gaps in Knowledge

4.1 Agricultural Practices

4.1.1 Basics

Several agricultural practices are known.

a) Horticulture

Criteria for crop types

Crops grown by the poor in cities must meet several criteria, such as:

- rotate rapidly due to land uncertainty and
- adapt to relatively uncontrolled conditions for lack of proper tools (Nugent, R.A., 1997).

Urban agriculture for spreading the risks

It is also very important to spread the risks. Streiffeler notes that mixed cropping spreads the risks of adverse climatic conditions and attacks by insects, fungi, etc. Furthermore, it can make effective use of limited space, especially if the plants have different nutrient requirements (Streiffeler, 1993, cited from Smit, 1996). A case study in Zambia revealed that diversity, determined by the factors related to species richness and evenness, decreased with increasing garden size of up to 600 m². The smallest gardens are located in the urban areas and show the highest diversity in crop species (Drescher, 1997a). Additionally, a study in Java revealed that intense multi-crop household gardens produce three times the monetary value per unit of land as three-crop rice farming (FAO, 1990, cited from Smit, 1996).

Production factors

The horticultural practices differ in accordance with the production factors available. The most important factors for production are: (1) land, (2) water for irrigation, (3) labour, (4) capital, (5) material, (6) seeds, (7) pesticides and herbicides, and (8) fertiliser. The crucial elements for low-income city dwellers to become involved in urban agriculture are access to land followed by the availability of irrigation water.

Small-scale crop cultivation is the most popular practice

Household gardening is the most common form of urban horticulture. The most important crops of urban farmers are perishable fruits and vegetables grown in or near the city by small or large farmers for home consumption or sale on the urban market (Nugent, R.A., 1997, Smit, 1996). In Nairobi, Kenya, for example, roughly four types of agricultural practices can be distinguished, however, small-scale subsistence crop cultivation is by far the most widespread form of cultivation (Foeken, et al., 2000).

Use of chemicals

Abuse of pesticides and, consequently, the risk of health hazards for the consumer seems to be one of the major constraints of home gardening (Gura, 1995 and Smit, 1995, cited from Drescher, 1997a). The often inappropriate use of chemical products and their application methods cause health risks to both farmers and consumers and are responsible for environmental contamination (Birley, M., et al., 1999, Drescher, 1996, cited from Drescher, 1997a). According to Drescher, 60% of all surveyed households in Zambia use chemical products for plant protection: about 61% in urban and about 78% in peri-urban areas (Drescher, 1997a). Other authors claim that pesticides and chemical fertilisers pose insignificant risks as they are too expensive for the poor farmers.

Location of agricultural practices Families without an own garden can perhaps gain access to public or abandoned land. Alternatively, they can start horticulture in a variety of containers, like boxes, rain gutters, used tires, even plastic bags, which can be placed in different locations, including patios, balconies and flat roofs (Smit, 1996, Medellín Erdmann, 1995, Hart, et al., 1996).

Soilless horticulture Soilless horticulture is another practice, and hydroponics the most important form (Smit, 1996). The simplest form is crops grown directly on solid waste or compost without soil. The challenge of this system is to maintain the nutrients required for plant growth. However, the system is very resource efficient, requiring less water than field crops. Its limited water use makes this technology especially suitable for areas with water shortages (Smit, 1996). A successful hydroponics project was, for example, implemented in Jerusalem, Bogota, Colombia in 1985. Another project started in La Molina, Lima, Peru (Bradley, 1999). Both these projects reveal that residents can build and run hydroponics. However, hydroponics production is rather more complex than conventional vegetable growing. For the urban poor with limited skills, it is difficult to apply this production technique (Dasso, et al., 2000). There is disagreement on whether soilless horticulture is capital-intensive or not. Contrary to the general opinion which regards hydroponics as a costly technique, Bohrt claims that popular hydroponics can be a low investment economic activity with low input costs that does not require large spaces, heavy nutrients or concentrated inputs. However, it requires continuous technical support (Bohrt, 1993).

b) Aquaculture

Tradition of aquaculture Production of fish and, to some extent, water vegetables (macrophytes) in ponds fertilised by human excreta or wastewater has long been and continues to be practised in many countries in South and South-East Asia (e.g. India, Thailand, Indonesia, Vietnam, Taiwan, China), in Western Asia (Israel), and Africa (Edwards, 1992, cited from Strauss, 2000).

Aquaculture is a simple and inexpensive technology Most importantly for the Third World is the fact that this relatively simple technology is inexpensive to construct and maintain. Fish production rates of 1-6 tons/ha-year are achieved, depending on the type of fish raised, pond operations and temperature. The Calcutta Wetlands, consisting of some 30 km² of fish ponds, is the world's largest sewage-fed fish production site. In the Wetlands of East Calcutta, Tilapia and carp are the two main types of fish raised. The Wetlands reportedly produce 22 tons of fish per day, treat 150 million gallons of Calcutta's wastewater and cover some 10-15% of the fish consumption in Calcutta (Strauss, 2000, Nelson, 1996). It is obvious that aquaculture mainly constitutes a cost effective way to treat waste and also provides food for the city.

Duckweed ponds An important form of aquaculture are duckweed ponds (Edwards, et al., 1990, Edwards, 1990). In the cities of Tainan and Chiai in Taiwan, wastewater-fed production of duckweed for use as fish and duck feed was practised on a large scale for 30-40 years until the late 1990s, when the duckweed ponds had to give way, partly at least, to the growing urbanisation (Iqbal, 1999). The economic viability of such systems is uncertain so far. The fairly labour-intensive and skill-requiring operations of duckweed ponds appear to be a major cost factor. Institutional settings, entrepreneurial organisation and operating costs could be the major factors which may have prevented larger-scale spreading of excreta/wastewater-based duckweed systems to date (Strauss, 2000).

c) Livestock Raising

Livestock production For traditional and economic reasons, livestock production is important in many cities (Allison, et al., 1998). The livestock raised in cities is typically poultry, birds, and smaller animals which are raised by the less affluent in the dense city cores. For example, pigs and poultry are very common in and around major Asian cities. Singapore is reported to be 100% self-sufficient in pork and poultry meat, and Hong Kong produces most of its poultry needs within the city (Nugent, R.A., 1997).

Small livestock Small livestock is important in sustainable development, since its meat to feed ratio is higher than that of large animals. Small livestock can be produced cheaply in small spaces, while all forms of livestock are becoming increasingly important sources of protein as rising incomes lead to changing diets.

