## Part 4

# Upscaling the Organic Sector in Africa

# 23 Urban Agriculture: Challenges and Opportunities in Urban Water Management and Planning

Maren Wesselow,[1]* Christina Kifunda,[1] Raymond Auerbach[2] and Bernd Siebenhüner[1]
[1]*Carl von Ossietzky University, Oldenburg, Germany;*
[2]*Nelson Mandela University, George, South Africa*

**Abstract**
Africa is urbanizing rapidly, and many unemployed or poor people are trying to produce food in urban and peri-urban areas. Many local authorities see this as high-risk food production, mainly because of the risk of use of contaminated water. However, with good planning, urban gardens can supply healthy food and exercise, while providing environmental amenity value and building community solidarity. In Dar es Salaam, many rivers are heavily polluted and gardeners are pumping clean water from springs, where they can afford to do so. Many use shallow wells, and sometimes pumps are later installed, or deep wells are developed for irrigation. Experiences from different African countries show that rainwater harvesting and water conservation can contribute to increasing plant available water, and methods which could be useful include swales, grass mulch, zaï pits, Fanya juu terraces and crescent embankments. Planners should see urban gardens as an opportunity for developing community green spaces rather than a threat to public health and orderly development.

## Introduction

Africa is among the fastest urbanizing regions in the world (UN, 2014; UN-Habitat, 2016). Population growth and rising economic opportunities attract ever more people to move from rural areas to cities and urban fringes. As recorded in Chapters 1 and 7 of this volume, climate change is now also a major factor in migration from rural areas to urban centres. Some of the world's fastest growing future megacities are to be found in the region, such as Nairobi, Kinshasa and Dar es Salaam. In low-income countries with relatively slow industrialization and large unskilled workforces (Potts, 2012), urbanization leads to high levels of poverty, unemployment and food insecurity accompanied by ineffective infrastructures and institutions. Unlike in rural areas, the urban poor have to purchase their food and food expenses often require almost all of their disposable income. This makes them especially vulnerable to price fluctuations and food insecurity (Poulsen *et al.*, 2015). What is more, settlement takes place mostly on marginal land, without defined and formal land titles or in highly vulnerable areas that are increasingly threatened by the impacts of land use and climate change such as flooding, water scarcity, erosion or mud slides.

*maren.wesselow@uni-oldenburg.de

Encountering these challenging conditions, inhabitants of urban and peri-urban areas increasingly resort to various forms of urban agriculture and horticulture. In small home gardens and open spaces, they grow their own food, keep livestock and produce other non-food products like wood, charcoal and fibres. Through urban and peri-urban agriculture, urban dwellers can reduce their food expenditure, obtain a more stable food source and income, and minimize the negative impacts of variable wages or food prices (Poulsen *et al*., 2015).

Urban and peri-urban agriculture also helps to green the city, to maintain buffer and reserve zones, and has positive impacts on the microclimates of cities. It can improve health both through better nutrition and through healthy outdoor activities. In contrast to rural agriculture, urban agriculture tends to be smaller sized, more dispersed, more adaptive and integrated with non-agricultural land uses, activities and services (Mougeot, 1999). Additionally, producers can exploit the proximity of the urban demand, specialty markets and quality-conscious consumers (Fig. 23.1).

However, agriculture in many urban areas of sub-Saharan countries faces various environmental and political challenges. Due to high land pressure in urban areas, urban farmers operate on smaller plots, on marginalized land, often with contaminated soil and with limited access to water, which may also be polluted.

Therefore, this chapter examines the conditions and strategies for urban and peri-urban farmers in African cities to advance organic solutions and to develop more systems-based approaches. These can help to tackle the core problems such as limited water availability, high pollution levels and deteriorating ecological functions in urban areas. This chapter draws on a case study of urban and peri-urban agriculture in Dar es Salaam in Tanzania which is part of the German government-funded ECOSOLA project (ecosystem-based solutions for resilient urban agriculture in Africa), and on a survey of organic agriculture (OA) carried out for the German agency GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) (Mashele and Auerbach, 2017).

