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GCRO OCCASIONAL PAPER
NO. 15

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JULY 2020

Compiled by
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URBAN AGRICULTURE IN THE GAUTENG CITY-REGION'S GREEN INFRASTRUCTURE NETWORK

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Acronyms and abbreviations

CLD	causal loop diagram
GCR	Gauteng City-Region
GCRO	Gauteng City-Region Observatory
GIS	geographic information systems
MCDA	multi-criteria decision analysis
QoL	Quality of Life (survey)
SWOT	strengths, weaknesses, opportunities and threats



Photograph by **Joshua Resnick/Shutterstock**

Preface

The Gauteng City-Region Observatory (GCRO) Green Assets and Infrastructure project is a multi-year programme examining the current state of green infrastructure in the Gauteng City-Region (GCR). The project's overall objective is to influence the approach to green asset management by assessing the extent to which green infrastructure has been valued by various stakeholders in the city-region, and by demonstrating ways to incorporate green infrastructure within government budgeting and planning processes. The project supports the Gauteng Provincial Government's uptake of a green infrastructure planning approach. The project provides insight into how to incorporate green infrastructure as part of the critical infrastructure trajectory that is being developed at both the provincial and local level. This publication helps build the evidence base to support the uptake of green infrastructure into policy interventions and implementation in the GCR.

The GCRO has undertaken and commissioned several research projects on urban agriculture across a number of the GCRO's research themes. In 2012, the GCRO undertook an initial scoping report to understand biomass flows in the city that would contribute to an effort to understand the city-region's urban metabolism (Schäffler, 2012). In 2013, the GCRO produced a report detailing the state of green infrastructure in the GCR (Schäffler et al., 2013), which was both an assessment of the set of natural and artificial landscape features in the city-region, including urban agriculture, and an interrogation into how the services provided by these assets are perceived, understood and valued. In 2016, the GCRO commissioned two working papers that outline the state of food security in Gauteng and possible pathways towards improved food systems governance (Kroll & Rudolph, 2016; Kroll et al., 2016). In 2018, the GCRO assisted the City of Johannesburg with the preparation of a Greening and Green Infrastructure Strategy detailing a case study on urban agriculture that highlighted urban food gardens as multifunctional green assets (City of Johannesburg, 2019).

This occasional paper, which builds on the collection of work above, is the result of a research partnership between the GCRO and University College London (UCL). As Master's of Public Administration (MPA) students in the Department of Science, Technology, Engineering and Public Policy (STEaPP), Eliana Camargo Nino, Sam Lane, Kanako Okano, Irvanu Rahman and Bo Peng undertook a research project for the Green Assets and Infrastructure team at the GCRO to gain a better understanding of urban agriculture within the green infrastructure network in the City of Johannesburg. The students collaborated with the GCRO team, which consisted of Christina Culwick, Gillian Maree and Samkelisiwe Khanyile, under the supervision of Dr Carla-Leanne Washbourne and with support by other experts at UCL STEaPP including Dr Rocio Carrero and Dr Ine Steenmans. The resulting student report (Carmargo Nino et al., 2016) was then reworked into this occasional paper by Hannah Benn, integrating the additional insights that emerged through the case study research undertaken for the Greening and Green Infrastructure Strategy for the City of Johannesburg. This work also draws on the GCRO's previous urban agriculture commissions.



Photograph by **Alastair Mclachlan**



Executive summary

Executive summary

Background and rationale

As cities in developing countries contend with the challenges of urbanisation, they need to rethink the traditional modes of urban planning and development. Part of this logic is to cater for growing populations without compromising urban environments and social development. Green infrastructure is one such approach that aims to meet infrastructure and service needs while ensuring the proper functioning of natural ecological systems. Urban agriculture can create multifunctional green assets in the form of urban farms and food gardens. When planned accordingly, urban agriculture can contribute to addressing a range of issues in the Gauteng City-Region (GCR). In the City of Johannesburg, the expansion of urban agriculture, and green infrastructure more broadly, aligns with and could contribute to multiple development goals.

This paper interrogates whether a green infrastructure approach could offer the potential to improve urban agriculture efforts if the approach can be mainstreamed into municipal development processes. Realising the benefits of urban agriculture hinges on integrating these approaches into municipal planning and projects, as well as on improving the productivity of ecosystem service delivery from both green infrastructure and urban agriculture. The focus of this report is pertinent in light of persistent infrastructure and service delivery backlogs in the GCR, considerable challenges around food systems and food security, and a highly unequal urban spatial form – all of which impact the distribution of infrastructure and services, both green and conventional. This report argues that a green infrastructure approach is valuable for drawing important connections between focus areas related to urban agriculture that are traditionally siloed. The analysis focuses on urban agriculture in the GCR's green infrastructure network using urban food gardens in the City of Johannesburg as the unit and site of analysis.

This occasional paper falls under the Gauteng City-Region Observatory (GCRO) Green Assets and Infrastructure research and links urban agriculture and green infrastructure in the GCR together for two main reasons. First, the paper outlines how food gardens are a key component of the interconnected set of the natural and constructed infrastructure systems within the city. This framing helps to link urban agriculture and food systems research to broader municipal development goals in terms of infrastructure and service delivery. Second, the paper outlines evidence of the wider social impact of food gardens which validates the ability of green infrastructure to meet social, economic and public health goals (e.g. social cohesion, employment, economic resilience) beyond a purely environmental focus. Understanding food gardens as multifunctional green assets is one way to promote and secure investment in urban agriculture in the GCR.

Context and considerations

Food gardens in the City of Johannesburg are analysed to demonstrate the range of ecosystem services that could be delivered when maintaining and investing in these assets. The paper contextualises its analysis using a comprehensive literature review that identifies the wider social, environmental and economic system interlinkages with urban agriculture, thus building the case for understanding food gardens as multifunctional assets. It draws attention to the potential ecosystem services that food gardens can

provide to the GCR, not only to situate food gardens as green assets but also to draw important connections between green infrastructure and municipal service delivery. Food gardens are sites where ecological and social systems overlap. As such, a diverse array of ecosystem services may be delivered, including:

- Supporting services, which provide the physical environment for ecosystem components to exist and develop, such as physical habitat and biodiversity.
- Provisioning services, which are the material outputs of ecosystems, including medicinal resources, ornamental plants and food supply.
- Regulating services, which control, manage and maintain ecosystems and their functioning, including air purification, local climate regulation and soil formation.
- Cultural/recreational services, which are ecosystem services that support human and social practices.

Efforts to improve urban agriculture and the service delivery potential of food gardens must navigate the broader dynamics of food systems within the GCR. The literature and policy review outlines (1) the dynamics relating to formal and informal food retail systems; (2) environmental drivers relevant to urban food gardens; and (3) the nature of community and household participation in urban agriculture in the City as they are relevant to food gardens and a green infrastructure approach. The food system in the GCR is characterised by interdependencies with water, energy, waste, transport and finance systems, as well as disparities and inefficiencies that persist from historical inequity. Food insecurity persists despite increases in productivity resulting from technical innovations in agriculture. The GCR is not primarily an agricultural region and access to productive inputs is limited. Food (in)security in the GCR reflects the city-region's food environments. In other words, food security is more a question of food access and the spatial layout of the food retail system than a question of insufficient food production (Kroll, 2016).

These realities justify the need for the promotion of food gardens as both a social and ecological instrument within urban sustainability efforts. However, this should be accompanied by the critical understanding that they will need to be part of a larger, targeted and more holistic strategy to combat development challenges in the GCR. Understanding the current policy approach to urban agriculture and green infrastructure in the GCR is necessary for identifying where and how food gardens can be framed as multifunctional green assets. Evidently, between the various policies, programmes and legislation, mandates often overlap between spheres of government, which causes a lack of clarity on responsibility and misalignment between programmes and efforts. This is a possible cause for the lack of impact and traction by some of the more promising policies in this space. Overall, there are limited linkages between policies for food security, food systems, urban agriculture and green infrastructure in Johannesburg and the greater GCR.

Analysis and results

The analysis in this paper adopts a multi-method modelling approach to (1) identify the interlinkages between urban agriculture and social, economic and environmental systems in the City of Johannesburg; (2) validate these critical interlinkages with stakeholder input and ground-level experience of urban agriculture; and (3) visualise the aforementioned interlinkages through a spatial analysis of food gardens in the City of Johannesburg.

The interlinkages are represented in a causal loop diagram (CLD). A CLD is a visualisation that shows how variables in a system are interrelated by linking them according to the nature of their correlations and relationships. The CLD demonstrates the multifunctional nature of food gardens by highlighting the range of services and benefits they could deliver. These include regulating and supporting services to the urban environment (food gardens' impact on and interaction with climate change and flooding), provisioning services through food access (food gardens' impact on and interaction with health and poverty, and food security), as well as cultural and recreational services to communities (food gardens' dependence on government investment, and food

gardens' contributions to socio-economic development and job creation). Furthermore, in the context of the GCR, these ecosystem services align to important needs in terms of municipal service delivery such as stormwater management, as well as priority focus areas such as youth unemployment. Overall, the CLD demonstrates how food gardens and urban agriculture are nested in the complex urban environment of Johannesburg.

The CLD was validated by stakeholders using semi-structured interviews and surveys, as well as a multi-criteria decision analysis (MCDA) with key experts. Data from the interviews and surveys informed the development of a summary strengths, weaknesses, opportunities and threats (SWOT) analysis highlighting the internal and external factors that impact food gardens in the city.

Lastly, to establish a new map layer and spatial understanding of food gardens that can assist decision-makers in the City, the spatial analysis located and investigated 198 food gardens in Johannesburg. This analysis enables the potential benefits of food gardens to be contextualised against the prevailing socio-economic conditions in the City of Johannesburg. Major trends show that the wards with a medium unemployment level have the largest number of food gardens, and the wards with the highest unemployment rate have few food gardens. In other words, the wards with higher food demand have fewer food gardens. Overall, the maps show that food gardens are less common in the northern and southern urban peripheries while particular wards in the urban centre have more food gardens.