Small livestock: poultry Urban poultry production plays a key role in the future food supply of the world's cities (Schippers and Lewcock, 1994, cited from Nugent, R.A., 1997; Dasso, et al., 2000; Nugent, R.A., 1997; Smit, 1996). In Dakar, Senegal, for example, poultry is the most important urban livestock activity, involving some 70,000 entrepreneurs (Touré Fall, et al., 2000). It is claimed that in Asia poultry production is shifting to large-scale factory systems, whereas in Africa it is becoming a middle-income farming system (Smit, 1996). In Lima, Peru, a number of small firms have recently engaged in raising quail. There is a market for quail eggs, mainly in the popular Chinese dishes (Dasso, et al., 2000).

Small livestock: rabbits and guinea-pigs Rabbits and guinea-pigs are a common form of urban agriculture in many Latin American cities. Rabbits and guinea-pigs are ideal animals to raise in the city because they do not take up much space and can be fed grass, leaves, greens discarded by stores, food scraps from the kitchen, or alfalfa. For many low-income farmers they are their only source of meat (Smit, 1996). In Lima for example, raising and consuming guinea-pigs is an ancient tradition, especially in the Andean Highlands. Roughly three production systems have been determined: household producers (one family produces on average 10-30 guinea-pigs), commercial family system (30-50 animals) and commercial enterprises (sophisticated techniques). The main producers in the first two groups are women (Dasso, et al., 2000).

*Large
livestock*

Significance and form of large livestock raising in urban areas vary from country to country (Foeken, et al., 2000; Lee-Smith and Memon, 1994, cited from Foeken, et al., 2000). In Africa, where cities show a multi-centred, “pluralistic” structure with a scattered distribution pattern, the practice of raising livestock for milk and meat is widespread (Streffeler, 1998, Smit, 1996, RUAF, 2000). For example, Maseru's (Lesotho) dairy plant in the mid-1980s processed 3,000 litres of milk per day from 94 urban producers, contributing to about 40% of the town's overall milk production (Greenhow, 1994, cited from Mougeot, L.J.A., 1994).

d) Urban Forestry

Importance of urban forestry

Urban forests act as natural filters and are central in combating urban air pollution, especially carbon dioxide and particulate matter (Smit, 1996). They cause considerable modifications to the microclimate. Furthermore, forests are important for the local water household, to ensure a clean water supply, prevent erosion, provide a habitat for urban wildlife and even disposal sites for liquid or solid waste. Therefore, forestry projects are projects of public interest. Furthermore, in much of the developing world, wood is the primary fuel for cooking and heating, and a low-cost construction material. In Lae, Papua New Guinea, a programme with different zones was created for ecological rehabilitation and conservation (erosion control), fuel wood cropping and agroforestry (Smit, 1996). However, there is immense pressure on urban space resources. In Mexico City for example, the urban green areas are decreasing annually by about 3.7% (Chacalo, 1996, cited from Nilsson, et al., 1997).

Street trees and urban community forestry project

Street trees serve primarily aesthetic and climatic purposes. The amenity and recreational value of forests, trees and green spaces is widely recognised (FAO). Additionally, street trees are used for fruit production in many countries (Smit, 1996). Urban agroforestry involves more than just street trees. In Panama, agricultural shantytowns produce forest and vegetable crops just across the Panama Canal from downtown Panama city. In peri-urban Nairobi, urban agroforestry produces coffee, vegetables and fruits (Smit, 1996). In Ahmedabad, India, an urban community forestry project was conducted in response to the findings of an environmental risk assessment. According to this study, the air quality was a major health risk to its residents (Marulanda, 2000).

e) Other Urban Farming Activities

Production of honey, mushrooms, beverage crops, medicinal herbs, and ornamental plants

Urban agriculture appears in many forms other than the aforementioned, such as for example apiculture, a labour-intensive activity which produces honey. Wax is also produced as by-product and used particularly as lightening material. As aforementioned, due to the great diversity of plant species in urban areas, production of honey is high. Furthermore, mushrooms form part of the diet of many cultures. They can be grown in cellars and sheds, thereby, making mycoculture an urban form of production. Beverage crops play also a significant role. A study in Tanzania revealed that two out of five farmers in the small town of Biharamulo added alcoholic beverage crops to their product mix. The use of medicinal herbs by urban residents remains widespread. Finally, a lucrative form of urban agriculture is the production of ornamental plants, such as flowers (Smit, 1996).

4.1.2 Gaps in Knowledge

The main gaps in this area are the following:

1. Contribution of urban agriculture to food security and poverty alleviation

The current and potential contribution of urban agriculture to food security and poverty alleviation has to be quantified. The information gained through research

activities should primarily raise the awareness of all stakeholders to the realistic potential of urban agriculture in contributing to food security (Jacobi, et al., 2000). This gap in knowledge implies two important aspects:

- Food quantity and economic value
- Nutritional value

Since very few studies have quantified the benefits and risks of urban agriculture, its nutritional value remains unknown (IBSRAM, 1999; Egziabher, et al., 1994). The literature is very scarce, especially concerning the impact of urban agriculture on the nutritional status of children (Armar-Klemesu, 2000). Furthermore, the contribution of urban agriculture towards increasing food quantities and its economic value remains to be investigated (Nugent, R.A., 1997).

2. Quantification of nutrient flows in existing urban farming systems

First, a typology of farming systems and mapping of nutrient flows in the different farming systems are necessary. The nutrient gap can then be quantified and the demand for fertilisers and waste stream products to improve soil fertility within these different farming systems identified. Specific crops and different geographic conditions have to be taken into consideration (IBSRAM, 1999).

3. Investigation of different opportunities for poor urban dwellers to gain access to credits

Microfinancing programmes have become an increasingly important component of strategies to reduce poverty or to promote the development of micro and small enterprises (Remenyi, 2000). Identification of the beneficial impacts of microfinancing programmes is claimed to be indispensable, however, it should be noted that microfinancing does not assist the poorest, as so often claimed (Hulme, 1999).

4.2 Soil Quality Management

4.2.1 Basics

Definition of soil quality

The term "soil quality" attempts to consider the complexity of soil by including its vital functions within the ecosystem. These are:

- biological activity, diversity and productivity (commonly understood as "soil fertility"),
- regulating and partitioning water and solute flow,
- filtering, buffering, degrading, immobilising, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric depositions,
- storing and cycling nutrients and other elements within the earth's biosphere,
- providing support for socio-economic structures.

Inorganic and organic fertilisers

To increase or maintain soil quality, conditioners have to be applied to the soil in different manners and forms. However, the following facts have to be taken into consideration: the inorganic NPK fertilisers have a rapid effect, as the nutrients provided can be taken up by plants and microorganisms without further transformation processes. Organic fertilisers have a long-term behaviour and decomposition rate and their impact varies in accordance with their C/N-ratio, content of dry matter and nutrient value. A high C/N-ratio can lead to a temporary nitrogen-barrier, as the nitrogen is taken up by microorganisms and released to the plant roots after the death of the microorganisms. (Parr & Papendick, 1982; cited from Rodrigues, et al., 1998).