**Fig. 23.1.** A peri-urban market near Kampala, Uganda. (Photograph by R. Auerbach 2008.)

## Challenges of Urban Agriculture in the Case of Dar-es-Salaam, Tanzania

As urban encroachments degrade natural water source areas, like watersheds, wetlands, springs and groundwater recharge areas, the quality, quantity, affordability and reliability of water constitute a key challenge for urban crop farmers (Fig. 23.2). Dar es Salaam in Tanzania receives on average 1148 mm rainfall/year with seasonal rains in October/November and March/April (referred to as *vuli* and *masika* seasons). Farmers in Dar es Salaam cultivate demand-driven and water-intensive crops such as aubergines, tomatoes, carrots, onions and leafy vegetables. While farmers struggle with water scarcity in dry seasons, they face the risk of flood events during rainy seasons. As rainfall is unpredictable and unstable, farmers rely on irrigated agriculture. However, their access to water is problematic and often informal.

In view of increasingly erratic rainfall patterns, access to water will be a decisive factor for the development of urban agriculture in Southern Africa. The water-holding capacity of the soil will also be an important factor. The research results from Chapters 18–22 of this volume show OA is more water efficient than conventional agriculture, and that mulching can help conserve moisture. While Dar es Salaam is a high-rainfall tropical city and already has problems with erratic rainfall, most of the Southern African urban areas are much drier, and will increasingly experience moisture- and temperature-related production challenges.

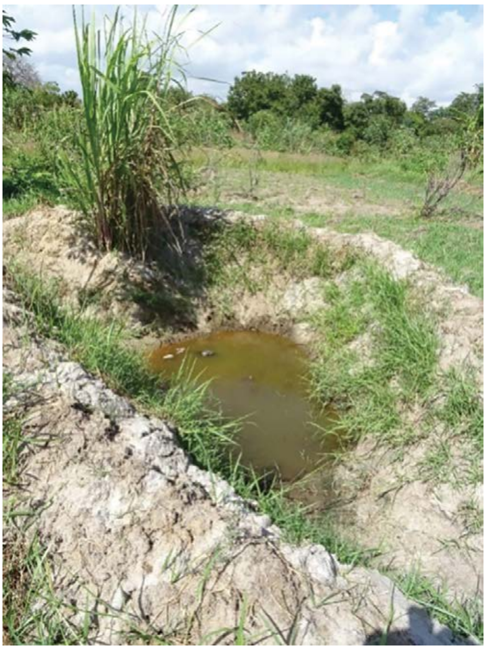

**Fig. 23.2.** Farmers dig wells to access groundwater for irrigation in Dar es Salaam. (Photograph by M. Wesselow.)

Chapters 7, 8 and 9 of this volume showed how water availability and access to urban land are interconnected in Cape Town and peri-urban KwaZulu-Natal (KZN), and how volatile food prices are in times of drought. Chapters 10, 11 and 12 showed the need to build capacity for peri-urban and rural food producers to participate in shortened value chains, and how gardens contribute to building community solidarity. Chapter 13 gave practical examples of urban rainwater harvesting (RWH), while Chapters 14, 15 and 16 showed how to support farmers in accessing these markets.

Against the background of climate change, African food production needs to become more water efficient; this is especially important for urban food production (Thomas *et al*., 2007; Montmasson-Clair and Zwane, 2016). Water efficient techniques encompass measures to improve the water-holding capacity of soil, to reduce water runoff and plant requirements (e.g. hydroponics or organoponics, drip irrigation, zero tillage, cover crops, zaï pits) and RWH, as well as techniques to recycle and reuse water resources. Other methods such as keeping flood plains free from housing construction help to reduce negative impacts from flooding.

## Access to water for Farmers in Dar es Salaam

Farmers in Dar es Salaam state that water is one of the most pressing challenges they face and consequently they have developed creative ways to access water, most of which are informal. In high-income areas people use piped water for irrigation, while in low-income areas farmers use water from open wells and rivers (Nganyanyuka *et al*., 2014).

The official supplier of water and sewerage services in the city is Dar es Salaam Water and Sewerage Corporation (DAWASCO). DAWASCO is responsible for the operation and management of water supply and sanitation services in Dar es Salaam city, parts of Kibaha and Bagamoyo in the coast region. The area for which DAWASCO is responsible has a total population of 5,781,557 of whom 3,931,459 (68%) are served by the utility through 256,290 domestic connections and 371 additional kiosks (EWURA, 2017).

