THE MICRO FARM NETWORK
Applying a Nexus Approach to Food Security in Kibera

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Abstract

The Micro Farm Network is a solution to food insecurity in informal urban settlements that takes a nexus approach to creating intra-household circular economies. Our modular, three-part system allows families to: (i) grow food to supplement their diet; (ii) filter water for drinking, bathing, and cooking; and (iii) compost their waste in order to add nutrients to their diet. We believe that this system can act to make urban slums around the world more sustainable and alleviate the problems of childhood malnutrition and polluted water sources. By incorporating elements that are cheap and easy to produce locally, this system can also boost local production.

This system is adaptable to different environments and contexts. Our design is a concept which can be applied to various patterns of local production or resource availability. We examine how it could be implemented in Kibera, Nairobi, demonstrating its flexibility in one of the most studied and targeted settlements in the world.

We recommend positioning the system in a community-based organization (CBO) network, which allows members to leverage benefits accrued to social capital and lend them access to valuable economic opportunities that are denied to them individually. The Micro Farm Network is a systems-level solution that has the potential to transform the lives of a large number of the world's urban poor.

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Table of Contents

Literature Review

Informal Food Systems And Household Strategies In Slums

The enormous growth of cities, chiefly through rural-urban migration, and the accompanying challenge of organizing adequate infrastructure, housing, and formal employment, has resulted in a burgeoning of informal settlements, the informal jobs sector, and a growing number of urban poor (UN-Habitat, 2016). The defining characteristics of these areas — predominantly referred to as slums in the international literature — are their insecure property rights, precarious legality and a distinct lack of public services such as potable water, waste removal, and community facilities (UN-Habitat, 2003). Currently, one in eight people across the world live in slums, and the absolute number of slum dwellers without adequate access to water, food, sanitation, or shelter continues to increase (UN-Habitat, 2016). If countries are to address the growth of urban poverty, they need to empower and support livelihood strategies that the urban poor have developed to survive (Gallaher et al., 2015). This follows Target 11.1 of Goal 11 of the sustainable development agenda, that seeks to ensure access for all to adequate, safe and affordable housing and basic services, and upgrade slums by 2030 (UN-Habitat, 2016). Clearly, promoting access to food should be one of the cornerstones of the new urban agenda.

With urbanization advancing at a remarkable pace, it is necessary for cities to play an increasingly important role in achieving food security (Redwood & Dennis, 2012). Research suggests that the food crisis is easier to address at the "local" level; moving away from old policies that have traditionally regulated (often unsuccessfully) food provisioning, a new bottom-up approach to development highlights the valuable role played by informal actors in meeting food security needs (Sonnino, 2009). In slums, where food provision services by the state and non-state actors is often very limited, poor households face a unique set of challenges compared to their rural counterparts. Slum dwellers are very vulnerable to price increases and other market shocks because they are almost entirely dependent on the market for food and other basic necessities (Mohiddin et al., 2012). Scavenging for food, especially discarded airline meals, is also an emerging trend (IIED, 2016). This is because many live in single rooms, especially tenants and single migrants, and therefore lack space to cook and store food.

Street vendors, often overlooked by policymakers, are increasingly regarded as key players in the food security agenda because they provide affordable and accessible food, sometimes in small quantities or on loan — an essential service for the urban poor (Ahmed et al. 2015, 4). However, the public spaces where they work are often contested, and poor facilities pose further difficulties (IIED, 2014). Moreover, food vendors in urban slums largely depend on the staple foods produced in often distant rural areas (Tacoli, 2013). Education, gender, and household composition are also major drivers of food insecurity among slums (Maitra & Prasada Rao 2015, 308), which indicates that solutions need to be complemented with gender empowerment and human capital investment to be most effective. This is because women often face greater constraints than men in urban areas (UN-Habitat, 2003). As a key coping strategy, involving women in developing informal food security systems can facilitate their ability to successfully combine their multiple roles in subsistence production, income generation and environmental management (Hovorka, 2006). Consequently, it is important that effective and appropriate gender planning and policy measures are formulated, evaluated and operationalized if food security initiatives are to provide a means of empowerment and improved quality of life for women.

Urban and peri-urban agriculture (UPA) is one such arrangement that could fundamentally alleviate food insecurity in slums. Micro-gardening has received much exposure and interest in recent years; not only can it improve household food security and well-being, but it can also thrive in situations where households have little more than a terrace for placing a container garden (Sonnino, 2009). UPA is already a significant food source and livelihood strategy in the slums of Sub-Saharan Africa: it provides employment and income; has the potential to improve food security and nutrition; significantly contributes to fresh food supply chains in urban zones, such as food vendors; minimizes the ecological impacts of food production by re-using waste and eliminating inefficient and costly transportation from rural areas; and women typically provide the labour for small-scale UPA (Hovorka, 2006; Prain & Lee-Smith, 2010). However, informal food production systems face severe challenges, such as a lack of storage; low earnings; exposure to health hazards due to poor access to clean water, limited sanitation, and lack of solid waste collection; insecurity; and limited state support.

Nexus Approach And Applications

With rising demands on available natural resources globally, the nexus approach can be leveraged in order to reap the benefits of synergies between the traditionally isolated sectors of food, waste, water, and energy. The nexus approach to natural resource management can be understood as a way of examining "the inter-relatedness and interdependencies of environmental resources and their transitions and fluxes across spatial scales and between compartments" (UNU-FLORES, 2015b). The importance of such interlinkages are expected to become increasingly acute in future decades due to factors such as climate change. As such, the nexus approach is considered a vital tool in achieving sustainability and resilience, underlining the need for policy to capitalize on the co-benefits resulting from this paradigm (Wakeford et al. 2015).

The nexus approach aims to achieve the following three goals:

1. Water Security: “The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environment and economies.” (Grey & Sadoff, 2007)
2. Food Security: “When all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” (World Food Summit, 1996)
3. Energy Security: “The uninterrupted physical availability (of energy) at a price which is affordable, while respecting environment concerns.” (IEA, n.d.)

The concept revolves around an appreciation of the way in which natural resources are inextricably linked, ultimately designing solutions that increase efficiency while simultaneously reducing environmental risk as well as ecological degradation (UNU-FLORES, 2015a). The diagram below lays out some ways in which water, food, and energy interlink.