What kind of waste is available for urban agriculture?

In developing countries, where cities have expanded rapidly and there is a lack of financial resources for environmentally sound waste disposal systems, a large share of the collected waste is dumped on unused land, such as abandoned quarries or wetlands on the outskirts of the cities. However, estimates on urban waste generation vary, particularly in cities of developing countries where much of the waste is not collected.

Organic waste constitutes the bulk of municipal solid waste

Municipal solid waste includes domestic, commercial and industrial waste. Salvaging and recycling of metals and other materials of value are common in many developing countries and partly account for the high organic content of waste. Therefore, organic waste generally constitutes the bulk of urban waste, with usually 60-80% by weight (Harris, et al., 1999; Wells, 1995, cited from Birley, M., et al., 1999; Deelstra, 1986, cited from Allison, et al., 1998). In urban areas of developing countries, significant quantities of organic waste are generated by food processing enterprises (Harris, et al., 1999). The nutrients contained in organic waste will gradually be mineralised and become available to plants. The nutrient content of municipal waste varies considerably (Table 1).

Potential soil fertility value of organic waste

Table 1. Nutrient content of municipal solid waste (Harris, et al., 1999)

	Nitrogen	Phosphorous	Potassium	Carbon
Municipal solid waste	0.4-3.6%	0.3-3.5%	0.3-1.8%	30-45%

Potential soil improvement value of organic matter

Organic matter should not only be regarded as fertiliser adding nutrients to the soil. It maintains and builds up the soil structure and provides an aerated moisture-retentive environment. Thus, the benefits of using organic materials for soil improvement contribute to increasing water infiltration in the soil and its water holding capacity, to improving aeration and permeability, soil aggregation and decreasing soil crusting. Furthermore, it has an inhibitory effect on soil born pathogens, probably by allowing increased microbial activity to take place in the rhizosphere, thereby, encouraging microbial antagonism to the growth of pathogens (Hoitink, 1997, cited from Harris, et al., 1999).

Fertilising potential of excreta and wastewater

The resource potential of excreta and wastewater has been widely investigated. Excreta is a rich source of inorganic plant nutrients, such as nitrogen, phosphorus and potassium, as well as organic matter (Table 2).

Table 2. Nutrient amounts excreted by humans per capita per day (Strauss, 2000)

	Nitrogen	Phosphorous	Potassium	Carbon
Urine	8-9 g	1 g	1.9 g	8 g
Faeces	2-3 g	0.8 g	0.6 g	24 g
Total human excreta	10-12 g	1.8 g	2.5 g	32 g

The fertilising equivalent of excreta (nitrogen, phosphorous and potassium) is nearly sufficient for a person to grow its own food (Drangert, 1998; cited from Strauss, 2000). Part of this potential is actually lost during storage and treatment (e.g. nitrogen loss through ammonia volatilisation).

Sanitation systems should be designed to maximise human excreta recycling

The majority of urban dwellers in Africa and Asia and a smaller fraction in Latin America are served by on-site sanitation systems. A change in the sanitation management paradigm from flush-and-discharge to recycling of urine and faeces (drop-and-store) is gaining ground in Europe (Larsen and Guyer; Otterpohl and Bark, 1999; Otterpohl, 2000; cited from Strauss, 2000). As a consequence, treatment strategies and technological options for faecal sludge and wastewater will have to be developed to allow optimum recycling of nutrients and organic matter to urban agriculture in accordance with the local situation and needs (Winblad, 1997; Esrey et al., 1998; cited from Strauss, 2000).

Composting

Organic waste should be composted prior to recycling. In the composting process, microorganisms break down organic matter. These are indigenous to such materials as soil, dust, vegetable matter, and waste of all sorts. Special organisms are not required. In composting, heat is generated with pile temperatures often reaching 70 °C. The material is biologically oxidised to carbon dioxide and to a stabilised organic residue. Owing to the time/temperature profile of the process, the compost will be sanitised. Levels of human, animal and plant pathogens are reduced, including highly resistant helminth eggs. Some hazardous and toxic waste contained in the organic waste is resistant to the process of composting and can impair the compost quality (Cointreau, 1982; Woolveridge, 1994; Lardinos and Klundert, 1994; Asomani-Boateng et al., 1996; cited from Asomani-Boateng, et al., 1999). A brief overview of composting technologies, composting mechanics and a comparison of composting processes are given by various authors (Hoornweg, et al., 1999; Rudat, et al., 1999).

Co-composting

Co-composting is a form of composting different types of organic waste suitable for composting. The compost produced from human waste (excreta), organic market waste and waste from industries, such as breweries, timber factories and chicken farms could, if used in a consequent manner and upon treatment by co-composting, replenish the soils of numerous urban farms (Leitzinger, 2000; Belevi, et al., 2000). Urban farmers will profit from an improved productivity of their land by using high quality compost (Peters, 1998).

<i>Economy of composting</i>	Production costs and the market for compost (compared to the price of artificial fertilisers) determine the long-term sustainability of waste reuse in urban farming. Production costs are affected by the technique of compost production (mechanised or labour intensive), labour costs and the generation of waste in sufficient quantities (Asomani-Boateng, et al., 1999, Sanio, et al., 1998). The quality of compost, transport and labour costs for its distribution from the production site to the place of use and the price of substitutes, are factors which determine the market for compost.
<i>Anaerobic digestion: biogas production</i>	In addition to aerobic composting, anaerobic digestion of biomass residues, waste and dung have gained increased interest (An, et al., 1997; Karekezi, 1994; United-Nations, 1996; Rutamu, 1999). Anaerobic digestion was introduced into developing countries as a low-cost alternative source of energy to partially alleviate the problem of acute energy shortage of households. In practice, however, few farmers have used biogas. The technical viability of biogas technology has been repeatedly proven in many field tests and pilot projects, however, numerous problems arose as soon as mass dissemination was attempted. The poor acceptability of the digestors is believed to be due mainly to the high costs of the digestors, difficulty in installing them and in finding spare parts (Karekezi, 1994). Various problems are known, such as for example the inability of small-scale farmers to obtain sufficient feedstock to feed the bio-digester unit and ensure a steady generation of biogas for lighting and cooking.
<i>Constraints</i>	Converging interests prevail between urban agriculture and waste reuse through composting to produce agricultural fertilisers or soil conditioners, and the feeding of food waste to livestock (Furedy unpubl., cited from Birley, M., et al., 1999). Tensions occur also between public health and urban agriculture specialists due to concerns about communicable diseases, zoonoses and injuries on the one hand, and increased food production and job creation on the other. Furedy claims that in contrast to hazards associated with excreta and wastewater, hazards associated with solid waste have not been well researched (Birley, M., et al., 1999).
<i>Source book</i>	A very comprehensive source book on organic waste use in peri-urban areas was published recently by gtz (Rudat, et al., 1999). The source book addresses questions like avoidance of organic waste, collection of waste, processing of organic waste for compost, marketing and sales promotion of compost, application, as well as economic and legal aspects. "Wasted Agriculture" is another report on a much more general level (Hart, et al., 1996).