However, the Ministry of Water and Irrigation admits that due to a lack of maintenance of pipes and valve meters, old infrastructure and illegal water connections, around 50% of water (49% in 2015, 53% in 2016) is lost (Ministry of Water and Irrigation, 2016). The water leaking out from defective pipes and valves is sometimes informally used for irrigation. A farmer from Kinondoni district describes how he depends on irrigation water from a broken water pipe:

> We depend on water that flows in this valley from up there. This water is from a DAWASCO pipe, which burst. When they burst up there they flow down here. So we use that water for our irrigation. When DAWASCO manages to repair and block, we get a water shortage.
>
> (Farmer from Kunduchi ward, 2017, personal communication)

Due to the lack of an efficient distribution network, and high prices, people resort to deep and shallow wells in order to develop groundwater (Figure 23.2). The rapid rise in the use of shallow wells increases the risk of groundwater contamination from pit latrines. Saria and Thomas (2013) found that water from shallow wells in Dar es Salaam city is bacteriologically and chemically contaminated. Kyessi (2005) describes how shallow wells are gradually upgraded in a step-by-step process starting with traditional open shallow wells, a hand pump in a second stage, and deep wells with motor pumps and raised water storage tanks as a third stage. Many farmers have boreholes and use water pumps to access groundwater.

When groundwater is accessed near the sea, salt water intrusion makes water unsuitable for irrigation purposes (Mtoni, 2013). A farmer in the Mapinga ward explains: ‘So if I use the drilled water which has some salt, I see the crops do not do well in a long time’ (Farmer, 2017, personal communication). The salinization of groundwater in coastal areas is an indicator of the high groundwater-pumping rates. The declining groundwater level in Dar es Salaam makes groundwater sourcing an unsustainable strategy (Ferguson and Gleeson, 2012; Javadi *et al*., 2015). A major joint study by the Universities of Sokoine and Ghent is examining sustainable management of groundwater resources around Dar es Salaam; part of the study led to the publication of an MSc thesis in geology by de Witte, whose study concludes:

> This means that every year about 70% of the recharge is removed by extraction. This is not a sustainable way of water extraction … Consequences of this overexploitation are a decrease of the groundwater level and salt water intrusion in areas close to the ocean.
>
> (de Witte, 2012)

Local rivers and streams (e.g. Msimbazi and Mpinji rivers) are very feasible sources of water for irrigation purposes. Many farmers cultivate vegetables along the riverbanks (Bahemuka and Mubofu, 1999) and they have agreements for sharing the water resources (Wesselow, 2019). However, water from these rivers is polluted by heavy metals (Bahemuka and Mubofu, 1999). The main sources of this pollution are industrial effluents, and indiscriminate disposal of domestic or sewage drainage directed to the rivers (untreated or partially treated).

Vegetables take up these metals by absorbing them from contaminated soils, as well as from deposits on parts of the vegetables exposed to the air from polluted environments (Zurera-Cosano *et al*., 1989). A farmer from Mzimuni ward explains that farmers were forced to use water from a spring as the local river is polluted by textile industries:

> The water we were supposed to use for irrigation from Mzimuni River valley is polluted by wastes from textile industries. Now we are using high costs to run the machine to pump water for irrigation from Mzimuni spring to our farms.
>
> (Farmer from Mzimuni ward, 2018, personal communication)

Sewage is often discharged untreated into streams. Biological agents discharged from households and industries were also present in the water including coliform bacteria (Muster, 1997). Pesticides (which are widely applied in urban agriculture in Dar es Salaam) also contribute to the pollution of the rivers (Mwevura *et al*., 2002).

Another problem for farmers in Dar es Salaam is that rivers and streams are highly seasonal. While they dry up in the dry season, they may flood during the rainy season. Cultivation areas along the riverbanks often serve as flood plains during this time of the year. As rain falls erratically, floods can cause harvest failures. The poor water quality and erratic quantity make rivers an insecure source for irrigation water (Kiangi, 2014).

In some parts of the city, farmers use wastewater to irrigate their crops posing environmental and health threats for farmers and consumers. The heavy metal contamination from wastewater irrigation is of serious concern due to its implications for human health (Kihampa, 2013).

## Rainwater Harvesting Techniques as an Opportunity to Balance Erratic Rainfall

As shown in Chapters 19 and 22 of this volume, organic farming methods improve the water- and nutrient-holding capacity of soil, and mulches reduce evapotranspiration. As soil organic matter (SOM) increases, water retention improves, and when mulches and RWH structures are present, water infiltration improves dramatically.