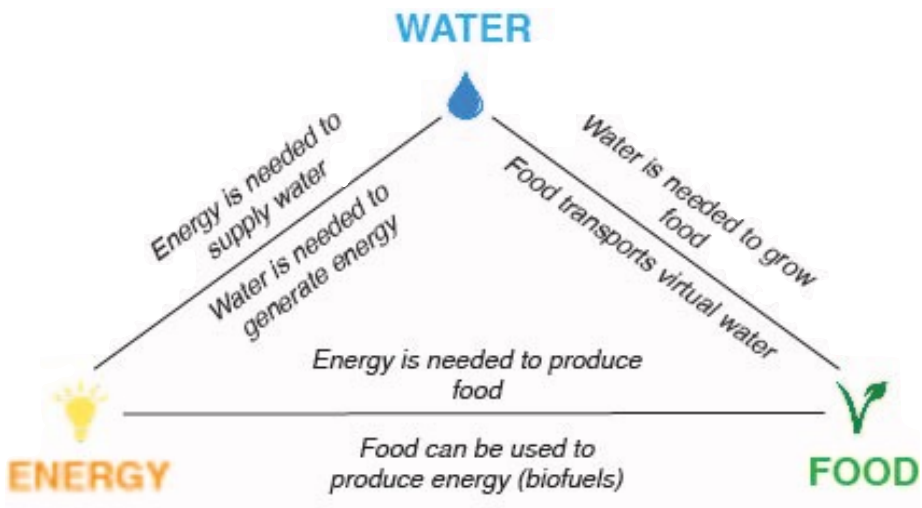

Figure 1: The Water, Energy and Food Security Nexus (Adapted from UNU-FLORES, 2015b)

For example, while agriculture requires irrigation, food itself represents virtual water. However, as will be discussed in the circular economy section below, waste also plays a crucial role in this ecosystem. These linkages have considerable policy implications, as decisions made pertaining to one resource can greatly impact availability of another (UNESCO, 2014). Notably, it is crucial to consider nexus sectors in tandem so as to ensure that actions related to, for example, water security at a local level does not generate adverse consequences relevant to energy security (Hoff, 2011).

Given its wide-ranging applications and crucial importance to development, the nexus approach has become increasingly prominent in the global sustainable development agenda (Wakeford, 2016). Indeed, the need to coordinate efforts across different sectors has been underlined as crucial to meeting the Sustainable Goals (SDGs) by 2030 (UNESCO, 2015). There is a great potential to address multiple issues simultaneously due to the large overlap that exists between those without access to water (1.1 billion people) and electricity (1.5 billion people), the undernourished (just under 1 billion people), and to some degree those living in urban slums (Hoff, 2011). However, negative repercussions of neglecting to acknowledge these interlinkages exist alongside the positive potential of incorporating a nexus approach into policies and programming. These include ecosystem degradation and natural resource depletion, both of which are especially felt by vulnerable or marginalized groups (Wakeford, 2016).

Within the "ecology" of slums, food, waste, water, and energy interact in complex ways that have not been sufficiently recognized or addressed by the numerous slum upgrading initiatives undertaken over the last decade, many of which have offered siloed approaches and technical solutions (Davis, 2007; Thieme & Kovacs, 2014). For example, while some concentrate on improving access to clean water, others exclusively target waste disposal or energy access. This is partly a symptom of the fact that institutional arrangements are not currently conducive to collaboration between sectors, making the necessary communication between ministries, departments, and donors difficult. While significant obstacles, notably insecure land tenure, complicate efforts to adopt bottom-up nexus approaches to slum service delivery, establishing robust institutions and governance mechanisms could set the scene for significant progress in overcoming nexus-related vulnerabilities. (Thieme & Kovacs, 2014; Wakeford, 2016).

Creating A Circular Economy

The circular economy presents an alternative to the dominant linear model of consumption that has characterized the last 150 years of industry, which entailed the use of raw materials in the manufacturing of goods that are bought, used, and ultimately discarded (WEF, 2014). As a result of this model, 65 billion tonnes of raw materials were injected into the economy in 2010, while this volume is projected to reach 82 billion by 2020 (Ellen MacArthur Foundation, 2012). By contrast, the circular economy eliminates the concept of waste. Instead of disposal or incineration, goods are transformed into resources for new products, thereby “closing loops in industrial ecosystems” (Stahel, 2016). It involves reuse, recycling, repairing, and remanufacturing, as well as a transition towards renewable energy, the elimination of toxic chemicals (which limit reuse potential), and improved product designs or business models. As the consumable components of goods do not contain toxic inputs, they can be reintroduced to the biosphere without harm, allowing the cycle to continue (Stahel, 2016; Ellen MacArthur Foundation, 2012).

Developed by David Pearce in 1990, this relatively new concept is gaining increasing traction globally (Andersen, 2006). The trend is being fuelled by increasing volatility in the global economy alongside accelerating resource depletion, leading to many businesses coming to appreciate their vulnerability to risks related to the linear model – notably higher resource prices (WEF, 2014). Making the shift towards circular systems holds the potential to generate a variety social, economic, and environmental benefits. For example, while bolstering economy-wide resilience, secondary benefits such as lower pollution have the potential to generate meaningful gains in terms of human development (Ellen MacArthur Foundation, 2012).

Some have argued that relatively materials-intensive emerging economies in particular stand to gain a great deal in terms of savings created by circular economy, and are potentially in a position to "leapfrog" towards this model as they are less "locked-in" to linear structures (WEF 2014). Slums are settings where circularity emerges almost organically through informal structures, as waste is almost ubiquitously valued, recycled, and reused. The Indian slum of Dharavi, which is the most densely populated place in the world, emerges as an example of this (Brecher, 2016). Micro-enterprises, employing nearly 10,000 people, process waste produced by the 19 million inhabitants of Mumbai, generating economic value to the tune of £700 million annually (McDougall, 2007). Despite issues relating to safety and conditions, this example illustrates how recognizing and building upon the existing mentality of appreciating the value of waste can be incorporated into slum upgrading projects to create economic, social, and environmental value.

Micro Farm Container Design and Specifications

The Micro Farm Containers

The Micro Farm Container project takes its inspiration from the ethos of the circular economy. It was designed to incorporate a sustainable “cradle-to-cradle” perspective, to create a circular economy scaled to the micro or household level, and to address slum dwellers’ most pressing needs, namely food production, water access and waste management. With the modular versatile and low-maintenance Micro Farm Containers, a nexus approach incorporating water, waste, and food, is implemented in the slum setting, offering the potential to simultaneously address inter-sectorial challenges. The advantage of the Micro Farm Containers is that they

What’s the Innovation?