The results of the various analyses confirm that food gardens are multifunctional green assets because they deliver a range of ecosystem services in the City of Johannesburg. The supply of provisioning services from food gardens plays an essential role in many communities in the City, and food gardens further contribute to the critical supporting and regulating services provided by the broader green infrastructure network. Ultimately, the delivery of these ecosystem services is well aligned to the social services and infrastructure development needs outlined in municipal service delivery goals. These findings justify investment in the management and provision of operational resources in food gardens within the broader green infrastructure network in the GCR.

Recommendations

This paper builds the argument that food gardens are a multifunctional element of the green infrastructure network in the GCR. It is worth maintaining and investing in food gardens because they contribute to a number of development imperatives in Gauteng. Food gardens enhance food security by broadening the range of locally produced food sources that improve the potential to help the poor to access fresh food. Food gardens also enhance the green infrastructure network in the GCR by strengthening the provision of a range of ecosystem services. Productive food gardens provide economic opportunities, particularly in areas with minimal access to retail outlets and where unemployment is high. Lastly, as part of the green infrastructure network, food gardens also contribute to addressing climate change and building disaster resilience through flood management and carbon capture.

This research contributes to the growing literature on urban agriculture and green infrastructure, and provides insights for integrated planning in the GCR. The key recommendations arising from this paper are to strengthen the productivity of food gardens for poverty alleviation and to improve land use policy support to ensure food gardens, as part of the green infrastructure network in the GCR, have an allocation within land use management.



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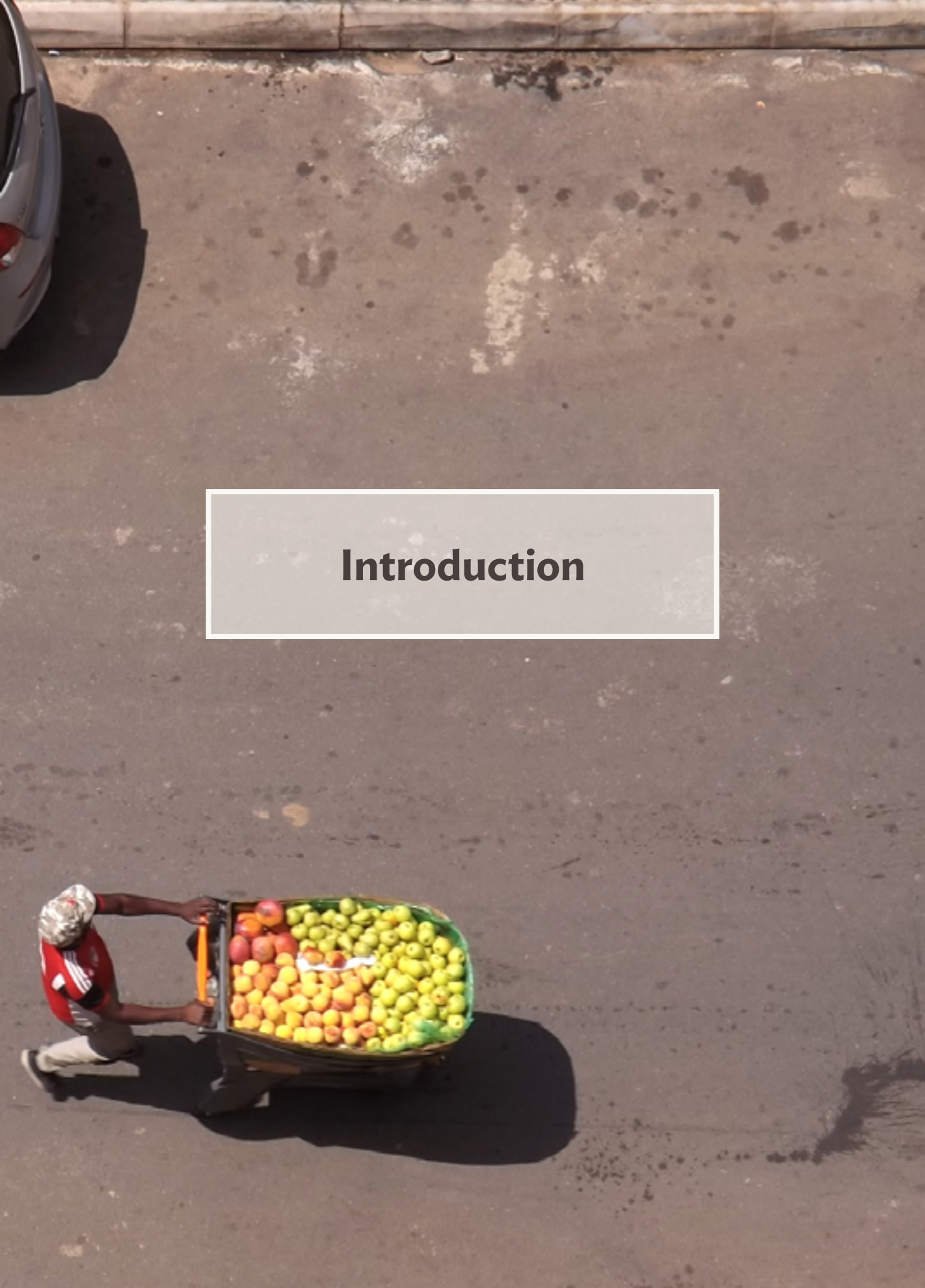


Introduction

Introduction

A green infrastructure planning approach

Globally, cities are contending with the challenges of urbanisation and, for the most part, current approaches are failing to achieve an urban transition that is both environmentally sustainable and socially just. In response, innovative and alternative approaches to development are emerging from a range of disciplines. Part of this logic for cities in developing countries is the need to rethink the traditional mode of urban planning and development in a way that can cater for the needs of the current and growing urban population, but without the negative impacts that have been characteristic of urban development in the developed world. Green infrastructure is one such approach that aims to meet infrastructure and service needs while ensuring the proper functioning of natural ecological systems. This, in turn, ensures the delivery of ecosystem services which can be complementary to, or commensurable with, traditional municipal service delivery. This paper considers urban agriculture as a key application of a green infrastructure approach.

Several benefits are envisioned from the expansion of urban agriculture, and of green infrastructure more broadly, because these two areas of practice have a reciprocal relationship that could align with, and contribute to, multiple development goals. Urban agriculture contributes to meeting some objectives of an effective green infrastructure network by enabling the delivery of a range of ecosystem services, including provisioning services (food and other products), supporting services (habitat functions and biodiversity), regulating services (soil nutrient formation, climate and climatic hazard regulation, and pollution control), as well as cultural services (recreation, social interaction and cohesion). A green infrastructure approach offers the potential to improve urban agriculture efforts if the approach can be mainstreamed into municipal development processes. Realising such benefits hinges on integrating these approaches into municipal planning and projects as well as on improving the productivity of ecosystem service delivery from urban agriculture, and from green infrastructure more broadly.

The focus of this paper is pertinent in light of persistent infrastructure and service delivery backlogs in the Gauteng City-Region (GCR), considerable challenges around food systems and security, and a highly unequal urban spatial form which impacts the distribution of infrastructure and services, both green and conventional. The GCR is not primarily an agricultural region. Nonetheless, activities such as the establishment of rooftop gardens in the inner-city (Vivier, 2018), or the mobilisation of small-scale farmers' networks (Malan, 2015) suggest that an urban farming movement is well underway. The policy and academic analyses in this space have tended to be siloed in either urban agriculture or food systems and security. First, this has contributed to an uneven distribution of research effort and knowledge building in each area. Second, there is also an inadequate understanding and appreciation of the interlinkages between these areas and the social, ecological and economic systems in which they exist.

This paper argues that a green infrastructure approach is valuable for drawing important connections between focus areas related to urban agriculture that are traditionally siloed. The analysis focuses on urban agriculture in the GCR green infrastructure network using urban food gardens in the City of Johannesburg as the unit and site of analysis. This paper defines urban food gardens (hereafter, food gardens) as domestic or small-scale commercial gardens that tend to operate at the

community scale.[1] Food gardens are considered as green assets in this analysis to demonstrate the complexities and opportunities available to urban actors taking these approaches forward. This paper considers whether improving the understanding of the benefits of food gardens (as green assets), together with a spatial analysis of existing food gardens, could help to inform decision-making around the support of urban agriculture and green infrastructure in the GCR.

It is important to recognise that green assets are accountable to several systems of governance and various infrastructure sectors. This is to say that, traditionally, social, economic, or technical and engineering focused sectors will all have various influences on green infrastructure. In the case of urban agriculture, the broader food system in the GCR is complex and dynamic and will exert influence over any approach taken. This paper explores whether using green infrastructure as a lens to implement, manage or support food gardens could have any benefits for broader greening efforts as well as for improvement in food and nutrition security.

Aims and structure

This occasional paper ties urban agriculture and green infrastructure together in the City of Johannesburg for two main reasons. First, the paper outlines how food gardens are a key component of the interconnected set of the natural and constructed ecological systems within the City. This framing helps to link urban agriculture and food systems research to broader municipal development goals in terms of infrastructure and service delivery. Second, the wider social impact of food gardens provides an example that validates the ability of green infrastructure to meet social, economic and public health goals (e.g. social cohesion, employment, economic resilience) beyond a purely environmental focus. Understanding food gardens as multifunctional green assets is one way to promote and secure investment in and support for urban agriculture in the GCR.