4.2.2 Gaps in Knowledge

The following main gaps in knowledge were identified:

1. Quantification of the reuse potential of organic waste in urban agriculture

Few data are available on the quantity, quality, and availability of the different organic waste. The organic material fluxes, including production, consumption, disposal and reuse possibilities in different regions have to be investigated (Belevi, et al., 2000). It is important to create a database on (i) rural-urban biomass (food)

and nutrient flows and (ii) on the quantity, quality, and availability of organic waste produced. Furthermore, the information on material flows has to be combined with geographical and sociological information (ethnic, religion, customs, etc.). Research should broaden the prevailing knowledge and provide increased decision support to municipal authorities on waste recycling and treatment options.

In this context, it is very important to view reuse options at different levels. According to the household centred approach (HCA), selection of reuse options should start at the household level. The problems should be solved where they are created. However, it is also possible that a reuse option at another level, such as neighbourhood, town, district, city, province, nation, is more appropriate than a reuse option at household level (Schertenleib, 2000).

2. Waste recycling and treatment technologies

Investigations on organic waste treatment and reuse technologies are necessary. Feasible, appropriate and effective technologies and equipment, easily maintained and transferred to local conditions, have to be identified (IBSRAM, 1999 de Vries, et al., 2000).

3. Different storage options, application rates and mixtures of treated material

Information on storage, mixtures, application rates, and handling precautions of organic and inorganic soil quality improving materials has to be gained to allow clear advisory messages (IBSRAM, 1999).

4. Effects of different nutrient sources on short and long-term soil quality

Long-term studies have to be conducted to identify the effects of different nutrient sources (compost, fertiliser, etc.) and their use on the short and long-term soil quality, especially on soil fertility. Therefore, physical, chemical, biological, and structural responses of the soil to different nutrient sources, and crop production have to be investigated (IBSRAM, 1999).

4.2.3 Gaps in Dissemination of Knowledge

Gaps in dissemination of knowledge also exist among planners, authorities and urban farmers (Peters, 1998, IBSRAM, 1999, Grennhow, 1994).

The dissemination of knowledge should aim at increasing:

- awareness of waste reduction, recycling and reuse,
- basic (community) knowledge of soil fertility decline and soil contamination in peri-urban farming systems,
- basic knowledge of the safe use of compost and adequate application methods, including monitoring of pathogenic contamination from use of not completely matured compost,
- basic knowledge of environmentally safe, socially/legal acceptable and viable options of nutrient recycling from waste stream products,
- capacities of local universities in analysing and understanding the rural-urban nutrient flows,

- the positive attitude towards the demand for waste stream products within different farming systems,
- business and marketing skills of people operating waste recycling plants,
- community support and involvement in composting projects.

4.3 Irrigation

4.3.1 Basics

Water requirements of urban agriculture

Irrigation requirements make up an important part of the urban water supply demand. In arid and semi-arid areas or in seasonally dry zones, for example, irrigation requirements make up 80-90% of the entire demand for the natural water resources. Therefore, it is very important to select the most appropriate irrigation system. Development of a reliable low-cost drip system which meets the needs of small farmers in developing countries has long been recognised to be of key importance (Pescod, 1992; IDE, 1998).

Wastewater use for irrigation

Where water-borne excreta disposal was put in place, use of wastewater in agriculture became rapidly established, particularly so in urban and peri-urban areas of arid and seasonally arid zones. Wastewater is used both as a source of irrigation water and plant nutrient, allowing farmers to reduce or even eliminate the purchase of chemical fertilisers (Niang, 1999, Strauss, et al., 1990; Shuval et al., 1986; Asano et al. (eds.), 1998; Khouri et al., 1994; all cited from Strauss, 2000). It has been estimated that about 10% of the world's wastewater is currently used for irrigation. 100% of the wastewater from the cities of Santiago (Chile) and Mexico City are used for irrigation, amounting to some 70% and 80%, respectively, of the irrigation waters used in the surrounding agricultural areas during the dry season. In South Africa, about 15-20% of the wastewater is reused in agriculture (Khouri et al., 1994). Morocco was using about 16% of its wastewater in 1990, amounting to some 0.5% of the entire irrigation waters used (Benckroun, 1991. Strauss, 2000). An important advantage of reusing urban wastewater is its availability even during periods of drought, allowing urban food production to continue and, thereby, increasing urban food security (Bruins, 1997).

Wastewater quality

Wastewater quality for irrigation purposes is very important (Niang, 1999). For example, water quality monitoring in the river system draining Kumasi and supplying many irrigators showed that levels of faecal coliform 32 km downstream of the city centre could be up to five times higher than the FAO guideline for irrigation (5500 FC 100 ml) (Wallingford, 2000).

Wastewater treatment

A review of mostly low-cost options to treat wastewater and faecal sludge has been conducted by Rose (Rose, 1999). Von Sperling published a compilation of wastewater treatments systems frequently used in developing countries (Von Sperling (1996) cited from Strauss, 2000). Faecal sludge treatment options have been discussed and presented (Strauss, et al., 1997, Montangero, et al., 2000). A report addressing questions of wastewater treatment and use in

agriculture (irrigation, use of sewage sludge, aquaculture) was published by FAO in 1992 (Pescod, 1992). After presenting an overview of wastewater characteristics, effluent quality parameters and wastewater treatment options, Pescod focuses on agricultural issues, such as irrigation with wastewater, use of sewage sludge and wastewater use in aquaculture.

4.3.2 Gaps in Knowledge

The following gaps in knowledge were identified:

1. Quantification of regional water requirements, water availability and water quality

Local variations in water quality (vis-à-vis local health and local production) have to be researched to assess the agricultural potential of (waste) water (re-)use in urban agriculture. Aside from various bacteria, protozoan parasites, viruses, and helminths, wastewater also contains anthropogenic substances (e.g. endocrine disrupting chemicals, toxic chemicals).

2. Quantification of the impact of urban agriculture on surface and groundwater

The impact of urban agriculture on surface and groundwater has to be quantified (pollution through agrochemicals or from the extraction of large quantities of groundwater for irrigation which affect the concentration of elements in residual groundwater). Ecotoxicological research on bio-accumulation of heavy metals is necessary (FAO-ETC, 2000).