While sack gardening approaches have already been adopted in slums, including Kibera, the proposed innovation is to reimagine the purpose and scope of this technique. Through our Micro Farm Container solution, a nexus approach that incorporates water and waste alongside food production offers the potential to address multiple challenges simultaneously through a single, modular, versatile, and low-maintenance container system (please refer to Figure 2 for the original Micro Farm Containers conceptual design). Additionally, we hope that a micro circular economy project can encourage macro-scale circular economy endeavours. Whilst similar circular approaches have taken root in developed countries, we believe the Micro Farm Containers hold tremendous potential settlements such as Kibera, where they can complement existing projects and practices.

require little space, occupying less than 1 sq. meter, can adapt to diverse contexts, and present future growth opportunities.

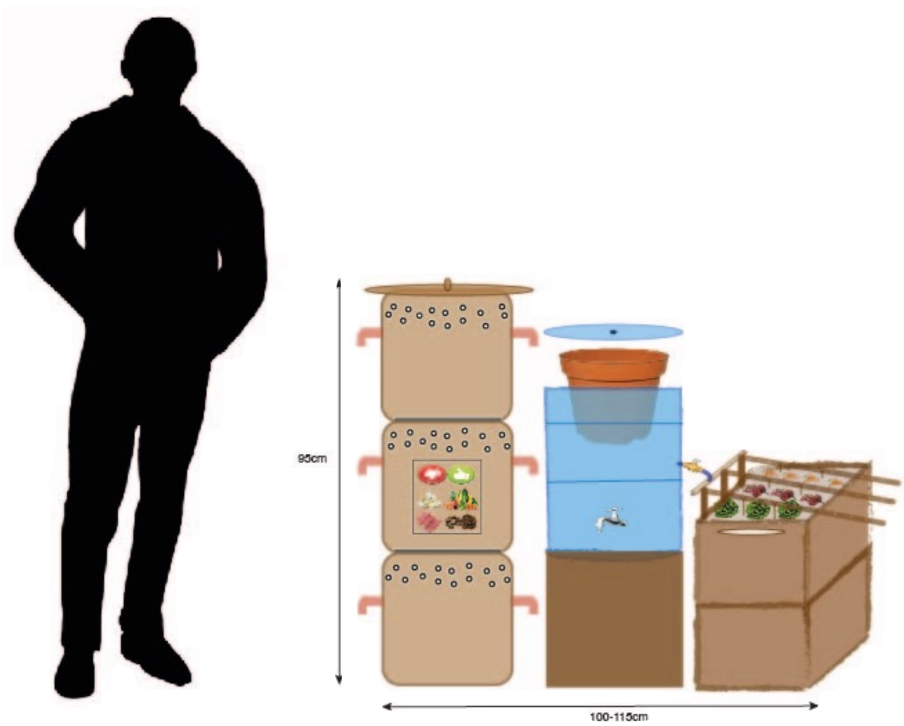

Figure 2: The Original Micro Farms Containers (Pancrazi, 2016)

The Composting Container

Composting is the biological breakdown of decomposed organic matter (Gupta, 2015). Closing the nutrient loop is integral to sustainable agricultural practices, to permaculture in small spaces, and to UPA (Andersen, 2006; EMF, 2012). Moreover, composting is already practiced in slums, allowing dwellers to improve their crops' growth, reduce their exposure to chemical fertilizers and recycle their household waste (Gupta, 2015; Practical Action, n.a). In Kenya's slums, dealing with waste has been an increasingly pressing issue: 4 million tonnes of waste are dumped in the soil and waterways every year. Yet, on average, 70% of slum waste can be composted, which could reduce unsustainable landfill waste as well as water and soil contamination (CWMI, n.a.; Manson, 2013).

Image 1: The Daily Dump Compost Systems (Source: Daily Dump Website, 2016)

In order to tackle this issue, the Micro Farm Containers' first container is the Composting Container. Based on the Indian Daily Dump Kambha System, this is composed of three units: Unit A, B and C (See Image 1). Waste is first put in Unit A, until the it is ¾ full. Then Unit A is shifted to the middle and Unit B moves to the top, allowing people to dump their waste in Unit B, until it is also ¾ full. Once Unit B is filled, the organic waste in Unit A has had time to reduce in size and can be transferred to the lower Unit C. Unit A can then return to the top of the system and Unit B is shifted to the middle. This cycle between Unit A and B repeats itself providing fresh compost in Unit C every 6 weeks (Daily Dump Website, 2016). Holes in each Unit as well as woven plastic wire mesh and newspaper sheets in Unit A and B allow air to circulate throughout the system. This Composting Container can be filled with brown and green plant matters. Requiring little skills, a simple Yes/No image-based Information Sheet will inform people on what to put in the Composting Container (CWMI, n.a.).

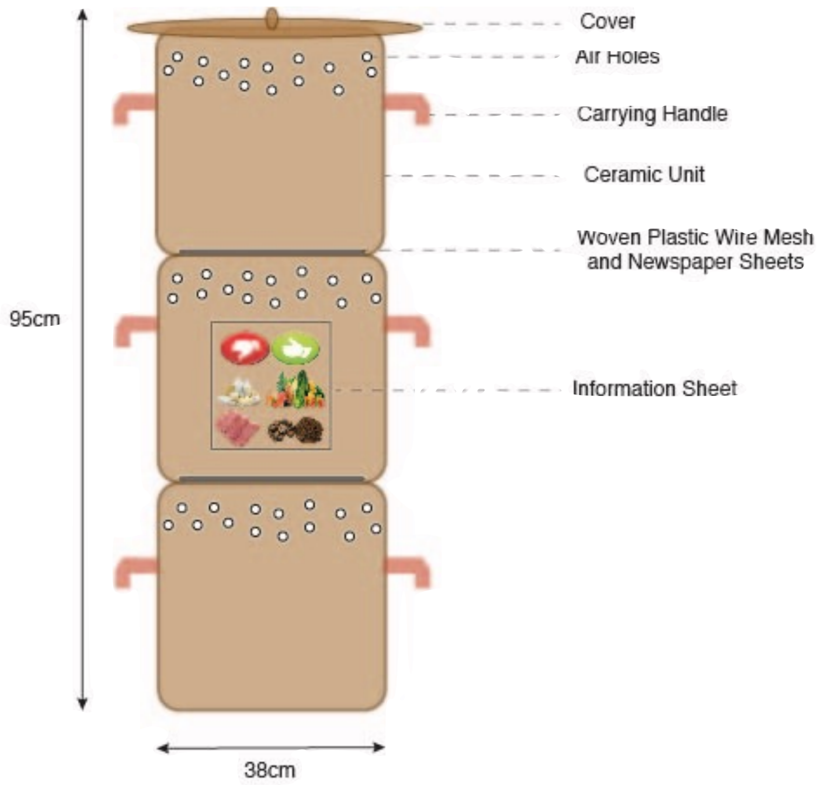

Figure 3: The Composting Container Conceptual Design (Pancrazi, 2016)