The next section comprises a comprehensive literature review that identifies the wider social, environmental and economic system interlinkages with urban agriculture, thus building the case for understanding food gardens as multifunctional assets. It draws attention to the potential ecosystem services that food gardens can provide to the GCR, not only to situate food gardens as green assets but also to draw important connections between green infrastructure and municipal service delivery. The review then outlines and compares the current policy approach to urban agriculture and considers the broader context of food systems and security in the GCR, noting the extent to which green infrastructure and, by extension, food gardens are influenced by these dynamics. The next section then outlines the multi-method investigative and modelling approach taken to understand how food gardens deliver multifaceted objectives as green assets, and the appropriate policy recommendations toward this end. The results of this analysis are then presented in the following section. The analysis involves a qualitative modelling exercise to create a causal loop diagram (CLD) that aids in visualising the various benefits associated with food gardens, as well as visualising the key policy connections that can inform food garden management. Surveys and semi-structured interviews inform a multi-criteria decision analysis (MCDA) that in turn validates the CLD with stakeholder input. The creation of a spatial layer of existing food gardens accompanied by a spatial analysis further contributes to situating and visualising the CLD and MCDA modelling outputs in relation to food gardens in the GCR. The results of the spatial analysis and modelling provide valuable insight that could be used to inform policy interventions for prioritising food gardens as part of green infrastructure policy in the GCR. The paper concludes with these recommendations in the final section.

1 Note that the medium- and large-scale commercial agriculture that occurs on the GCR's urban periphery is not included in the scope of this paper. However, this agricultural land remains a key part of the GCR's green infrastructure network, potentially providing valuable ecosystem services, particularly if managed according to agro-ecological and climate-smart agricultural principles.



Photograph by **Cari Griffith/Shutterstock**



Literature and policy review

Literature and policy review

Urban agriculture as a green asset

A green infrastructure approach is valuable for drawing important connections between focus areas related to urban agriculture that are traditionally siloed. An urban ecosystem service framework (Bolund & Hunhammar, 1999) is useful in understanding the concept of multifunctionality. Food gardens foster the stewardship of natural assets within cities (Langemeyer et al., 2018). At these sites, where ecological and social systems overlap, a diverse array of ecosystem services may be delivered. Langemeyer et al. (2018) demonstrate that food gardens are indeed sites that deliver a range of ecosystem services in cities. Olivier and Heinecken (2017) found that urban gardens are also places of economic and social benefit for poor or marginalised cultivators. The potential that they identified for ecosystem service delivery from food gardens is demonstrated in Table 1.

Cilliers et al. (2017) emphasise that communal food gardens are a viable means of providing social and economic benefits, especially in contexts where the majority of the population do not have access to, or land for, a private garden. The extent to which food gardens can provide various ecosystem services is considered in this review according to ecosystem service typologies, which are explained next.

Supporting services

Supporting services include the enabling of biodiversity and the preservation of habitats for wildlife and other ecosystem processes. Biodiversity supports and maintains habitats that deliver all other ecosystem services (De Groot et al., 2002). Home gardens, used here as a proxy for food gardens due to the availability of relevant research, make a major contribution towards urban biodiversity. A study of 100 domestic gardens in the Tlokwe municipal area (Potchefstroom) produced a list of 251 indigenous plant species (Lubbe et al., 2011) which are purposely cultivated to produce provisioning services (e.g. firewood, shade, leafy vegetables and fruit), supporting services (e.g. hedges as habitat) as well as for their cultural significance and aesthetic improvement. Molebatsi et al. (2013) found that home gardens contribute more to plant diversity than open space and natural areas.

However, to allow for the introduction and maintenance of high plant diversity, the successful delivery of supporting services is dependent on a household's purchasing power, knowledge of plants and consistent labour. This in turn is valuable in supporting the everyday life of the household as it contributes towards nutrient recycling, primary food production and soil formation (De Groot et al., 2002). Relatively high plant species richness and the diversity of home gardens are dependent on garden size and socio-economic factors (Lubbe et al., 2010). Thompson et al. (2010) showed in a comparative study of peri-urban gardens in Sudan that plant diversity is greatly reduced in areas where urban and peri-urban agriculture becomes predominantly concerned with fast-growing, high-yielding cash crops.

Provisioning services

Food gardens have been identified as an affordable way to access fresh produce for people willing to participate (Armstrong, 2000; Patel, 1991; Teig et al., 2009). Urban agriculture has been a successful strategy for improving food access in food insecure areas (Armstrong, 2000; Balmer et al., 2008; Corrigan, 2011; Larsen & Gilliland, 2008). However, there is little evidence to support a significant contribution of urban agriculture towards household food security strategies; this is because the impact depends on how certain prerequisites and other conditions are met (production, land, inputs, knowledge, among others)

Table 1: Ecosystem services provided by urban gardens

DATA SOURCE: Adapted from Olivier and Heinecken (2017) and Langemeyer et al. (2018)

Service type	Services
Supporting services *Provide the physical environment for ecosystem components to exist and develop*	• Habitat provision • Biodiversity
Provisioning services *Material outputs from ecosystems*	• Medicinal resources and ornamental plants • Food supply (quantity) • Food supply (quality)
Regulating services *The services which control, manage and maintain ecosystems*	• Air purification • Local climate regulation • Global climate regulation • Maintenance of soil fertility • Pollination
Cultural and recreational services *Ecosystem services that support human cultural and recreational practices*	• Social cohesion and integration • Place-making • Aesthetic information • Nature and spiritual experiences • Relaxation and stress reduction • Entertainment and leisure • Exercise and physical recreation • Learning and education • Maintenance of cultural heritage • Personal empowerment through life skills and business training • Physical (health) and psychological benefits (relief from anxiety) • Sense of pride and accomplishment • Social capital and community building

to develop successful urban agriculture strategies (Frayne et al., 2014). In addition, the small scale of food gardens and their low productivity can limit their positive benefits with regards to meeting food security and poverty reduction goals in Johannesburg (Malan, 2015). On a small scale, while food gardens provide vegetables and edible plant products, their ability to address food security is contested. Adekunle et al. (2013) caution that home garden production is not optimal in sub-Saharan Africa due to constraints such as the lack of space, water and technical gardening skills and information. Domestic food gardening would therefore not have a lasting effect on food security. As such, the general perception that urban and peri-urban agriculture alleviates poverty and increases food security in developing countries is heavily debated. According to Webb (2011), these claims mostly neglect adequate consideration of the 'poorest of the poor' who are engaged in urban and peri-urban agriculture.

Nonetheless, food gardens can contribute to the process of diet diversification in which a greater variety of food is made available and accessible, especially when gardens promote biodiversity (Cilliers et al., 2017). Some recent studies have shown the

importance of native plants as diverse sources of nutrients (Faber et al., 2010; Van Jaarsveld et al., 2014). Van Jaarsveld et al. (2014) indicate that traditional leafy vegetables can considerably increase iron and vitamin A in people's diets in developing countries. The use of traditional vegetables differs, however, between provinces in South Africa and between rural and urban areas in terms of type and source, consumption patterns and preference (Faber et al., 2010).

The contribution of urban agriculture to food supply within broader food systems as well as to community food security in urban areas is contested. While highly localised cases have demonstrated urban agriculture as a successful grassroots solution to food security (e.g. Olivier & Heinecken, 2017), other literature suggests that these benefits are overstated and the impact of urban agriculture on a developing country's food security is limited (Badami & Ramankutty, 2015; Cilliers et al., 2017). Nonetheless, food gardens are important socio-ecological systems that incorporate vegetation for provisioning services in the urban setting.

Regulating services

Regulating services include, inter alia, climate regulation, water purification and pollination. It is unlikely that urban agriculture efforts will lead to considerable provision of regulating services. Furthermore, the demand for specific ecosystem services from food gardens differ along a socio-economic gradient (Davoren et al., 2015). For example, poor communities in South Africa often place greater value on 'useful plants' (provisioning ecosystem services such as food and medicine) rather than plants providing only regulating or cultural (aesthetic) ecosystem services (Davoren et al., 2015). The more affluent communities in South Africa can, however, afford to purchase their food and medicine and, therefore, their larger tree-dominated gardens are good suppliers of regulating services (Davoren et al., 2015) and provide aesthetic improvement of the urban environment.

In terms of regulating urban services, Labuschagne and Zulch (2016) demonstrate how food gardens on inner-city rooftops provide benefits such as insulation (both thermal and sound). In summer, vegetated roofs protect buildings from solar radiation, contribute to cooling and ultimately diminish urban heat islands. In winter, rooftop gardens prevent loss of heat through external layers. Vegetated roofs also save electricity for both heating and air conditioning and can therefore extend the life of roof insulation. Other benefits include the control of rainwater runoff, habitat provision and the improvement of urban air quality.

Cultural and recreational services

Socially, food gardens may also contribute to cultural and recreational services. Food gardens have been credited with the ability to create areas which can contribute to, rebuild and improve recreational areas in communities. Food gardens and urban farming beautify communities and may reinforce social cohesion among residents where gardens are managed communally (Bradley & Galt, 2013; Teig et al., 2009). Some studies have shown that communities where food gardens exist have lower crime rates (Bradley & Galt, 2013; Ober Allen et al., 2008; Teig et al., 2009). This view complements the findings in this paper, namely, that communal food gardens encourage neighbourhoods to become more familiar with each other and occupy leisure time in a productive way (Armstrong, 2000). This point of view is widely reiterated by community garden programmes, which can act as places for increased communication and social interaction within the community (Saldivar-Tanaka & Krasny, 2004; Teig et al., 2009).

In terms of mental health and physical activity, food gardens, especially community gardens, have built an entry point for residents to take part in farming and thereby participate in physical activities (Armstrong, 2000). It has been noted that community food gardens could create opportunities for physical activity for sustained periods of time. This aligns strongly with the findings of this paper that mental health benefits are gained from engaging with food gardens.

To ensure and enhance the delivery of such services in the Gauteng City-Region (GCR), policy interventions for food gardens should consider the wider social, economic and political realities in the region.