4.3.3 Gaps in Dissemination of Knowledge

The following gap in dissemination of knowledge was identified:

Support of community-based water management

Dissemination of knowledge aims at supporting communities to improve their water management practices by adopting hygienic, low-cost irrigation methods adapted to their socio-economic conditions (Niang, 1999, IDE, 1998, IBSRAM, 1999).

4.4 Animal Feeding

4.4.1 Basics

Importance of waste as animal feed

Municipal waste is a significant source of food for urban livestock in many countries. In India for example, "khatalas" (feedlots) are an important feature of many Indian cities. They eat a significant amount of urban organic waste and, thereby, produce milk for the urban population (Blore pers. comm., cited from Allison, et al., 1998). In many other places chickens, goats and cattle can be seen rooting through piles of refuse.

Waste material used as animal feed

Some animals, such as ruminants, have very simple feed requirements and can eat materials with a high cellulose content. Others, like pigs, have a simple digestive system that cannot manage straws or low quality fodder, but eat almost any food waste (Schiere, et al., 2000). Therefore, supplements are often needed in addition to the bulk feed. Waste materials commonly used for animal feed are blood meal (dried blood from slaughterhouses), fish soluble (a by-product of the fish meal industry) and brewer's grains (the residue from beer production). However, their quantities vary depending on the season.

Criteria for waste

Waste used as animal feed has to meet a number of criteria and is subjected to various constraints, such as nutritional value, safety and health aspects for the animal. Waste should form part of a balanced diet. However, it may be anti-nutritional, toxic or may pose a risk of diseases which can be introduced into the food chain (Allison, et al., 1998). Furthermore, a major problem with using solid waste as animal feed is the presence of heavy metals, particularly lead (newspapers are a source of lead), mercury and chlorinated hydrocarbons (Silva, 1994).

4.4.2 Gaps in Knowledge

The following gap in knowledge was identified:

Assessment of the nutritional value and concentration of hazardous substances and pathogens in organic waste used as animal feed

4.5 Public Health Management

4.5.1 Basics

Urban agriculture lacking the support of municipal authorities may increase health risks

The aim of public health is to promote physical and mental health and prevent disease, injury and disability. Urban agriculture affects human health in a beneficial way, however, it may also have adverse health impacts. The positive impacts of urban agriculture on public health are described in Chpt. 3.3. Mainly health risks are addressed in the literature dealing with urban agriculture. Prohibiting laws do not seem to hinder people from becoming engaged in urban agriculture. On the contrary, practising urban agriculture with or without limited support and supply can increase the health risks. Therefore, it should be of greatest concern to anyone involved in the field of urban agriculture to propose measures to diminish the risks for urban farmers and their families, consumers and others. It is very important to systematically integrate public health and safety concerns into urban agricultural practices.

<i>Suggestions to manage health risks from urban agriculture are essential</i>	It is essential to address the potential hazards in order to protect producers, their families and consumers from contaminated foods and occupational hazards. However, addressing these potential health hazards will also help to secure the support of municipal authorities and state officials who have remained wary and sometimes even hostile to urban agriculture due to actual and perceived health and environmental risks. They may have heard of other activities and programmes with obvious health benefits, but also of unintentional adverse health impacts. However, it may also simply be an excuse not to introduce urban agriculture in their towns and cities. Therefore, when speaking about possible health risks, it is very important to also make suggestions on how to address these problems. Management practices are necessary to reduce the health risks related to urban agriculture.
<i>Source book</i>	In urban resource management, the work of Birley and Lock on health and natural resource management in peri-urban areas is a comprehensive study with a focus on health (Birley, M. H., et al., 1998; Birley, M., et al., 1999).
<i>Control measures to reduce health risks from wastewater reuse</i>	Technical options for health protection have to be taken into account to prevent health hazards emerging through irrigation with wastewater. Health guidelines have been developed for the safe use of wastewater in agriculture and aquaculture. These can be grouped under four main headings (WHO, 1989; Mara, et al., 1989; Strauss, et al., 1990): <ul style="list-style-type: none"> – treatment of wastewater (Strauss, 2000; Mara, et al., 1989; Rose, 1999) – crop restriction/selection (WHO, 1989; Pescod, 1992) – irrigation methods (Kandiah, 1990, cited from Pescod, 1992) – adoption of appropriate management practices - control of human exposure (WHO, 1989)
<i>Health risks from fish production in wastewater-fed ponds</i>	Extensive field research has also been conducted on microbial contamination of fish grown in wastewater-fed ponds (Buras et al. (1982 and 1987); Edwards et al. (1987) and Edwards (1992), cited from Strauss, 2000). Health risks and protection were major focuses in those activities. A summary was published on the pathogen transmission risks of human waste use in aquaculture (Strauss, et al., 1997).

4.5.2 Gaps in Knowledge

The existing gaps in knowledge in the field of public health management can be grouped into three main categories:

1. Quantification of health benefits related to consumption of food produced in urban agriculture

- The contribution of urban agriculture to improve the health status of urban farmers and their families by consuming healthier food has to be quantified.

2. Development of methods to prevent health risks related to consumption of contaminated food

- Contamination of crops with pathogenic organisms (bacteria, protozoa, viruses) and (agro)chemicals (heavy metals, persistent organics, pharmaceuticals), including identification of polluted streams (de Zeeuw, et al., 2000; Flynn, 1999).

- Contamination of crops by unsanitary post-harvest processing, marketing and preparation of locally produced food.
- Transmission of diseases and hazardous substances from domestic animals to people during meat consumption.

3. Development of methods to prevent health risks from urban agricultural activities in the urban environment

- Occupational health risks for urban farmers and other workers.
Handling of solid waste and wastewater can pose significant health risks to those who have direct contact with it. Non-biodegradable components may cause injuries, skin infections, respiratory problems and other occupational problems to waste pickers, waste selectors and others involved in the reuse of waste (composting process, wastewater) (Birley, M., et al., 1999, Rose, 1999, Allison, et al., 1998).
- Human diseases transferred from disease vectors attracted by agricultural activity.
Inadequately maintained compost heaps may attract rodents (potential reservoirs of diseases) and insects (potential vectors of diseases). Furthermore, the question whether urban agricultural activities provide new breeding sites for mosquitoes transmitting malaria (FAO-ETC, 2000, (Rodier, 1995, cited from Flynn, 1999)) must be investigated.
- Transmission of diseases from domestic animals to people (zoonosis) during animal husbandry and processing of meat.