Designed for outdoor use and aerobic environments, each Composting Container can keep 30kgs of waste from landfills, the equivalent of 360kg per year (Daily Dump Website, 2016; Hoornweg et al., 1999). The Container would be made of ceramic, a lightweight material commonly found and used in Kenya. Production of this container could provide employment opportunities for local workers and capitalize on existing resources, materials and local practices. Indeed, it could be manufactured abroad and distributed by INGOs and/or local organizations, or it could be built by local artisan communities and/or slum households themselves. Additionally, the retail price of a Daily Dump Kambha, with its starter kit, is £32, yet we estimate that if the Composting Container is manufactured locally, prices would fluctuate between £15-20 (Daily Dump Website, 2016). Finally, this Composting Container can, and optimally should, be combined with the Water-Veggie Containers (see below), in order to create a micro circular economy. However, this Composting Container can be used on its own, depending on local needs (CWMI, n.a.). Figure 3 provides a conceptual design of the Composting Container.

The Water Container

Until recently, Kibera had no running water, which instead had to be collected from the Nairobi dam. However, this water is unclean, causing typhoid and cholera outbreaks. Although Kibera now possesses two main water pipes and residents are able to collect water, water security remains a pressing issue, with many slum dwellers still lacking access to clean water. Inhabitants have also been encouraged to install rainwater/water harvesting systems, valuable systems in tropical climates where the quality and accessibility of groundwater varies throughout the year (Chacha, 2016; Preston, 2012). With an average precipitation above 50mm/month for at least half a year, Kibera has some of the most suitable and feasible environmental conditions for rainwater/water harvesting (Expert Africa Website, 2016; Gur & Spuhler, 2011; World Weather Online Website, 2016) (See Figure 4).

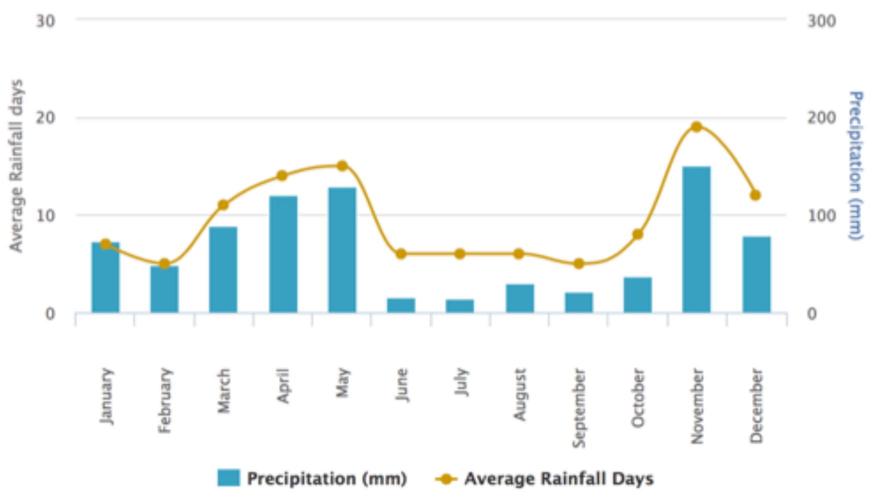

Figure 4: Average Precipitation and Rainfall Days in Kibera (Source: World Weather Online Website, 2016)

The Micro Farm Containers' second Container is the Water Container, which filters water for drinking and irrigation purposes, as well as provides storage for filtered water. This system is similar to the Cambodian Ceramic Water Purifier Project (2002-06), which significantly improved drinking water quality and health in participating communities (See Image 2) (IDE, n.a.). These household-scale ceramic filtration systems are amongst the most promising low-cost options for treating drinking water in developing countries. The Water Container is composed of a flower-pot shaped ceramic Unit that acts as a water filter, and of a larger plastic tank/bucket Unit to collect the filtered water. Producing up to 20-30 litres of clean water per day, contaminated water passes through the porous ceramic filter (average capacity 10 litres) at 1-3 litres per hour, and goes into the plastic tank (average capacity 20 litres) where it is dispersed via a plastic spigot or tap to prevent post-filtration contamination (IDE, n.a.; FAO, 2014b). The Water Container can be filled with collected contaminated water and/or with harvested rainwater (See Additional Items Section). Additionally, the Water Container can be connected to the Veggie Container through the drip irrigation unit in order to close the circular economy loop (Anderson, 2006; WEF, 2011).

Image 2: The Cambodian Ceramic Water Filter Project (IDE, n.a.)

The Water Container, like the Composting Container, is made of ceramic, weighing only 4.8kg, making it easily movable (IDE, n.a). The project could adopt a similar model to the variant used in the Cambodian project, where the ceramic water filters were built by local artisans and households, an option we promote (IDE, n.a.). Alternatively, the ceramic pots could be manufactured abroad and distributed by INGOs and/or local organizations. The Cambodian Ceramic Water Filter have a £6 retail cost, yet we estimate that if built locally the production costs could be reduced to £4 (IDE, n.a). Finally, the design and size of the system can be adapted to different context and local needs, allowing for community-based approaches (Anderson, 2006; Betts et al., 2015). Figure 5 provides a conceptual design of the Water Container.