Urban food systems and broader dynamics in the GCR

Efforts to improve urban agriculture and the service delivery potential of food gardens must navigate the broader dynamics of food systems within the GCR. Kroll et al. (2016) undertook a review of stakeholders and flows in the GCR that revealed a sophisticated, dynamic and adaptive food system. However, stakeholders in each phase of the food system require inputs from other systems in order to function, such as from water, energy, transport, communications and finance systems. These dependencies mean that each phase of the GCR food system is vulnerable to impacts from other systems. Such dependencies also cross levels of scale so that the GCR is exposed to global trends. Kroll and Rudolph (2016, p. 32), who have done extensive research in this space, summarise these dynamics below.

> *The GCR food system reveals huge disparities in knowledge, power and voice, is rooted in historical inequity and dispossession, produces huge inefficiencies (wasted food, water, electricity, fuel), erodes ecosystems throughout the region, is vulnerable to economic and environmental shocks and ultimately harms those least empowered: the elderly and the children. Food insecurity is an intrinsic outcome produced and required by the complex power dynamics and interdependencies operating in the food system. Food insecurity persists despite increases in productivity resulting from technical innovations in agriculture. The scale and nature of support to smallholders is inadequate. It is unlikely that the bulk of food required to sustain the 13 million residents of the GCR can be consistently supplied by smallholders. The GCR is not primarily an agricultural region and access to productive inputs is challenging. The food system currently disadvantages smallholders, making participation in the formal food economy difficult, risky and unsustainable. The inequities and inefficiencies of the food system are a necessary outcome of a neoliberal political agenda in which the interests of large corporations and transnational capital are disproportionately represented and supported by regulations and legal systems favouring further concentration, accumulation and adverse incorporation. Technological innovation and improved efficiencies may mitigate some impacts but are likely to intensify value-chain consolidation which is a key driver of adverse incorporation, environmental and climate change. Furthermore, technological innovations and improved efficiencies are generally out of reach for most smallholders.*

The GCR food system dynamics are examined briefly below in terms of formal and informal economy dynamics, environmental drivers and the nature of citizen participation in urban agriculture in Gauteng.

Formal and informal food retail systems

Food (in)security in the GCR reflects the city-region's food environments. In other words, food security is more a question of food access and the spatial layout of the food retail system than a question of insufficient food production (Kroll, 2016). Gauteng has not been immune to the processes of agro-industrialisation of the global food system. There is a growing demand for processed and meat-based meals, growing dependency on rural food production to supply growing cities and, above all, the urban demand for food is increasingly met through large supermarket chains (Kroll, 2016; Schäffler, 2012). There are several geopolitical and sustainability issues associated with this kind of system. The impacts of 'the industrialised and unregulated nature of the modern food system include environmental degradation, climate change, high dependency on fossil fuels, marginalisation of small farmers and high levels of food insecurity linked to unfair global trade' (Schäffler, 2012, p. 42). Rudolph et al. (2012) found that more than 70% of households in Johannesburg source food from informal markets or roadside stalls at least once a week. This may be linked either to high levels of mobility and long-distance commuting within the City (and the difficulty and cost of transporting large volumes of food from supermarkets) or to inadequate cold storage in households which may not have fridges or electricity (Rudolph et al., 2012). However, these small-scale or informal actors are repeatedly marginalised by the broader industrialised food system, leading to

considerable challenges when aiming to expand local markets and the impact of food gardens.

Nonetheless, the informal economy is an important source of food for poorer households in the GCR, with street vendors, corner stores and other small-scale operators and micro-entrepreneurs operating alongside supermarket chains (Kroll, 2016; Rudolph et al., 2012). Informal food sources play a significant role in urban household food provisioning strategies, bolstered by sharing and borrowing, especially among the food insecure (Battersby & Marshak, 2013; Crush & Caesar, 2014; Rudolph et al. 2012). Skinner and Haysom (2018) show that about 40% of informal workers are involved in trading and 67% of those workers trade in food, which reflects the national trend where South Africa's 'modern' food retailers (such as supermarkets, hypermarkets and discounters) constitute only between 44% and 54% of the total food wholesale and retail market. The balance consists of smaller so-called 'traditional' grocery retailers, independent grocers and a large number of informal 'spaza' shops. Currently the latter sub-sector is treated as secondary in policy and is often considered a backward system in need of modernisation (Skinner & Haysom, 2018). Skinner and Haysom (2018) introduce the idea that, in aggregate, the informal or small food retailers could be similar to, or even larger than, the formal retailers in monetary terms. This is significant because it suggests that while corporate wholesalers and retailers have concentrated market power, there is also a wide base of economic activity beyond corporations. Moreover, estimations show that the five big retailers only employ about 25% of all retail workers – the vast majority of retail workers work in spaza shops or as street traders.

Informal food retailers have several characteristics which distinguish them from formal food retail, including that they: (1) are not registered for tax or employee benefits; (2) have few employees (often within the same household); (3) have minimal infrastructure and equipment; (4) have comparatively narrow margins; (5) have strong backward linkages into the formal economy; and (6) are located in public spaces with high pedestrian traffic or in small shops attached to people's homes (spaza shops) (Chen, 2007; Devey et al., 2006; Horn, 2011; Lehola, 2014; Neves et al., 2011).

In the case of community food gardens, it is also important to understand the spatial arrangement of the food system in Johannesburg within the green infrastructure network. The distribution of food gardens should be considered alongside the distribution of supermarkets and informal food traders and providers. The distribution of supermarkets is unequal in Johannesburg, with greater frequency in wealthier areas (Kroll, 2016). However, supermarkets are becoming closer and more accessible to the urban poor through their expansion along busy transport corridors and placement at transport nodes (Kroll, 2016). There are also distinct patterns in the location and distribution of informal food traders, who are also concentrated at transport nodes. The inner city in Johannesburg is more densely served by both food traders and supermarkets than the urban periphery despite the apparently greater need in the relatively under-served urban periphery (Kroll, 2016). The inner-city prevalence may reflect that these areas are able to sustain relatively more food traders due to passing trade, and also that higher levels of unemployment and lower incomes mean that the peripheral urban economies can sustain fewer food traders (Kroll, 2016).

In Johannesburg, 54% of the population are food insecure or hungry (Shisana et al., 2013). Dietary diversity is generally low, and the poor and food insecure increasingly live in urban contexts (Crush et al., 2011). As discussed above, the formal food retail system has limitations and these will impact the success of food gardens. Given that the urban poor in South Africa frequently access food from informal food retailers (Crush & Caesar, 2014; Rudolph et al., 2012), informal food networks need to be considered in the support and expansion of the supply from urban agriculture (Malan, 2015).

Environmental drivers

There is a bi-directional relationship between the natural environment and food gardens. As demonstrated above, food gardens are an important asset that can contribute several ecosystem services to the GCR. Conversely, environmental factors affect

urban agriculture, green infrastructure and food systems. Among the environmental drivers relevant to the GCR, climate-change related shifts in weather – including rainfall and temperature patterns, extreme weather events such as hail, sudden downpours or extreme winds, natural climate events as well as climate variation – impact green infrastructure ecosystem service provision.

Water security is also a major factor impacting urban agriculture in the GCR, which is not immune to the water risks facing the country as a whole. Given the province's location in the watershed that separates the Orange and Limpopo basins, there are very limited natural streams (Maree et al., 2017). The urban region relies on an engineered solution that transfers water from Lesotho to the Vaal River system in addition to other catchments to meet the GCR's water demand (GCRO, 2018). With multiple uses competing for water, the findings in this paper suggest that food gardens suffer as a lower-priority recipient of increasingly scarce and contested water in the GCR.

In addition, the food system is itself a major contributor to global environmental change and is implicated in several ecological problems, including increased demands for irrigation water, increased pollution from agricultural inputs (fertilisers, weed killers, pesticides), soil loss and increased energy demands in food production sectors. Land use change and associated land degradation also diminish the land available in the GCR for which food gardens could possibly be used. Food production activities, especially commercial agriculture, compromise ecosystem services and erode natural capital in the form of land, water and biological resources used for human activities (Millennium Ecosystem Assessment, 2003).



Photograph by **Cecil Bo Dzowa/Shutterstock**

Participation in urban agriculture in Gauteng

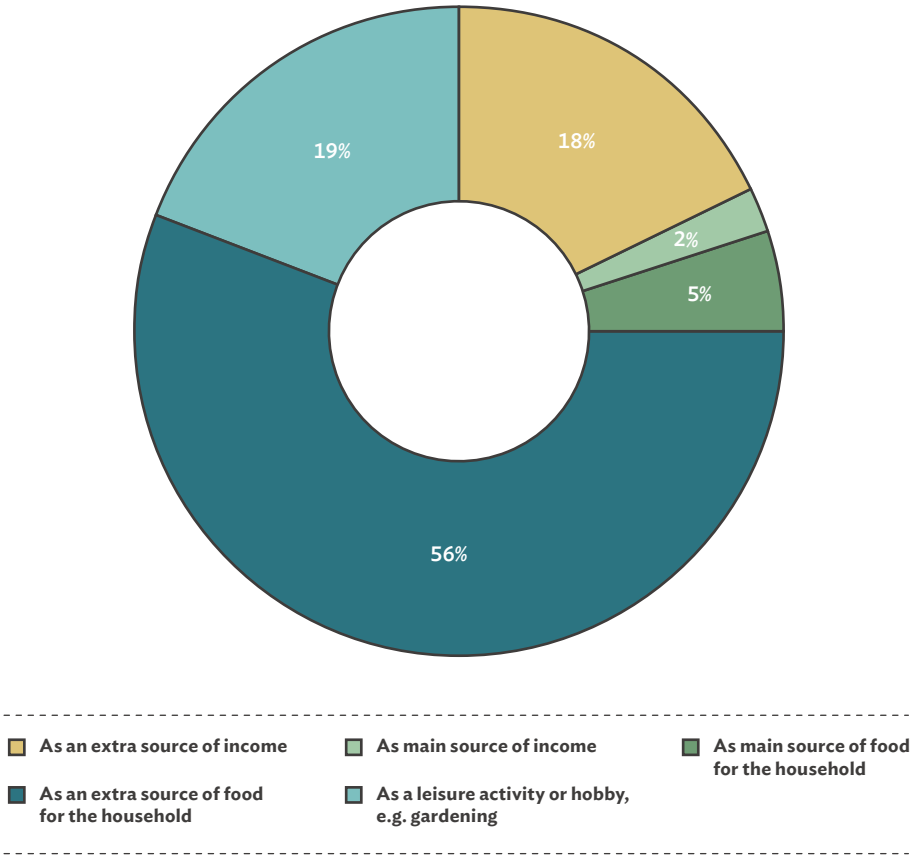
In this paper, participation in urban agriculture is understood as domestic or community-scale food growing practices in private and communal food gardens. There are several sources of data available that outline domestic food growing practices in the city-region. Warshawsky (2011) found that only 9% of households in South Africa grow some of their own food; the proportion is higher in peri-urban areas (16%) than in townships (8%) and the inner city (2%) where land is less available. It is important to consider these realities against the broader status of food security in the GCR. According to the 2011 General Household Survey, only 6% of Gauteng households participated in urban agriculture (Statistics South Africa, 2011). These households reported various different reasons for participating in agriculture, outlined in Figure 1.