4.6. Urban Policy and Planning

4.6.1 Basics

*Importance
of urban
planning*

Rapid urbanisation and, in particular, the high population growth and low controlled planning by municipal bodies in urban fringe areas, are a challenge to the urban planning process (Tewari & Muthoo, 1997, cited from Nilsson, et al., 1997). Both the increasing urban poverty and decreasing environmental quality give cause for concern and call for government interactions. Urban agricultural planning is almost non-existent, as it seems to have been neglected or forbidden by governments and researchers (Binns, et al., 1998). Tanzania's National Urban Water Agency for instance expressed strong opposition to urban agricultural use of water supplies. Since an estimated 35% of the fresh drinking water supply was lost through leakage and illegal tapping, a penalty fee was imposed on agricultural uses of water in the city (Schippers and Lewcock, 1994, cited from Nugent, R.A., 1997). Substitutes for such practices are known, however, a mechanism must be found to bring together authorities and urban farmers (Nugent, R.A., 1997).

<i>Stakeholder participation</i>	Stakeholders should be involved in the formulation of urban agricultural policies. These include authorities and government officials from all levels (local, regional and national) and all the involved sectors: city planning and urbanisation, urban environmental management, social development and welfare, as well as urban farmers. Many articles published on this subject make policy support suggestions for urban agriculture to overcome legal and regulatory obstacles.
<i>Recognition of waste reuse in urban agriculture</i>	In Africa for example, solid waste management experts, consultants and researchers are increasingly becoming aware of the great potential of waste reuse in urban farming to reduce the solid waste collection and disposal problems (Chimbowu and Gumbo, 1993; Lee-Smith and Menon, 1994; Abutiati, 1995; cited from Asomani-Boateng, et al., 1999; Egziabher, et al., 1994; Furedy, C., 1994; Furedy, Ch., 1990).
<i>Contribution of urban planners to urban agriculture</i>	Urban planners could identify appropriate areas for farming activities, encourage infrastructural developments required by farmers and implement protective measures to provide land security. Many creative approaches to these measures are available, including land swaps, long-term leasing arrangements and community ownership (Smit, et al., 2000). Greenhow claims that legislation has to be adapted to be more favourable to controlled urban agriculture (Greenhow, 1994). Regarding the access to land, he proposes the following options: zoning and permissible land uses, provision of land for allotments, incorporation of gardening areas close to school and nursery sites, and explicit incorporation of household urban agriculture in green areas and recreation land uses.

4.6.2 Gaps in Knowledge

The prevailing gaps in knowledge are grouped in the following three categories:

1. Legislation and enforcement

The overall aim is to conduct research on creating favourable preconditions for urban agriculture to take place. The two hypotheses underlying this aim are: (1) legality is an important possibility for the creation of favourable preconditions, and (2) urban agricultural activities performed legally are more efficient and secure than if performed illegally.

The important gaps in knowledge to provide a scientific basis for a legal framework are the following:

- Regulating access to land and water (resources).
As aforementioned, access to land and water are crucial factors for urban farmers to become active in urban agriculture. Research is necessary to revise and implement legislation to allow poor urban dwellers to gain access to these important resources (Smit, et al., 2000; Drescher, 1997b; Greenhow, 1994; FAO-ETC, 2000, Quon, 1999, Jacobi, et al., 2000).
- Definition of environmental and health standards.
As agricultural activities take place even under unfavourable conditions with limited resources and lack of support, legality could help to minimise the negative impacts. It is very important to define minimum quality standards for agricultural soils and irrigation water, including health standards tailored to the ultimate consumers (Quon, 1999, Jacobi, et al., 2000, Smit, et al. 2000).

- Establishment of law enforcement.
In addition to a law, procedures for law enforcement, like protective measures and other instruments, must be also established (Jacobi, et al., 2000).

2. Policy formulation and planning

The overall aim is to gain an overview of urban agriculture and its related activities.

The following information has to be gained on the fundamental tools for planning:

- State and role of urban agriculture in the social and economic lives of urban residents.
Investigation on the importance of urban agriculture and its perception by urban residents. This knowledge could be used as a basis for altering negative perceptions (awareness creation) and to understand who benefits mostly from improved urban agriculture ((Mougeot, cited from Egziabher, et al., 1994; Hovorka, 1998; (Quon, 1999, Jacobi, et al., 2000).
- Understanding of the relationship of the different actors involved in urban agriculture.
- Monitoring of positive and negative effects.
Positive and negative effects with regard to social, economic and environmental conditions have to be monitored continuously to improve urban agriculture in the local context and to draw conclusions for policy formulation (Jacobi, et al., 2000).
- Evaluation of community support given to urban agriculture.
Agricultural capacity (skills and knowledge, time availability) of a community to improve the basic conditions of urban farmers (Quon, 1999).
- Evaluation of policy measures.
Know-how and experience in policy measures have to be evaluated and integrated into supportive policy formulation (Quon, 1999).

3. Institutionalisation of administrative procedures

Administrative procedures have to be simple and clear and involve all stakeholders. The following procedures have to be institutionalised:

- Monitoring (Jacobi, et al., 2000; FAO-ETC, 2000)
- Co-ordination of urban agricultural activities (Haughton, 1999; Jacobi, et al., 2000).
- Capacity building of institutions and research (IBSRAM, 1999; Grennhow, 1994; Sawio, et al., 1999).

Before institutionalising these procedures, their applicability by the poor urban farmers has to be determined.

5. Summary and Conclusions

The main motivation of urban farmers to become involved in urban agriculture are food security and income generation. However, urban agricultural activities are also very important from a public point of view. They can highly contribute to enhancing public health by providing more food and more diverse diet. Urban agriculture can also help to improve resource management by reusing wastewater and organic waste.

To reach these goals, activities in the field of agricultural practices, soil quality management, irrigation, animal feed, public health management, urban planning, and policy development have to be pursued. These fields are termed processes in this paper. Although numerous publications on urban agriculture focus on these processes, gaps in knowledge have been identified. Publications on urban agriculture in connection with environmental sanitation in developing countries are generally not based on scientific investigations. Consequently, more scientific research is required on the following issues:

- The actual and potential contribution of urban agriculture to food security and poverty alleviation has to be quantified.
- Nutrient gaps, including the demand for fertilisers and organic waste as a function of different crops and geographic conditions have to be quantified.
- The prevailing and potential organic material fluxes, including production, consumption, disposal, and urban agriculture in different regions have to be investigated to identify the role of urban agriculture as organic waste recipient and food supplier.
- Reuse options have to be elaborated at different levels, starting with the household level.
- Organic waste treatment and reuse techniques which are easily maintained and transferred to local conditions have to be investigated.
- Information has to be acquired on storage, mixtures, application rates, and handling precautions of soil improvers.
- Long-term studies have to be conducted to identify the short and long-term effects of different water sources (wastewater, surface waters, etc.) and different nutrient sources (compost, treated faecal sludge, fertiliser, etc.) on the soil quality. The results should allow the setting of quality requirements for irrigation and reuse as soil conditioner and fertiliser.
- Research on water requirements and water availability in a region has to be conducted to assess the impact of urban agriculture on the water household of the region, and the potential of wastewater reuse in urban agriculture.
- The negative impacts of urban agriculture on surface and groundwater quality have to be quantified.
- Contribution of urban agriculture to improving the health status of the urban farmer and his family has to be quantified.