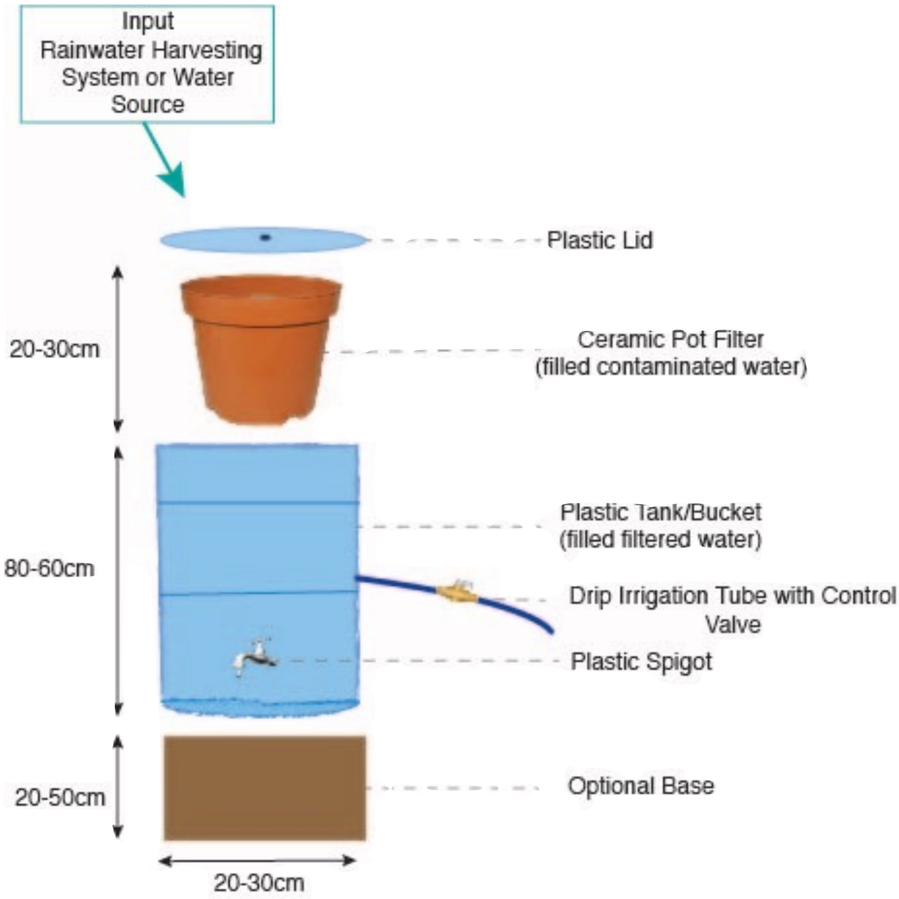

Figure 5: The Water Container Conceptual Design (Pancrazi, 2016)

The Veggie Container

In slums, household are extremely vulnerable to food insecurity, and according to a study conducted by Kimani-Murage et al. (2014), 85% of households in the slums of Nairobi were food insecure. This chronic problem is further worsened by ineffective coping strategies (Gallaher et al., 2013; Kimani-Murage et al., 2014). Hence, improving access to food is an integral part of improving urban food security, reducing slum households' vulnerabilities, reducing chronic pervasive poverty and improving slum dwellers' health and resilience. In order to address Kibera's food insecurity, the Micro Farm Container system include a Veggie Container.

Image 3: Example of a Drip Irrigation Pipe
(Source: http://permaculturenews.org/2014/02/28/bamboo-drip-irrigation/)

This Veggie Container allows individuals to grow small amounts of fresh food whilst using the compost from the Composting Container as fertilizer and the Water Container's filtered water for irrigation (EMF, 2012). The Veggie Container is composed of detachable Crop-Box Units to grow crops and of a drip irrigation Unit. The drip irrigation Unit consists of pipes, made from bamboo and/or plastic tubes (e.g. PVC pipes or PVC irrigation micro tubes). This system can be linked to the Water Container, through one of these pipes and with a control valve (*Note: the control valve is separate from the plastic spigot for drinking water*) (See Image 3). Diverse studies, conducted in India, Israel, Spain and the United States have shown that drop irrigation system is a highly efficient method that can raise crop yields by 20-90% and can reduce water usage by 30-70% (Suryawanshi, 1995).

The Crop-Box Unit is made of plastic and has detachable sides and handles, making the entire Unit durable, versatile and easily movable. Additionally, Crop-Box can be stacked to grow plants that require more space. Table 1 provides a list of some of the vegetables that can be planted in these Crop-Box.

Shallow Rooting (45-92 cm)	Medium Rooting (92-121cm)
Broccoli	Beans, Snap
Brussel Sprouts	Carrots
Cabbage	Chard
Cauliflower	Cucumbers
Celery	Courgette
Chinese Cabbage	Peas
Corn	Peppers
Endive	Rutabaga
Leeks	Squash
Lettuce	Turnip
Onions	
Potatoes	
Radishes	
Spinach	

Table 1: Crops suitable for the Veggie Container (Source: Albert, 2009)

(*Note: the table also includes crops that are not specific to Kenya, highlighting the versatility of this Veggie Container*). With intensive gardening techniques, such as permaculture, slum dwellers can harvest a large amount of fresh products in a reduced space. Additionally, the Veggie Container allows for inter-planting, which is the growing of two and/or more different types of plants in the same space. This

Image 4: Alternative Recycled Crop-Box Unit
(Source: http://freshorganicgardening.com/plastic-containers-as-planters-safe-or-not/)

provides several benefits such as natural pest management and improved nutrient absorption (Albert, 2009; Nekesa & Meso, 1997; UoA, 1998).

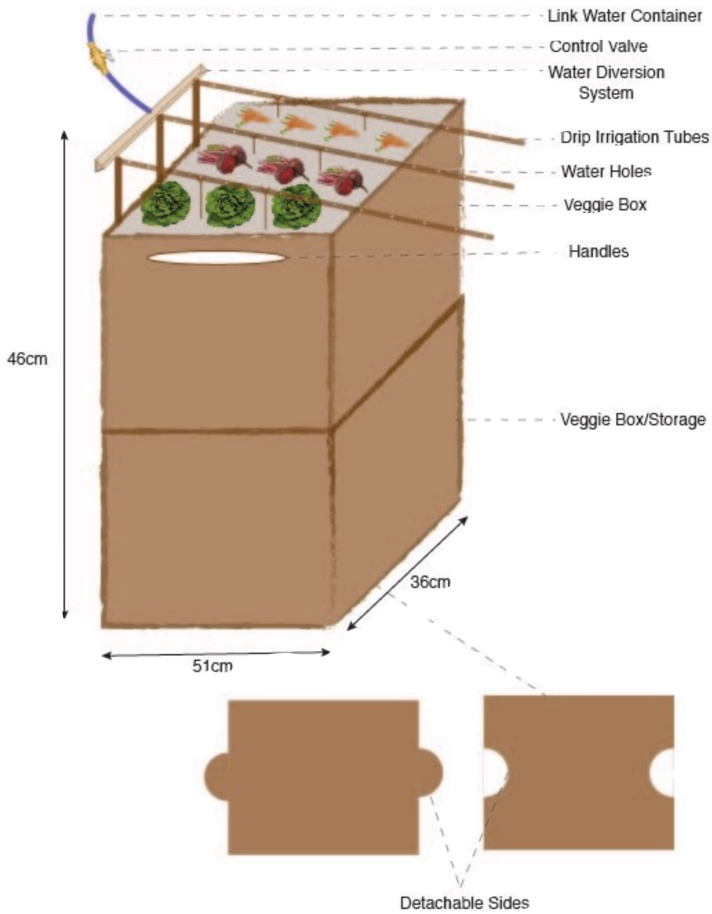

Figure 6: The Veggie Container Conceptual Design (Pancrazi, 2016)

The Veggie Container provides numerous benefits to slum dwellers, whilst occupying little space and being low-cost (De Zeeuw et al., 2011). It costs between

£3-5, since a bucket-drip irrigation system that irrigates individual plants over a 25 m^2 area costs only £3.8 and the cost of a running meter of drip irrigation pipes in Nairobi costs KES 7-15 (£0.5-0.11) (KeBuySell, n.a; Postel et al., 2001). Furthermore, if the Veggie Container remains unaffordable to some household, the Crop-Box Units can be made with recycled plastic boxes (See Image 4). Figure 6 provides a conceptual design of the Veggie Container.