Most of these households participated in agriculture to provide an extra source of food for the household. Similar proportions grew food as a primary food source (18%) or were involved in farming as a leisure activity (19%). The nature of these activities suggests that farming in Gauteng is polarised between very impoverished and affluent households.

Figure 1: Reasons for growing food in Gauteng, 2011

GCRO

DATA SOURCE: Statistics South Africa (2011)

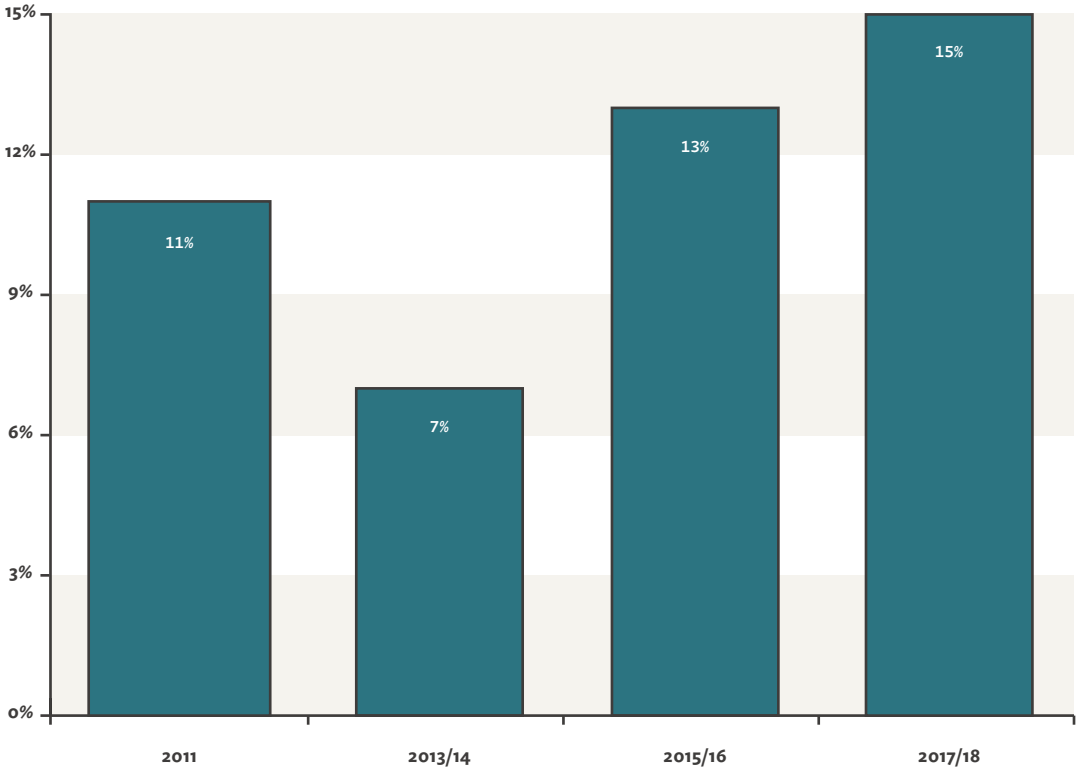


The GCRO's Quality of Life (QoL) survey includes the latest information relating to domestic food growing practices in the GCR. Among other findings, the survey identified the proportion of households in the GCR growing produce to eat, sell or to eat and sell, as well as how this proportion has changed since 2011 (Figure 2).

The low participation in urban agriculture seems to be the result of various factors, which include lack of access to adequate land due to the marginalisation of poor communities to areas with poor soils, competition for land use for housing development, poor access to markets due to inadequate quantities and inconsistent quality of produce, restrictive municipal by-laws, lack of access to extension services, inadequate training opportunities, inadequate urban farming and entrepreneurial skills, and lack of access to agricultural inputs such as seed, fertilisers and water (Kroll, 2016; Kroll et al., 2016). This paper argues that a green infrastructure approach to urban agriculture may contribute to addressing some of these challenges. For example, mainstreaming a green infrastructure approach is intended to improve the quality of the urban environment, which may, in turn, improve the conditions that support successful urban agriculture (such as through enhanced regulating services that improve soil conditions).

Figure 2: Proportion of households in the GCR growing food to eat and/or sell, 2011–2017/18

DATA SOURCE: GCRO QoL II–V (2011–2017/18)



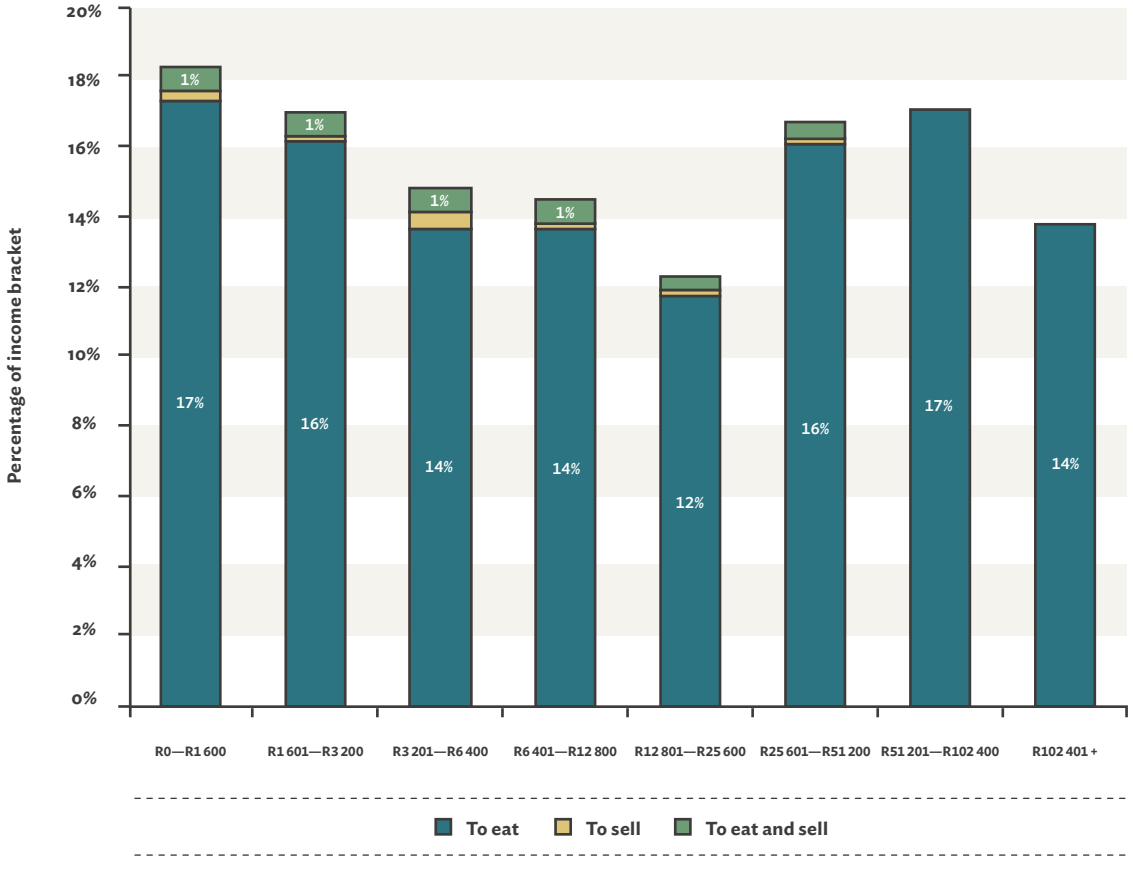
The GCRO's QoL V (2017/18) survey demonstrates that growing food is primarily to eat within the household. However, the survey shows that some lower earning households grow food in order to supplement their monthly household income (Figure 3).

These realities justify the need for the promotion of food gardens as both a social and ecological instrument within urban sustainability efforts. However, this should be accompanied by the critical understanding that they will need to be part of a larger, targeted and more holistic strategy to combat food insecurity in the GCR. Understanding the current policy approach to urban agriculture and green infrastructure in the GCR is necessary for identifying where and how food gardens can be framed as multifunctional green assets. The final section of this paper's literature and policy review establishes this baseline.