Rainwater harvesting structures may include zaï pits, Fanya juu terraces, half-moons, and these African innovations from different countries are summarized below (from Auerbach, 2003).

### Zaï pits

Zaï pits are dug into degraded soils to collect and concentrate water at the plant. They were traditionally small pits, but now are often larger, with compost added. This technique spread from Burkino Faso to Niger (there, they are called 'improved tassa'). They were rapidly adopted in the 1990s when they were clearly seen to help improve yields in dry years. This seems to be a very effective rehabilitation system for degraded lands. Reports are that 12,000–25,000 zaï pits/ha are used; 1 ha of zaï takes about 60 × 5 h workdays to construct. During the dry season, zaï trap litter and fine sand deposited by the wind. They also create a microclimate which protects young plants against wind and runoff. Weeds do not grow on the crusted, barren land between the zaï. Mulching has also been widely adopted, using 3–6 t/ha of grass. This supplies nutrients, conserves water and also attracts termites which open up the compacted and crusted soil.

### Fanya Juu terraces

Fanya juu terraces are formed by throwing soil up slope from a trench to make bunds on the contour, which eventually become bench terraces. They are usually protected by a cut-off drain or diversion ditch (Fig. 23.3).

### Half-moons

Low lying crescent embankments (about 100 cm high) are used to harvest runoff on areas up to 100 ha. Lateral structures and cross embankments are also constructed to maximize surface runoff from the *wadis.* Organic matter is added, and fields are levelled, breaking up clods. Vegetation is planted on the embankments to stabilize them; stones and plastic sacks may also be used to reinforce weak points.

### Vetiver grass on swales

Auerbach (2003) describes his own RWH system on his KZN smallholding of 8 ha:

> vetiver grass is effective when planted on swales. The effect of the swale is to catch water which falls on the area above the swale, and to slow the water down, maximising infiltration. The vegetation on the crest holds the soil of the swale in the event of intense rainfall causing


**Fig. 23.3.** Trees have grown on this Fanya juu ditch in Uganda and these form a windbreak and trap water. (Photograph by R. Auerbach, 2009.)

> runoff flow to overtop the swale. The swale also creates a moist microclimate in the furrow above the swale wall, which often becomes highly productive, as plant available moisture is much greater here. Swales are different to contour bunds commonly erected in soil conservation programmes. Soil conservation aims to remove water from the field without damage to the soil; swales promote infiltration.
>
> (Auerbach, 2003)

Swales and mulch in combination can effectively halve the amount of water required for irrigation (Fig. 23.4).

## Integrating Rainwater Harvesting Structures into the Urban Context

Nuhu Hatibu and Henry Mahoo (2000) describe the history and effectiveness of RWH in semi-arid parts of Tanzania, and summarize some of the most important processes. In many parts of Tanzania, the fact that there is a dry spell in the middle of the growing season makes the aridity even worse, and is compounded by the unpredictable nature of this dry spell – its timing varies from place to place, and from year to year. Clearly in such an environment, RWH strategies can make the difference between a viable crop yield and a crop failure. Responses in the past have often been inappropriate, such as cut-off drains, which increase runoff, and tree planting, which decreases the amount of plant available water. Approaches other than drought-resistant varieties have now been shown to be effective. In Tanzania, approaches such as '*Mashamba ya Mbugani*' are traditional. In this case farmers plant high-water-demand crops lower down the landscape to exploit the concentration of rainwater flowing into the valley bottoms from surrounding high ground. These approaches concentrate on increasing water supply, rather than reducing demand. If rainwater is not managed, it quickly evaporates or flows away as flash floods, often into saline sinks. Microcatchment systems have

**Fig. 23.4.** Swales (planted with vetiver grass) and natural mulch can halve water use by reducing evaporation. Cliffdale (near Durban), KwaZulu-Natal. (Photograph by R. Auerbach, 2009.)

catchment areas which generate runoff, and cultivated basins where runoff is concentrated.