- Transmission of diseases and hazardous substances from crops and animals to consumers during food consumption has to be identified.
- Transmission of diseases and hazardous substances from wastewater, solid waste and animals to urban farmers during agricultural activities has to be investigated.
- The question whether urban agriculture provides additional breeding sites for disease vectors has to be examined.
- Creation of favourable preconditions for urban agriculture by urban planners has to be investigated.
- The opportunities for the urban farmer to gain access to credits have to be identified.
- Urban agriculture and its related activities as part of urban planning have to be overviewed.
- Integration of urban agriculture in a regional waste management plan has to be examined.
- Institutionalisation of administrative procedures relating to urban agriculture has to be investigated.

6. References

- Adam, M.G. (1999), "Definition and boundaries of the peri-urban interface - patterns in the patchwork", International Workshop on Urban and Peri-Urban Agriculture - Closing the nutrient cycle for urban food security and environmental protection, NOVOTAL, Ghana
- Aldington, T. (1997), "Urban and peri-urban agriculture - Some thoughts on the issue", *Land Reform*, 2, 43-45
- Allison, M., P.J.C. Harris, A. H. Hofny-Collins and W. Stevens (1998), "A Review of the Use of Urban Waste in Peri-Urban Interface Production Systems", The Henry Doubleday Research Association, Coventry, UK
- An, B.X., T.R. Preston and F. Dolberg (1997), "The introduction of low-cost polyethylene tube biodigestors on small scale farms in Vietnam", *Livestock Research for Rural Development*, 9, 2
- Armar-Klimesu, M. (2000), "Urban agriculture and food security, nutrition and health", In: *Growing Cities, Growing Food* (Ed.: N. Bakker, M. Dubbeling, S. Guendel, U. Sabel-Koschella and H. de Zeeuw), DSE, Eurasburg, Germany, 99-118
- Asomani-Boateng, R. and M. Haight (1999), "Reusing organic solid waste in urban farming in African cities: A challenge for urban planners", In: *Agriculture urbaine en Afrique de l'Ouest* (Ed.: O. B. Smith), International Development Research Centre, Ottawa, 138-154
- Bakker, N., M. Dubbeling, S. Guendel, U. Sabel-Koschella and H. de Zeeuw (2000), "Growing Cities, Growing Food - Urban Agriculture on the Policy Agenda", DSE, Eurasburg, Germany
- Belevi, H., C. Leitzinger, C. Binder, A. Montangero, M. Strauss and C. Zurbrügg (2000), "Material flow analysis: a planning tool for organic waste management in Kumasi, Ghana", SANDEC, Duebendorf
- Binns, T. and K. Lynch (1998), "Feeding Africa's Growing Cities into the 21st Century: the Potential of Urban Agriculture", *Journal of International Development*, 10, 777-793
- Birley, M. and K. Lock (1999), "The Health Impacts of Peri-urban Natural Resource Development", Liverpool School of Tropical Medicine, Trowbridge, UK
- Bohrt, J.P. (1993), "Urban Agriculture Research in Latin America: Record, Capacities and Opportunities", CFP Report Series 7, IDRC
- Dasso, A. and T. Pinzas (2000), "NGO experiences in Lima targeting the urban poor through urban agriculture", In: *Growing Cities, Growing Food - Urban Agriculture on the Policy Agenda* (Ed.: N. Bakker, M. Dubbeling, S. Guendel, U. Sabel-Koschella and H. de Zeeuw), DSE, Eurasburg, Germany, 349-362
- de Zeeuw, H. and K. Lock (2000), "Urban and Periurban Agriculture, Health and Environment. Discussion paper", FAO-ETC/RUAF electronic conference "Urban and Periurban Agriculture on the Policy Agenda", <http://www.fao.org/urbanag/>, 8/21-9/30/2000
- Dittrich, C. and F. Krueger (2000), "Urbanization and Polarization in Developing Countries; a theoretical framework", In: *Urbanization, Vulnerability and Resource Management in Developing Countries* (Ed.: A. Drescher, C. Dittrich and F. Krueger), Freiburg, 34-40
- Drechsel, P., C. Quansah and F. Penning De Fries (1999), "Urban and peri-urban agriculture in West Africa - Characteristics, challenges, and need for action", In: *Agriculture urbaine en Afrique de l'Ouest* (Ed.: O. B. Smith), International Development Research Centre, Ottawa, 19-40
- Edwards, P. (1990), "An alternative excreta-reuse strategy for aquaculture: the production of high-protein animal feed", *Wastewater-fed aquaculture - Proc. of Int. Seminar on Wastewater Reclamation and Reuse for Aquaculture*, Calcutta, India
- Edwards, P., C. Pacharaprakiti and M. Yomjinda (1990), "Direct and indirect reuse of septage for culture of Nile Tilapia (*Oreochromis niloticus*)", In: *The Second Asian Fisheries Forum* (Ed.: R. Hirano and I. Hanyu), Asian Fisheries Society, Manila, Philippines, 165-168