Figure 3: Households in the GCR growing food to eat and/or sell disaggregated by income bracket, 2017/18

GCRO

DATA SOURCE: GCRO QoL V (2017/18)



Policy overview

Here, a brief overview of key national, provincial and local policies and programmes around food security aims to contextualise the current government approach to urban agriculture and its impact on food gardens in Johannesburg. A thorough review of relevant food security and urban agriculture policies is available in Kroll and Rudolph (2016). The policy framework for green infrastructure rests largely within individual municipalities, either through explicit green infrastructure programmes or strategies, or through inferred policies such as bioregional plans. A review of green infrastructure policies for the GCR is available in Schäffler et al. (2013). Evidently, between the various policies, programmes and legislation, mandates often overlap between spheres of government, which causes a lack of clarity on responsibility and a misalignment between programmes and efforts. This is a possible cause for the lack of impact and traction of some of the more promising policies in this space. Overall, there are limited linkages between policies for food security, urban agriculture and green infrastructure.

National Policy on Food and Nutrition Security

The National Policy on Food and Nutrition Security aims to ensure the availability, accessibility and affordability of safe and nutritious food at national and household levels (Department of Agriculture, Forestry and Fisheries & Department of Social Development, 2013). The policy recognises the connection between food security, and poverty and unemployment. However, there is no link in the policy to urban agriculture as a possible source of food in South Africa, nor is there a consideration of green infrastructure and the potential provision of services that green assets may deliver to support food access.

The policy does reflect a nuanced consideration of the complexity of challenges to food security that link to social, political and environmental systems. These include:

- Distribution inequalities and waste;
- Inadequate knowledge, information and money to enable healthy choices;
- Lack of emergency management systems to assist people in chronic or acute need;
- Climate change, poor land management, mining and urban development threaten production;
- Rising farm input costs threaten viability of farming operations;
- Limited opportunities for smallholder farmers to access markets;
- Reduced number of farms and land area cultivated;
- De-regulation disadvantages smallholder farmers;
- Dependence on global input supply chains and link to global price fluctuations, especially fertilisers and fuel; and
- Rural–urban disparities in food prices (Kroll & Rudolph, 2016).

While there is work to be done to improve the framing and understanding of urban agriculture and green assets as multifunctional, a 'systems' understanding is emerging in policy development at the national level.

Gauteng 20-year Food Security Plan

The release of the Gauteng 20-year Food Security Plan by the Gauteng Department of Agriculture and Rural Development (2014) is an important step towards developing coherent food security policies and planning. By 2030, the plan aims to reduce by half the 2011 levels of hunger and inadequate access to food by coordinating targeted programmes to this end.

However, the approaches detailed in the plan lean heavily towards an agricultural and rural food security paradigm, and thus fail to consider and address the contextual challenges of decentralised and small-scale urban agriculture efforts. This is a critical oversight as, despite the fact that food gardens are unlikely to solve food insecurity in Gauteng, the primary function of food gardens is to produce food.

Gauteng Green Strategic Programme

A food sector review conducted for the Gauteng Green Strategic Programme identified several key issues with the food security policy and strategy landscape and formulated specific recommendations in response (Gauteng Department of Economic Development, 2011). The key issues include lack of transparency, awareness and participation; scattered responsibility and a disconnect between local and provincial spheres; over-emphasis on food production as opposed to food access, utilisation and resilience; lack of capacity in government and in communities; and, lastly, a weak and uncompetitive small-scale and organic or conservation agricultural sector. The strategy makes several recommendations to alleviate these key issues, such as collaboration with the corporate sector and strengthened collaboration with community-based organisations to promote awareness and relieve capacity constraints. This would also involve providing resources and land to train and enhance urban agriculture efforts, which could be administered by improving interdepartmental coordination and alignment through a central food security and urban agriculture task team. While these recommendations are appropriate and would impact the functioning and success of food gardens, they would require considerable political will and action to implement. The framing of food gardens and urban agriculture as a multifunctional green asset is strongly aligned to these recommendations.

City of Johannesburg Food Resilience Policy

The City of Johannesburg has a dedicated Food Resilience Unit. Through this unit, Johannesburg has its own Food Resilience Strategy to combat food security issues in the urban context. Among the proposed action areas in this strategy are improving the knowledge base as well as raising public awareness and mobilising citizens. Improving access to food will be enabled through support for food gardens; a food bank, smartcards or vouchers as a way for qualifying families to access subsidised food; development of the informal trading sector; people's restaurants; food-for-waste exchange; and food credits that can be redeemed at local stores and markets. Support to micro-farmers and emerging agriculture is also detailed in the strategy through resource centres and extension services. However, the Food Resilience Unit currently sits in the Department of Social Development, where the consideration of food gardens and urban agriculture is framed both too vaguely and narrowly for the purposes of education and broader food security (Kroll & Rudolph, 2016).

Therefore, in practice, many of these mechanisms have yet to be established, and the urban agriculture sector remains severely hindered by constraints on the potential for commercialisation of urban agriculture; a lack of institutional mechanisms to promote access to the necessary resources; a lack of adequate and appropriate training; and inadequate organisational and social capital development among farmers' organisations (Rudolph & Kroll, 2016). The result is that the multifunctional ecosystem services that could be delivered by food gardens are yet to be supported by effective policy, thus delaying their realisation in Johannesburg.

City of Johannesburg Green Infrastructure Strategy

The Johannesburg Metropolitan Open Space System (JMOSS) was developed in 2002 with the view to address the loss of green spaces. JMOSS was reviewed and revised in 2004 but, due to concerns over inadequacies in the base data, the City developed a bioregional plan in 2011 with an expectation that the plan would feed into broader planning and development frameworks, and be streamlined with other planning tools such as the Spatial Development Framework, which defines the strategic spatial areas to be used in the City's capital investment

Overall, there is limited linkage between the individual policies relating to urban agriculture and green infrastructure

prioritisation model (City of Johannesburg, 2016; Schäffler et al., 2013). The latest addition to the policy framework surrounding green infrastructure is the forthcoming Green Infrastructure Strategy, which provides more practical guidance on green infrastructure applications and focus areas for the City, including the support of urban agriculture and food infrastructure within the green infrastructure network. The strategy will detail how green assets are capable of delivering multiple ecosystem services and the necessary practical considerations for managing and enhancing ecosystem service delivery. Importantly, the delivery of ecosystem services is linked to traditional municipal infrastructure and service delivery goals so as to motivate for the necessary integration of green infrastructure into municipal infrastructure management. Ensuring that the Green Infrastructure Strategy and the Food Resilience Policy are aligned and implemented with mutual consideration will be necessary for the effective expansion of food gardens.

Policy summary

Overall, there is limited linkage between the individual policies relating to urban agriculture and green infrastructure. This lack of consideration for systems interlinkages negatively impacts the understanding and formulation of food gardens as multifunctional assets. Therefore, this paper provides the necessary evidence to support a shift in the understanding of food gardens and the services they can provide. The evidence built in this paper can then inform the type, level and focus of engagement by the Gauteng Provincial Government and its constituent municipalities in the management of food gardens in the GCR.



Photograph by **Charles Mphahlele**



Photograph by **Kgao Mashego**



Methodology: Multi-method modelling

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This section outlines the multi-method approach taken in the analysis of the relationships and connections between the social, economic and political systems in which green infrastructure exists, as well as in the analysis of the physical and social ecosystem services which green infrastructure provides. The methodology applied in this paper involves several analytical approaches in order to visualise and communicate the economic, social and environmental value of food gardens. The methods used assist with building the evidence behind this argument as well as with identifying key policy recommendations to improve investment in and support for food gardens and urban agriculture within the green infrastructure network. Given the potential interconnectedness of multiple urban systems with green infrastructure and urban agriculture, a systemic approach is followed.

Qualitative systems modelling

A qualitative systems modelling approach was chosen in order, first, to capture the dynamic interactions of variables related to food gardens and urban agriculture and, second, to analyse the behaviour of the whole system across technical and strategic boundaries through both qualitative and quantitative approaches. Several constraints pertaining to the availability and suitability of data prevented a quantitative system dynamic modelling exercise[2] as part of this study. As such, a qualitative exploration of the system interactions between urban agriculture and social, economic and environmental systems in Johannesburg was undertaken. The literature and policy review presented earlier informed the creation of a causal loop diagram (CLD) (Sterman, 2000). A CLD is a visualisation that shows how variables in a system are interrelated by linking them according to the nature of their correlations and relationships. The use of a CLD in this project explores the dynamic relationship of social, economic and environmental variables that are directly and indirectly connected with urban agriculture in Johannesburg. The CLD helps to visualise and communicate the economic, social and environmental value of green infrastructure to support decision-making and planning in Gauteng. The CLD further identifies, from strategic to grassroots levels, policy retention challenges to food garden implementation. Six loops are identified and classified into the categories of (1) health and poverty, and food security; (2) government investment, socio-economic and job creation; and (3) climate change and flooding. These are discussed in detail in the results section.

The CLD was contextualised and validated through surveys and semi-structured interviews. In the first instance, surveys and interviews were conducted with urban farmers and food garden participants to provide ground-level evidence that

2 System dynamics is a useful method that has been used to evaluate ecosystem services in combination with a spatial modelling approach. Gharib (2008) describes the combination of system dynamics and spatial modelling as a useful method for identifying social, economic and environemtnal benefits of green assets alongside spatial–temporal processses through the accumulation of process, feedbacks and nonlinearities. Such modelling capabilities allow policy-makers to measure the economic value of their interventions on ecosystems in a spatial and timely manner (Neuwirth et al., 2015). Recommendations from this paper include improving the availability and suitability of the data required to undertake such an exercise in the future.

contextualises the operational realities of food gardens in the Gauteng City-Region (GCR). In the second instance, surveys and interviews were conducted with academic and policy specialists in the urban agriculture space to identify and contextualise policy gaps and recommendations emerging from this study.