According to Hatibu and Mahoo (2000), planning of both agricultural and urban areas should give more attention to RWH. Factors influencing runoff include: (i) land surface (slope, length, vegetation, roughness and erosion risk); (ii) soil type; (iii) rainfall characterisics (rainstorm amount, intensity, distribution); and (iv) catena sequences. Types of runoff include rill-flow, gully-flow and ephemeral stream-flow. Assessing RWH potential requires identification and quantification of naturally occurring runoff and its current use, assessment of effects on downstream users if water is harvested, and assessment of alternative water sources. The essence of RWH is to capture water where it falls, in order to meet local needs. Strategies for doing this seek to improve infiltration, minimize rootzone water loss and improve crop water use and productivity. This is done through runoff harvesting (e.g. strip catchment tillage, basin systems, semicircular hoops, conservation bench terraces) and floodwater harvesting (e.g. cultivated reservoirs, stream-bed systems, hillside conduits and ephemeral stream diversion).

In urban areas, where many gardens are relatively small in area, and where much of the surface is hardened (roads and buildings), RWH can contribute significantly to water resources for irrigation. Water may be stored in tanks (see Chapter 13, this volume, where four rainwater tanks with a total storage of 8000 L were found to provide adequate water for a home vegetable garden of 7 $m^2$ plus an extensive flower garden), but then systems need to be developed to make use of this water efficiently, and to provide adequate storage for periods of drought. This is an expensive solution, but ofen represents a worthwhile investment.

Because urban areas have many hardened surfaces, good urban design can plan to move water from these hard surfaces (mostly roofs and roads) and lead this water to wetlands, dams or water tanks, where the water can be stored for use during dry periods (Fig. 23.5). As for the open



**Fig. 23.5.** Where water can be stored (a), even in dry Giyanai, South Africa, good quality crops can be produced (b). (Photograph by R. Auerbach, 2008.)

soil, here the objective is to 'slow down, spread and sink' the water, as advocated by many African water strategists, such as Robert Mazibuko (KZN) and Zephaniah Phiri Maseko (Zimbabwe). Maximizing directed runoff from hard surfaces and minimizing runoff from the fields will help to use all rainfall more effectively. Building SOM and making use of mulches will help to hold the moisture where it can be productive. Water quality is often a problem in urban agriculture; sometimes, artificial wetlands can be constructed, and often solutions have to do with formalising sanitation.

Use of mulches can reduce evaporation, as shown in Chapter 29 of this volume; in OA, grass mulches are preferred, as plastic mulches are expensive, and difficult to recycle.

Water use efficiency depends on using good irrigation technology: drip irrigation systems can function at low pressure, and use less water than sprinkler systems (Fig. 23.6).

Water quality is often a problem in urban agriculture (see Fig. 23.7 where polluted water was used for an urban gardening project in Kampala). Sometimes, artificial wetlands can be constructed, and often solutions have to do with formalizing sanitation.

## Conclusion

Urban agriculture will play an increasingly important role in feeding Africa's rapidly urbanising population. Urban authorities are challenged to provide urban farmers with adequate infrastructure for irrigation and security. Moreover, the urban design can support farmers by conserving natural wetlands, and use natural ways of rain water collection. City Engineers and Planners should be working together to harvest water of hardened surfaces, lead this water into wetlands for purification, store the water safely and make it available for organised, productive use, especially by poorer communities. With some community organisation and education about water efficient irrigation systems, food can be produced cost-effectively where needed.

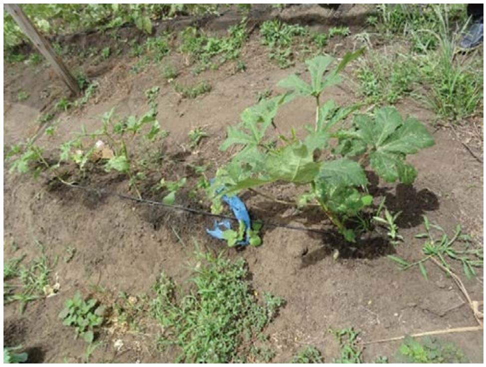

**Fig. 23.6.** Drip irrigation in Dar es Salaam. (Photograph by M. Wesselow.)

Farmers should be helped to join together to develop social groups to address water use for irrigation, and strategies for urban gardening. They could collaborate in the construction of deep wells, with local government assistance, and learn from other communities in various locations, using farmer to farmer approaches, and farm family learning groups. Urban gardens can

**Fig. 23.7.** Polluted water, urban gardening project, Kampala. (Photograph by R. Auerbach, 2006.)

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