Additional Items

The additional items described below can be provided based on local needs and capacities. This section also exemplifies how diversified, adaptable and versatile the Micro Farm Containers are. It also shows that this micro circular economy project can be scaled up by increasing its complexity and physical size and/or by incorporating additional aspects and cycles of the circular economy. These additional items show the potential for growth, as they can be added to existing containers and/or can form new containers altogether:

Rainwater Harvesting System

These low-cost systems require little expertise and are already used in slums. The most common model is the small-scale rooftop system. Rainwater is collected on roofs and transported through gutters to a storage reservoir, such as a Water Container (see Image 5), where water is filtered for consumption. These systems represent an easy solution to increase access to filtered water, and also provide an opportunity to recycle existing infrastructure and materials (Gur & Spuhler, 2011).

Image 5: A Rainwater Harvesting Tank in Bangalore (Source: https://www.commonfloor.com/articles/wp-content/uploads/2012/05/Rainwater-Harvesting.jpg)

Community-Based Digester

Digesters produce energy-rich biogas and a nutritious digestate that can serve as a fertilizer. Even though digesters are larger in scale and require more expertise, they remain an attractive solution for slums. Community-based digesters incorporate additional elements of the circular economy: they reduce greenhouse gas emissions, and improve waste management, namely human/animal waste (UN-Habitat, 2014; Manson, 2013; Whitehead, 2014). (*Note: the latter are not yet integrated in the Composting Container*)

Image 6: Kibera's Bio-Gas Building (Source: http://www.afrigadget.com/wp-content/uploads/2007/03/kibera-bio-gas2.jpg)

Hydroponics

Small-scale and/or large scale hydroponics could be added to the Micro Farm Containers, even though these systems are costly and necessitate additional skills. To be sustainable, these hydroponic systems need to be connected to an electrical source, (*Note: potentially the digester and/or the solar panels*) in order to power the systems' small motors (FAO, 2014b).

Solar Panel

Solar panels are already a popular option in urban slums (Pearce, 2015). Based on local needs, small to medium-scale solar panels can provide a source of renewable energy to recharge reusable batteries, to power small night lamps, thereby increasing security, and/or to recharge cell phones through a USB plug. Solar energy is already popular in Kenya with numerous organizations, like Azuri, involved in solar panel projects (Betts et al., 2015; Bransfield-Garth, 2013; Mongalvy, 2015).

Image 7: Azuri's Solar Panels (Source: https://s-media-cache-ak0.pinimg.com/564x/e3/07/3d/e3073d4ed70bd4bf379ea95b00b6b3f0.jpg)

Governance and Implementation

The proposed Micro Farm Container system is both low-cost (totalling between £35 and £40 per household for all three components combined) and simple in design in order to ensure that most components can be manufactured and repaired locally. However, it is clear that the technical specifications must be accompanied by a robust governance structure for the solution to take root within any community. Given the unique conditions and challenges that exist within slums, it has become clear to development practitioners that neither the state nor the market can be relied upon to improve living standards for the urban poor (Ravindra & Sweta, 2013). It is for this reason that both potential models outlined below are intended to be orchestrated by a community-based organization (CBO), working in collaboration with existing local bodies or international development agencies dedicated to achieving food security for community members. These organizations are often non-profits but exist in many varieties, many informal, and are extremely common in slums where they serve to fill “an institutional vacuum” (UN-Habitat, 2003). They achieve this partly by facilitating collective social action, which is a crucial aspect of life in poor communities, and by maintaining the community’s trust through effective and accountable leadership (Ibid).

This central CBO structure, which would be responsible for initiating the project by designing training materials and delivering basic capacity building exercises (refer to implementation plan below), would aim to collaborate with existing informal food systems, which despite their importance have been marginalized by proponents of the food security agenda (SDI, 2015). A grassroots approach such as this would ensure that the program remains responsive to realities on the ground. For example, some common obstacles noted in food safety and standards within slums including pest infestations and rapid spoilage (Ibid), would be noted quickly, allowing for solutions to be designed in collaboration with members.

In contrast with the frequently male-dominated arenas of crime control and infrastructure, CBOs responsible for such things as communal kitchens and income-earning schemes tend to be the domain of women within poor communities (Douglass, 2006). Matched with the observation arising from one survey that showed 90% of sack farmers in Kibera are female suggests that women should play leadership roles in the governance of this scheme (Gallaher et al., 2013). This approach would amplify the currently existing benefits of sack farming in Kibera, which include the opportunity to supplement available livelihood strategies and create, in the words of one female resident, “a sense of community” among women (Ibid). While difficult to monitor or quantify, this sense of recognition could serve to advance women’s position within the household.

Income Generation And Non-Profit Exchange

As UPA can be a viable income source (Mohiddin et al., 2012), the food produced through the Micro Farm Containers can serve as an additional income stream for households. Even specifically within Kibera, existing forms of sack gardening have been found to improve not only improve household food security and nutritional diversity that makes them more resilient in the face of food shortages, but also provides an additional income stream that is often used to purchase more desirable food from the market (Gallaher et al., 2013). Given the economic benefits, and given the modular and low-cost nature of the containers, households may be willing to purchase the system in the absence of donor funding. A way of organizing this economic activity across households would be to establish a cooperative business, which is one common and growing form of CBO – with over 200,000 in existence by

1998 (Douglass, 2006). Cooperatives are created when individuals “unite voluntarily to meet their common economic, social and cultural needs (through) business enterprise that seeks to strike a balance between pursuing profits and meeting the needs and interests of members” (FAO, 2012a). This model is very well suited to food production, and is making a significant reappearance in development discourse through the SDG implementation plan (UNDESA, 2016). One possible plan is tasking the central CBO with organizing women into a cooperative, which would allow them to share expertise and sell excess produce at the local food market. These networks of micro farms would have the potential to become autonomous neighborhood enterprises consisting of several households.