The questionnaire design for the urban farmers' survey was based on a pilot study in London (Cranbrook Community Food Garden, 2017). The questions were then contextualised for application in the GCR through engagement with project partners at the Gauteng City-Region Observatory (GCRO). In addition to the survey, the application of the questionnaire in semi-structured interviews ensured an acceptable response rate. The principal advantage of applying this flexible method is to create a discussion about any key variables the causal loop was missing. Additionally, it allows analysis of the benefits and barriers of growing food gardens in a city with respect to development issues such as poverty, inequality and migration, amongst others. A multi-criteria decision analysis (MCDA) was applied to rank food garden challenges and prioritise policy responses for urban agriculture in the GCR.

The MCDA process was undertaken with key stakeholders and policy experts to further validate the CLD and better understand how policy-makers should respond to the conflicting challenges in managing multiple ecosystem services simultaneously. MCDA assists the decision-making process by identifying various causes for trends as well as by evaluating alternate courses of action. The use of MCDA for ecosystem service assessment has received wide attention in the literature with diverse purposes of analysis. In this way, MCDA has served to provide an alternative method for economic valuation, to complement cost–benefit analyses, as well as to provide a decision support system that incorporates both economic and non-economic values (Saarikoski et al., 2016). MCDA also provides a compatible methodological framework for deliberative valuation, which is considered helpful in addressing plural value dimensions related to common goods such as ecosystem services (Maxwell et al., 2011; Vatn, 2009). In addition, MCDA is frequently used in spatially explicit land use models (Geneletti, 2013; Schaldach et al., 2011).

An MCDA was used to provide a systematic methodology to quantify stakeholders' judgements to prioritise 15 pressing issues in the study area of Johannesburg. These issues were derived from an initial scoping exercise and discussions with relevant stakeholders. The nature of these issues is such that there are no universal criteria against which to compare them. The issues deal in non-monetary impacts and appeal to differing value systems based on the stakeholder's own preference or beliefs. In order to simplify this complexity and facilitate the comparison of alternatives, an analytical hierarchy process (AHP) is used. AHP uses pairwise comparisons, asking how important one issue is when compared to another, to enable relative measurement between multiple stakeholders. Stakeholders assign relative ranks of importance between issues by scoring between '–4' (least important) to '4' (most important). The results of this measurement assist with the comparison of the most pressing issues in Johannesburg based on the relative judgement from stakeholders with diverse backgrounds. Their judgements not only highlight priority areas for policy-makers to focus on, but also enrich a contextual understanding of interconnections depicted in the CLD. This iterative modelling approach was informed, first, by a review of globally relevant and local literature and, second, by the local knowledge and experience of key actors in the urban agriculture and green infrastructure space.

A multi-criteria decision analysis was applied to rank food garden challenges and prioritise policy responses for urban agriculture

Spatial modelling and analysis

Spatial mapping and analysis is used in this study to establish a spatial dataset of food gardens and to visualise the multifunctionality, or multiple ecosystem service delivery potential, of food gardens as green assets in the GCR. The mapping and spatial analysis in this paper was conducted using GIS (geographic information systems) software and supports the CLD by providing the geographic occurrence of food gardens in Johannesburg and their connection with other socio-economic variables, such as population and poverty distribution. Urban agriculture, and thus the management and maintenance of food gardens, is the responsibility of multiple government departments for various reasons. For example, the Department of Social Development promotes and supports food gardens for the purposes of food security, while Johannesburg City Parks and Zoo supports a school food garden programme for educational purposes and to improve nutrition in schools. Food garden names and locations were collected from these departments as well as the City's Environment and Infrastructure Services Department. This study locates and analyses 198 food gardens in Johannesburg, which has not been done before. These locations were then converted from an Excel spreadsheet to a shapefile as a new spatial layer using ESRI ArcMap software (Figure 4). The locations of food gardens were collated from a range of secondary data provided by the departments and stakeholders involved. Where location data was accurate, a red dot was used to identify the food garden. However, where the location data was uncertain, the location of the garden's owner was used as an approximate indicator, and a yellow dot was used.

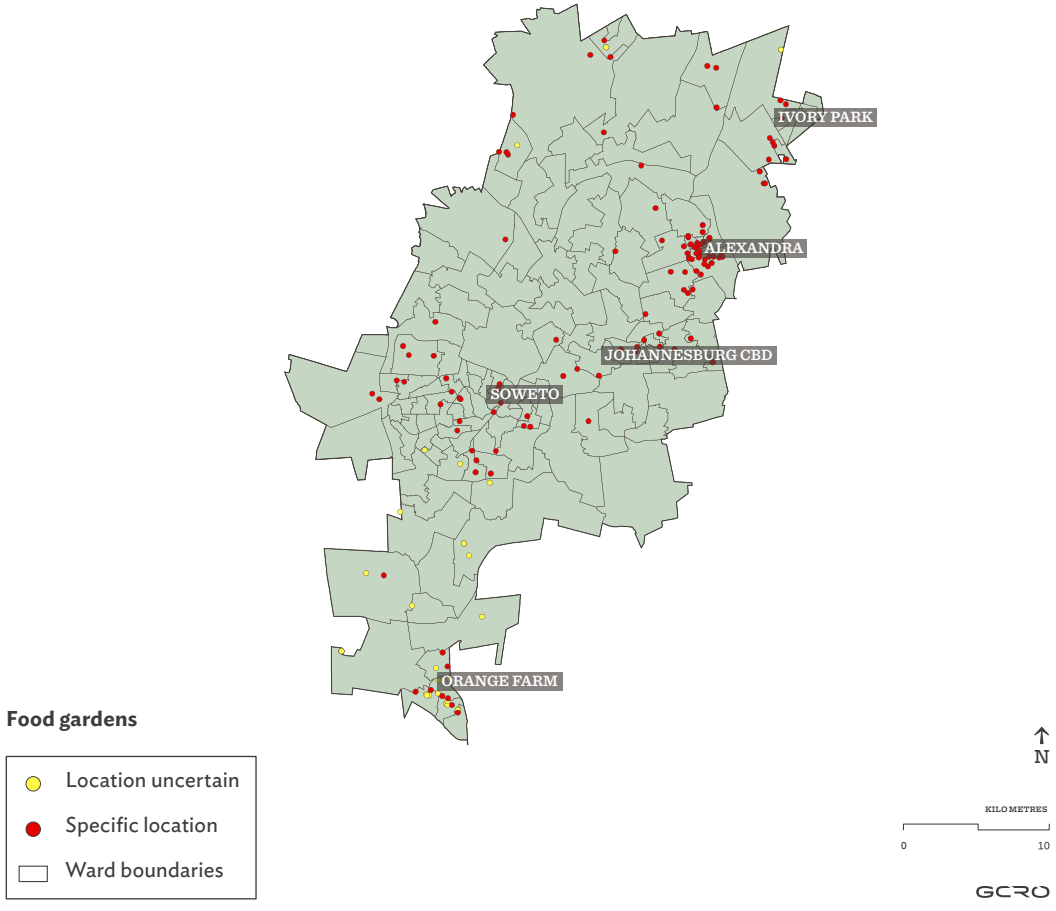
The food garden location layer was superimposed on the other socio-economic and demographic data to visualise and understand relationships between food gardens and the adjacent environmental, economic and social issues. The spatial analysis enables the potential multifunctional benefits of food gardens to be contextualised against the prevailing socio-economic conditions in Johannesburg. The maps derived from this exercise visualise correlations (rather than developing statistical relationships), and the results inform the CLD by providing quantitative data. Major trends show that the wards with a medium unemployment level have the largest number of food gardens, and the wards with the highest unemployment rate have few food gardens. In other words, the wards with higher food demand have fewer food gardens. In summary, the maps show that food gardens are less common in the northern and southern urban peripheries while particular wards in the urban centre have more food gardens.



Photograph by **Steffi Pereira/Unsplash**

Figure 4: New layer of food garden locations in the City of Johannesburg

DATA SOURCE: Supplied by the Gauteng Department of Social Development, Johannesburg City Parks and Zoo, City of Johannesburg and Infrastructure Services Department, and other stakeholders, digitised manually



The spatial analysis enables the potential multifunctional benefits of food gardens to be contextualised against prevailing socio-economic conditions



Photograph by **Alison Hancock/Shutterstock**



Results

Results

Causal loop diagrams

Causal loop diagrams (CLDs) are effective in demonstrating the multifunctional nature of food gardens. As green assets, food gardens are able to deliver a range of ecosystem services. These include regulating and supporting services to the urban environment (climate change and flooding loops), provisioning services through food access (health and poverty, and food security loops), as well as cultural and recreational services to communities (government investment, socio-economic and job creation loops). Furthermore, in the context of the Gauteng City-Region (GCR), these ecosystem services align with important needs in terms of municipal service delivery such as stormwater management (climate change and flooding loops) and youth unemployment (government investment, socio-economic and job creation loops). Each of these loops is presented individually as well as how they are nested within the overall CLD.