- Egziabher, A. G., D. Lee-Smith, D. G. Maxwell, P. A. Memon, L.J.A. Mougeot and C. J. Sawio (1994), "Cities Feeding People - An Examination of Urban Agriculture in East Africa", IDRC International Development Research Centre, Ottawa
- Flynn, K. (1999), "An Overview of Public Health and Urban Agriculture: Water, Soil and Crop Contamination & Emerging Urban Zoonoses", Cities Feeding People Series 30, IDRC, Ottawa
- Foeken, D. and A. Mboganie Mwangi (2000), "Increasing food security through urban farming in Nairobi", In: Growing Cities, Growing Food - Urban Agriculture on the Policy Agenda (Ed.: N. Bakker, M. Dubbeling, S. Guendel, U. Sabel-Koschella and H. de Zeeuw), DSE, Eurasburg, Germany, 303-327
- Furedy, C. (1990), "Social aspects of solid waste recovery in Asian cities", Urban studies working paper 15, York University, North York
- Furedy, C. (1994), "Solid wastes in the waste economy: socio-cultural aspects", VIETPRO - 2020 Vietnam Environmental Training Program. The Urban Waste Economy in Vietnam, Hanoi, August 22-25
- Grennhov, T. (1994), "Urban Agriculture: Can Planners Make a Difference?", CFP Series Report 12, IDRC International Development Research Centre
- Harris, P.J.C., M. Allison, G. Smith, H. Kindness and J. Kelley (1999), "The potential use of waste stream products for soil amelioration in peri-urban interface agricultural production systems", International Workshop on Urban and Peri-Urban Agriculture - Closing the nutrient cycle for urban food security and environmental protection, NOVOTEL, Ghana
- Hart, D. and J. Pluimers (1996), "Wasted Agriculture - The use of compost in urban agriculture", WASTE, Gouda
- Hovorka, A. (1998), "Gender Resources for Urban Agriculture Research: Methodology, Directory and Annotated Bibliography", IDRC, CFP Report Series Report 26, Ottawa, Canada
- IBSRAM (1999), "International Workshop on Urban and Peri-Urban Agriculture - Closing the nutrient cycle for urban food security and environmental protection", International Workshop on Urban and Peri-Urban Agriculture - Closing the nutrient cycle for urban food security and environmental protection, NOVOTEL, Ghana, 2-6 August
- IDE (1998?), "Low cost micro-irrigation", International Development Enterprise, Lakewood, USA
- Karekezi, S. (1994), "Renewable energy technologies as an option for low-carbon energy future for developing countries: case examples from Eastern and Southern Africa", International Conference on National Action to Mitigate Global Climate Change, Copenhagen, 7-9 June
- Leitzinger, C. (2000), "Ist eine Co-Kompostierung aus stofflicher Sicht in Kumasi/Ghana sinnvoll?", Diploma thesis ETH, Zurich, Switzerland
- Mara, D. and S. Cairncross (1989), "Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture", WHO, Geneva, Switzerland
- Montangero, A. and M. Strauss (2000), "Faecal Sludge Treatment - Strategic Aspects and Treatment Options", International Workshop on Biosolids Management and Utilisation at Nanjing and to the Forum on Biosolids Management and Utilisation at Hongkong, Nanjing and Hongkong
- Mougeot, L., N. Faruqui, O. Smith, B. Wilson and A. Hovorka (1998), "Program Initiative - Program Summary 1997-2000", CFP Report Series 22, IDRC, Ottawa
- Mougeot, L.J.A. (1994), "Urban food production: evolution, official support and significance (with special reference to Africa)", CFP Report Series 8, IDRC, Ottawa
- Mougeot, L.J.A. (1999), "Urban Agriculture: Definition, Presence, Potential and Risks, Main Policy Challenges", CFP Report Series 31, IDRC, Ottawa
- Nelson, T. (1996), "Closing the Nutrient Loop", *World Watch*, 9, 6, 10-17
- Nilsson, K. and T.B. Randrup (1997), "Urban and peri-urban forestry", World Forestry Congress, Antalya, Turkey, 13-22 October

- Nugent, R. (2000), "The impact of urban agriculture on the household and local economies", In: Growing cities, growing food (Ed.: N. Bakker, M. Dubbeling, S. Gündel, U. Sabel-Koschella and H. de Zeeuw), DSA, Eurasburg, 76-97
- Pescod, M.B. (1992), "Wastewater treatment and use in agriculture", FAO Irrigation and drainage paper FAO, Rome
- Quon, S. (1999), "Planning for Urban Agriculture: A Review of Tools and Strategies for Urban Planners", CFP Report Series 28, IDRC, Ottawa
- Remenyi, J. (2000), "Poverty reduction and urban renewal through urban agriculture and microfinance: A case study of Dhaka, Bangladesh", Urban Agriculture and Horticulture - The linkage with Urban Planning, Berlin
- Rose, G.D. (1999), "Community-Based Technologies for Domestic Wastewater Treatment and Reuse: Options for urban agriculture", Cities Feeding People Series 27, IDRC, Ottawa
- Rudat, H., U. Sabel-Koschella, R. Niemeyer, S. Sanders and C. Werner (1999), "Utilisation of organic waste in (peri-)urban centres", gtz / GFA-Umwelt, Bonn / Eschborn
- Rutamu, I. (1999), "Low cost biodigestors for zero grazing smallholder dairy farmers in Tanzania", *Livestock Research for Rural Development*, **11**, 2
- Sanio, M.R., D. Burack and S. Siddiqui (1998), "Reuse of Urban Waste for Agriculture: An Investment Program for Progressive Action", World Engineering Partnership for Sustainable Development, Alexandria, USA
- Sassen, S. (1996), "Metropolen des Weltmarkts - Die neue Rolle der global cities", Campus, Frankfurt/New York
- Sawio, C.J. and L. Spies (1999), "Towards the Establishment of a Development and Research/Training Network on Urban Agriculture for East and Southern Africa", ISBRAM-FAO Workshop on Urban and Peri-Urban Agriculture, Accra, Ghana, 2-6 August
- Schertenleib, R. (2000), "The Bellagio Principles and a Household Centered Approach in Environmental Sanitation", Ecosan – Closing the Loop in Waste Water Management and Sanitation, Bonn, Germany
- Silva, S. (1994), "The use of municipal solid waste in agriculture and animal breeding and its environmental impact", In: The management of municipal solid waste in Europe - Economic technological and environmental perspectives (Ed.: A. Quadrio Curzio, L. Prosperetti and R. Zoboli), ELSEVIER
- Smit, J. (1996), "Urban Agriculture - Food, Jobs and Sustainable Cities", UNDP United Nations Development Program, New York
- Smit, J., L. van den Berg, S. Quon, P. Jacobi, A. Drescher, J. Amend and D. laquinta (2000), "Urban and peri-urban agriculture and urban planning. Thematic paper for FAO-ETC electronic conference on UPA. Discussion paper", FAO-ETC/RUAF electronic conference "Urban and Periurban Agriculture on the Policy Agenda", <http://www.fao.org/urbanag/>, 8/21-9/30/2000
- Strauss, M. (2000), "Human Waste (Excreta and Wastewater) Reuse - Outline", Duebendorf, unpublished
- Strauss, M. and U.J. Blumenthal (1990), "Human Waste Use in Agriculture and Aquaculture - Utilisation Practices and Health Perspectives - Executive Summary", No.09/90, EAWAG/SANDEC, Duebendorf
- Strauss, M., S.A. Larmie and U. Heinss (1997), "Treatment of Sludges from On-Site Sanitation - Low-Cost Options", *Water Science and Technology*, **35**, 6, 129-136
- Streiffeler, F. (1998), "Urban Agriculture in Africa", First General Assembly of the Forum of Research on Human Settlements
- Streiffeler, F. (2000), "Rural and urban agriculture by valorisation of domestic waste in DESAR in Africa", EURO Summer School - DESAR - Decentralised Sanitation and Reuse
- Touré Fall, S. and I. Cisse (2000), "Urban livestock systems in the Niayes zone in Senegal", *Urban Agriculture Magazine*, **1**, 2, 17-19

Wallingford, H.R. (2000), "Informal peri-urban irrigation in Africa", *Water*, **May**, 1

WHO (1989), "Health guidelines for the use of wastewater in agriculture and aquaculture", Technical Report WHO, Geneva, Switzerland