Aside from income generation, sack farming within communities can also be a powerful tool for social capital generation and strengthening. Cooperatives themselves draw on “the deep social networks that exist in the informal settlements” (IIED, 2014), providing an opportunity to strengthen relationships while embedding the Micro Farm Network in social structures already in place. Existing evidence suggests that current forms of sack gardening do increase social capital, in particular for households that garden in groups (Gallaher et al., 2013). Leveraging these networks might enable households to further improve their food security and nutritional diversity. For example, efficiency gains may occur if each household in a network specialized in growing one particular crop and then exchanged portions of different food varieties with neighbors. Equally, given limited space, forming alliances allows households to make use of communal areas for the micro farm system, while pooling resources may make the purchase of new seeds or additional container components more manageable. This may also generate spillover benefits such as knowledge-sharing among households.

Relevance To The Kibera Context

Kibera is the largest informal settlement in Africa, with over 250,000 residents. It has been growing since Kenya's independence in 1963, when newly mobile rural farmers began migrating to Nairobi to find work. The land is owned by the government, which has not formally recognized the settlement and therefore has refused to invest in vital infrastructure such as electricity, roads, running water, or sewage. Because of this, most of this area's economy remains informal. Residents that are employed commute out of the settlement to jobs in Nairobi, but, with unemployment at 50%, many people are idle during the day.

There are many international and local organizations acting within Kibera. Their exact number is up for debate but has been estimated to be anywhere up to 200 (Jafar, 2014). Regardless, they are key to providing much-needed services to residents that the state fails to deliver, for instance, water and sanitation services. The arrangement in Kibera means that any solution to the settlement's problems will most likely not come from the government.

The area's lack of economic resilience, coupled with the absence of competent government services, has led to severe food insecurity for families living in the settlement. This manifests itself in rapidly fluctuating markets for basic food products that can price households into malnutrition arbitrarily (IRIN, 2009). Past sources of market volatility have varied from post-election violence to outbreaks of infectious disease (Kimani-Murage et al., 2014). Kibera is desperately in need of a way to ensure that families can smooth their consumption of food in times of crisis, a need that we believe we can meet through our intervention.

Kibera is an ideal site in which to pilot such a program because of its needs, the capacity of existing civil society organizations in the area, and its history of taking to similar small-scale agricultural models. Below is an example of what a program implementing the Micro Farm Network would look like in Kibera. Keep in mind that the schedule is dependent on existing capacity in target communities and accessibility to supply networks - both of which are well-functioning in the area.

Implementation Plan

The following plan could be implemented in Kibera to create a Micro Farm Network in the settlement. Its key components should be replicable in other contexts. To implement:

Phase 1: Pilot

1. **Baseline Survey**

    1.1. Preparation (pre-arrival, Week 1)

    1.1.1. Connect with local NGO for local access: in Kibera there are a large number of NGOs with the capacity to implement this sort of project. For this hypothetical scenario, we would recommend reaching out to groups that adopt community-driven, participatory approaches. This could be achieved through networking with larger organizations with a history in the area, such as Solidarites International. See below for a discussion of potential partners.

    1.1.2. Identify Target Neighborhood: the target neighborhood should be as representative of the median household as possible. In Kibera this means selecting areas that are near the middle of the settlement, with median access to water and other services provided by NGOs.

    1.1.3. Recruit Local Staff: it is important to maintain a small staff (no more than one full-time employee and ad-hoc assistants), who should be paid at minimum the living wage of 18-25K KSh (£134-187) per month . The staff member is responsible for conducting surveys and recruiting any further assistance needed.

    1.2. Data Collection

1.2.1. Conduct Survey: the survey process should use the basic survey format described above.

1.3. Data Analysis

1.3.1. Recruitment of 15 baseline households

2. Capacity Building

2.1. Preparation (Week 1, 2)

2.1.1. Secure instruction space: space should be large enough for 30 people (women and guest/head of household if not the women themselves).

2.1.2. Identify suitable instructor: if the local staff member is able to run the training, she should do it. Otherwise she should recruit a short-term specialist in UPA from the NGO community in Kenya to run the training sessions. The large number of organizations doing this in Kenya would make it very simple to recruit such a specialist. Cost would come to expenses + hourly rate (est. < £75 total budget for both sessions).

2.2. Training (Week 3)

2.2.1. First Session: this session should serve as an introduction to the concept of the circular economy, with demonstrations of how the composting system works and how to mix the compost with soil for the veggie container, as well as an overview of the water filtration container.

2.2.2. Follow-up Session: at this session, households should be introduced to the governance system, with a series of simulations where they can practice exchanging seeds, food, and other materials they can get from the Micro Form Containers.

3. Rollout of Pilot Products (Week 3-4)

3.1. Local Partner Receives, Distributes Products

3.2. Ongoing Test Period – 6 months

Phase 1 should last for roughly 1 month, after which there will be a 6-month testing period. A proposed schedule for this phase is outlined in the gantt chart on the following page.

Phase 1: Pilot Week 1, 2

Week	1							2						
Day	M	T	W	R	F	S	S	M	T	W	R	F	S	S
Task														
1. Baseline Survey														
1.1. Preparation														
1.1.1. Connect with local NGO for local access														
1.1.2. Identify target neighborhood														
1.1.3. Recruit local staff (1)														
1.2. Data collection														
1.2.1. Conduct Survey														
1.3. Data Analysis														
1.3.1. Recuitment of 15 initial households based on survey														
2. Capacity Building														
2.1. Preparation														
2.1.1 Secure instruction space														
2.1.2. Identify suitable instructor														
2.2. Training														
2.2.3. First Session														
2.2.4. Follow-up session														
3. Rollout of Test Products														
3.1. Products are delivered to local partner														
3.2. Products are distributed to households														
3.3. Test Period														

Phase 1: Pilot Week 3, 4

Week	3							4						
Day	M	T	W	R	F	S	S	M	T	W	R	F	S	S
Task														
1. Baseline Survey														
1.1. Preparation														
1.1.1. Connect with local NGO for local access														
1.1.2. Identify target neighborhood														
1.1.3. Recruit local staff (1)														
1.2. Data collection														
1.2.1. Conduct Survey														
1.3. Data Analysis														
1.3.1. Recuitment of 15 initial households based on survey														
2. Capacity Building														
2.1. Preparation														
2.1.1 Secure instruction space														
2.1.2. Identify suitable instructor														
2.2. Training														
2.2.3. First Session														
2.2.4. Follow-up session														
3. Rollout of Test Products														
3.1. Products are delivered to local partner														
3.2. Products are distributed to households														
3.3. Test Period														

Phase 2: Evaluation and Scaling Up

This phase would include returning to the project after 6 months to evaluate its progress. Key indicators of success would be:

- Diversity of production
- Rates of childhood malnutrition in families in the Network
- Specialization in one plant and exchange for others

After evaluating the impact of the program and making adjustments to the structure of the CBO as necessary, implementers could then scale up by repeating the process above in other neighborhoods.

Opportunities For Integration With Existing Projects In Kibera

In recent years, Kibera has seen a rapid growth of CBOs. These locally based membership organizations — such as the Kenya Slum Upgrading Programme (KENSUP) and the Kenya Informal Settlement Improvement Project (KISIP) — work to develop their own communities, often with the collaborative support of NGOs (Ahmed et al., 2015). Other influential voices – including the Kenya Agricultural Research Institute, the CGIAR's Urban Harvest initiative, the environmental NGO Mazingira Institute, and the Nairobi urban farmers' forum – have argued that UPA is an essential survival strategy for Kenya's urban poor which could make a great contribution to the country's economic development (FAO, 2012b). As such, there are opportunities for integrating our idea into existing projects. For instance, Nairobi's Food Vendors' Association (FVA), a cooperative that champions food security issues in the informal settlements, offers another encouraging example (Githiri et al., 2016). Within a few months of being founded, its membership soared to almost 400 individual food vendors and producers, suggesting there is great interest in urban food production (IIED, 2014). Members are organized into local groups, who jointly buy maize flour and soap, and develop a saving scheme from which they can get loans to expand their businesses.

Such tools and principles could be transferred and integrated with an UPA cooperative – a possibility that our Micro Farm Containers/Network could deliver. Considering that slum residents are already organized around issues of home ownership and security (Wanyama, 2009), it would not be a farfetched for food production cooperatives or community gardens to develop. These cooperatives could also link up with commercial food outlets outside of the slums as a means to provide a steady market for their organic products. With food vendors' access to food being a key issue (Githiri et al., 2016; Tacoli, 2013), linking the FVA with a food production cooperative could help mitigate this problem.

The success of earlier projects in Kibera — most notably the “Garden-in-a-Sack” initiative implemented by the French relief NGO Solidarités, who handed out one sack and 43 seedlings to each family who participated in the project — also shows that there is a clear pull factor for UPA in slums (Gallaher et al., 2015). The approach is cheap and readily embraced by slum dwellers, many of whom practiced agriculture in rural areas before migrating to the city to look for jobs. Similar projects in Nairobi’s Kibera slum also saw great success. For example, Collective Community Action (CCA), a Kenyan NGO that assists with micro-gardening projects, operates in the informal settlements of Nairobi and is committed to community level development (Ahmed et al., 2015). Although Solidarités’ sack gardening program officially ended in 2012, the practice of UPA has been widely adopted and sack gardens continue to be seen throughout Kibera today. The benefits are clear: through self-consumption and the sale of surplus production on local markets, a household can save up to £15 per month (the average rent in Kibera is about £4.50 per month) (Pascal & Mwende, 2009). Sack gardening is clearly successful, but our Micro Farm Container would improve upon the idea because, through investment, it can evolve incrementally over time to become a waste management system, water filtration system and energy source for the household. By integrating our Micro Farm Container system with these networks, and building upon the successes of previous initiatives, our project aims to become an effective self-sustaining programme.

UPA is labour intensive, and therefore creates employment directly through production as well as input supply — by one calculation, there is one job for every 110 sq m (FAO, 2012b). Consequently, there are opportunities for growers to integrate with other local producers — such as ceramic manufacturers, small-scale composting enterprises or other production inputs — in order to set up and maintain the container garden. Moreover, if growers' informal associations were better organized in professional associations or legally recognized cooperatives, growers could offer economies of scale that reduce the costs of service delivery (ibid). Governments, city municipalities, input suppliers, gardeners, processors, wholesalers and retailers – need to all work together to optimize the flow of produce from grower to consumer. Interactions in and around the micro-garden can also create and reinforce social status and ties between the household and the community (Gallaher et al., 2015). As such, when properly organized and supported, it is possible for UPA to make a significant contribution to employment, nutrition and economic development in slum areas (FAO, 2012b).

Scalability and Further Applications

Pothukuchi and Kaufman (1999) note that food systems are inextricably linked to other community systems, including housing, transport, land use and economic development. Therefore, it is reasonable to suggest that by improving slum dwellers' access to healthy food, a causal sequence may occur whereby other aspects of the beneficiaries' environment may be enhanced. For example, alongside the modularity of the Micro Farm Containers, our project has the potential to create a circular economy – both at the micro level of the individual container, through the food-water-waste nexus, but also at the macro level, through food production / distribution / waste picking cooperatives in the community. As such, the project lends itself to being integrated with existing initiatives and municipals. This is bolstered by research in slum communities that has not only revealed numerous ways in which small-scale social organizations have social mechanisms to ensure cooperative behaviour, but also historical examples of successful, informal food production initiatives in urban environments (UN-Habitat, 2003). For instance, the Centre for Agro-ecological Production Studies (CEPAR), an Argentinean NGO, has promoted micro-gardening in Rosario's slums since 1987 (FAO, 2014a). Furthermore, the findings from Gallaher et al. (2015) have broader implications for UPA in cities worldwide, because they demonstrate that slum dwellers are able to successfully integrate small-scale UPA activities into their urban livelihood strategies, but also link these initiatives with community cooperatives and the local municipality.

The flexibility in function and scope of the Micro Farm Containers means that they can be successfully scaled-up and replicated in a variety of contexts. This feature is important because Latin America, Asia and Africa face very different challenges in relation to governance, private sector engagement, and the nature of slum environments. For example, the most significant issue for Africa is that industrialization is at a lower level than in Latin America and Asia, which could make a fundamental difference to slum dwellers ability to graduate from extreme poverty (Mohiddin et al., 2012). In Latin America, where the slum population has increased by some 50 million to almost half a billion since 2009, many buildings have flat rooftops with easy access, creating excellent spaces for our Micro Farm Containers to grow food (FAO, 2014a). Further evidence for this applicability exists in many of the densely populated cities of India, where rooftop gardening is becoming increasingly utilised as means to provide nutritious food to the slum community (Kumar, 2011). However, for UPA to be viewed as a viable, long-term option for urban food security, more needs to be done to formally recognise UPA as a legal activity (Gallaher et al., 2015). In many countries in Sub-Saharan Africa, UPA is still illegal or lacks official government support. Nonetheless, it is clear that low-space UPA activities like micro-gardening should receive greater consideration as part of urban development initiatives in slums. By offering an innovative product (which has a proven demand), and by forging alliances with existing initiatives, it may be possible to sustainably tackle food insecurity.

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