Climate change and flooding loops

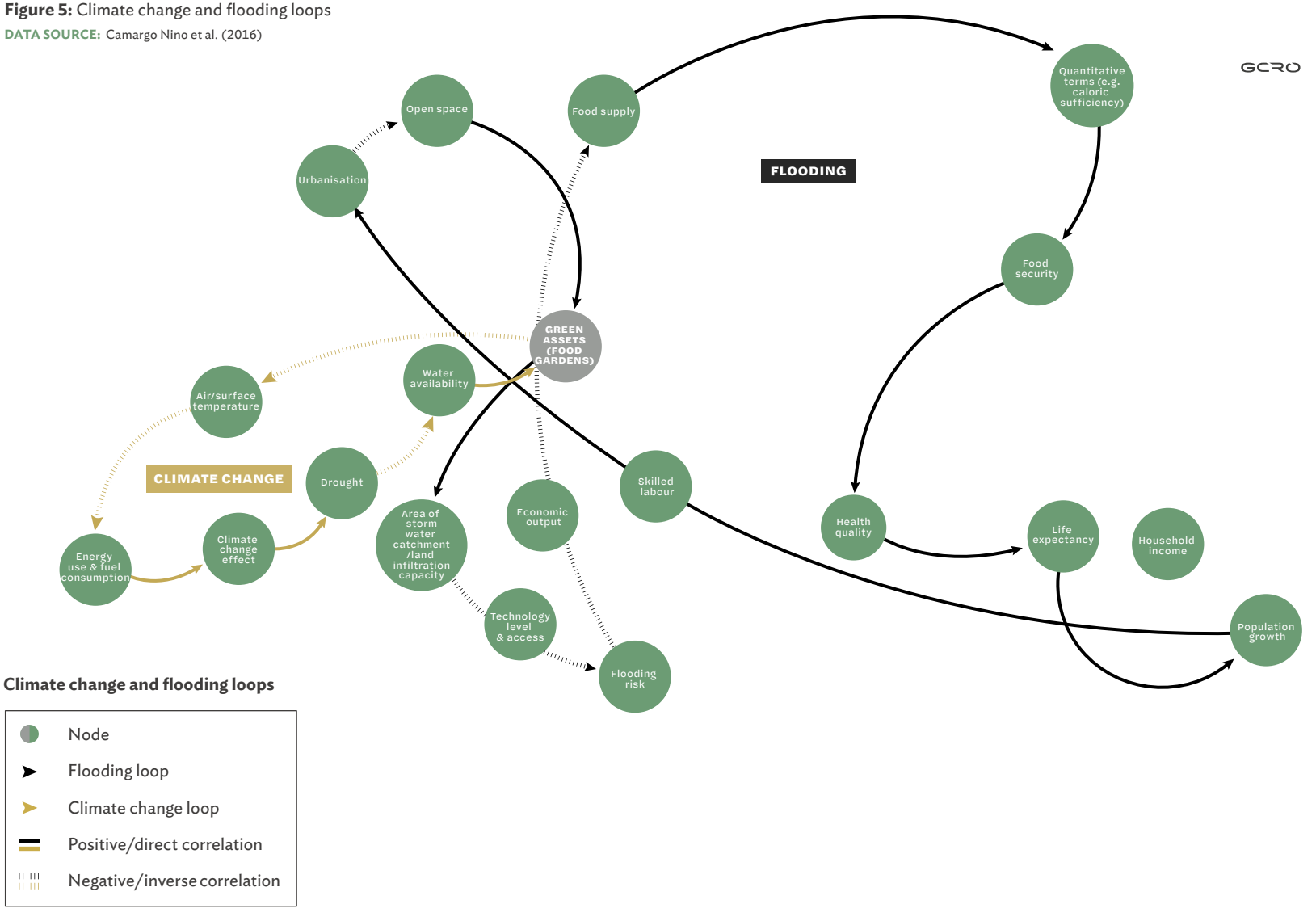
Food gardens have a potential role in minimising the urban heat island effect by lowering surface air temperature in the city (Bass et al., 2003; Hien et al., 2007). The reduction of surface heat lowers energy use for cooling (e.g. fans and air conditioners) and decreases the negative impacts of the heat island effect, which is set to worsen with climate change. On a broader scale, rooftop food gardens moderate water runoff, which could increase water availability and potentially reduce drought risk. However, these relationships are still limited and have not been addressed much in the climate change literature in the South African context. In reducing flooding risk, few researchers have assessed the relationships between food gardens and flood attenuation in an urban environment. Asadian and Weiler (2009) explain that stormwater runoff can be reduced by green assets through delaying precipitation from reaching the ground (interception loss), soil infiltration and evapotranspiration; however, the rate of interception is determined through various factors, such as climatic conditions, canopy structure and rainfall characteristics. Gill et al. (2007) found that increasing green space through tree and shrub development in the streetscape could potentially reduce stormwater runoff by 5%. Climate change and flooding relationships are presented in Figure 5 and located within the broader CLD in Figure 6.

How to read the CLDs

Nodes, indicated by coloured circles, are linked by lines known as connections. Connections represent positive/direct (solid line) or negative/inverse (dashed line) correlations between nodes. For example, flooding is inversely correlated to food supply, meaning improved food supply is observed when there is less flooding. The colour and thickness of lines only serve to emphasise thematic loops within the broader CLD. See Figure 11 for the most detailed representation of direct and inverse correlations between nodes. It must be noted that although the diagrams are referred to as 'causal loop diagrams', no causation is assumed between nodes.

Figure 5: Climate change and flooding loops

DATA SOURCE: Camargo Nino et al. (2016)



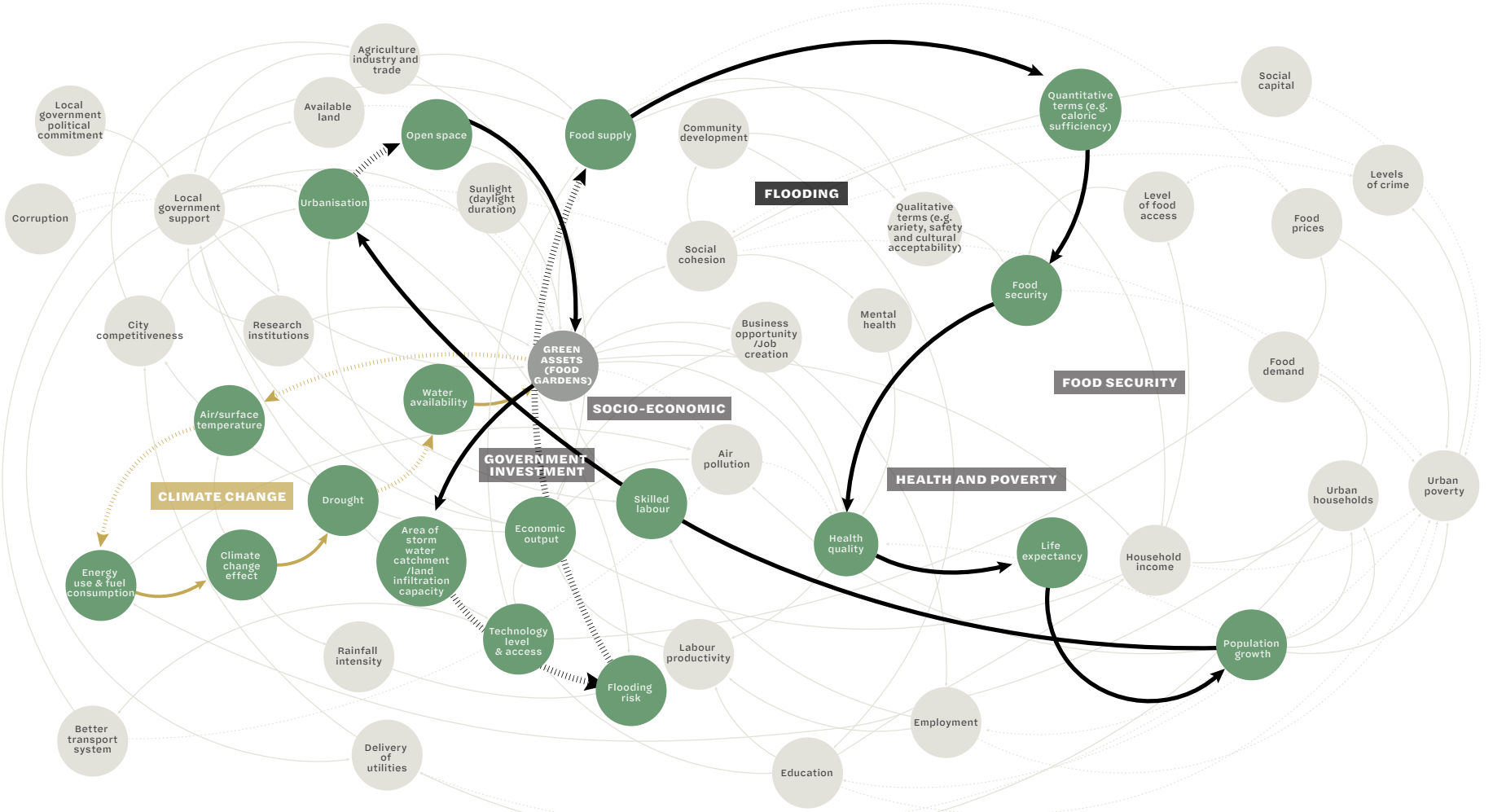


Photograph by **Clive Hassall**

Figure 6: Overall CLD with emphasis on climate change and flooding loops

DATA SOURCE: Camargo Nino et al. (2016)

GCRO



Health and poverty, and food security loops

Empirical evidence from Armstrong (2000), McCormack et al. (2010) and Teig et al. (2009) shows that urban agriculture has positive impacts on community health, promoting lifelong active lifestyles and personal wellness. However, Corrigan (2011) highlights that it requires more support to influence healthy living. Brown and Jameton (2000) claim that stronger policy support for urban gardening could both trigger better food access and improve community mental health. However, improved health equity induces longer life expectancy and population growth, which could in turn increase food demand and pose a risk to urban food security. Besides increasing food demand, the increasing population also potentially triggers crime, especially where population growth happens in a context of poverty. In confronting this challenge, Iles (2005) argues that effective policy towards supporting urban agriculture could enable small communities to address crime through the employment and recreational opportunities that food gardens provide. This is also found by Averbeke (2007) and Graefe et al. (2008), who report that urban agriculture plays an important role in alleviating poverty in the African context. Health and poverty, and food security relationships are presented in Figure 7, with their interaction in the broader system presented in Figure 8.

Figure 7: Health and poverty, and food security loops

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DATA SOURCE: Camargo Nino et al. (2016)

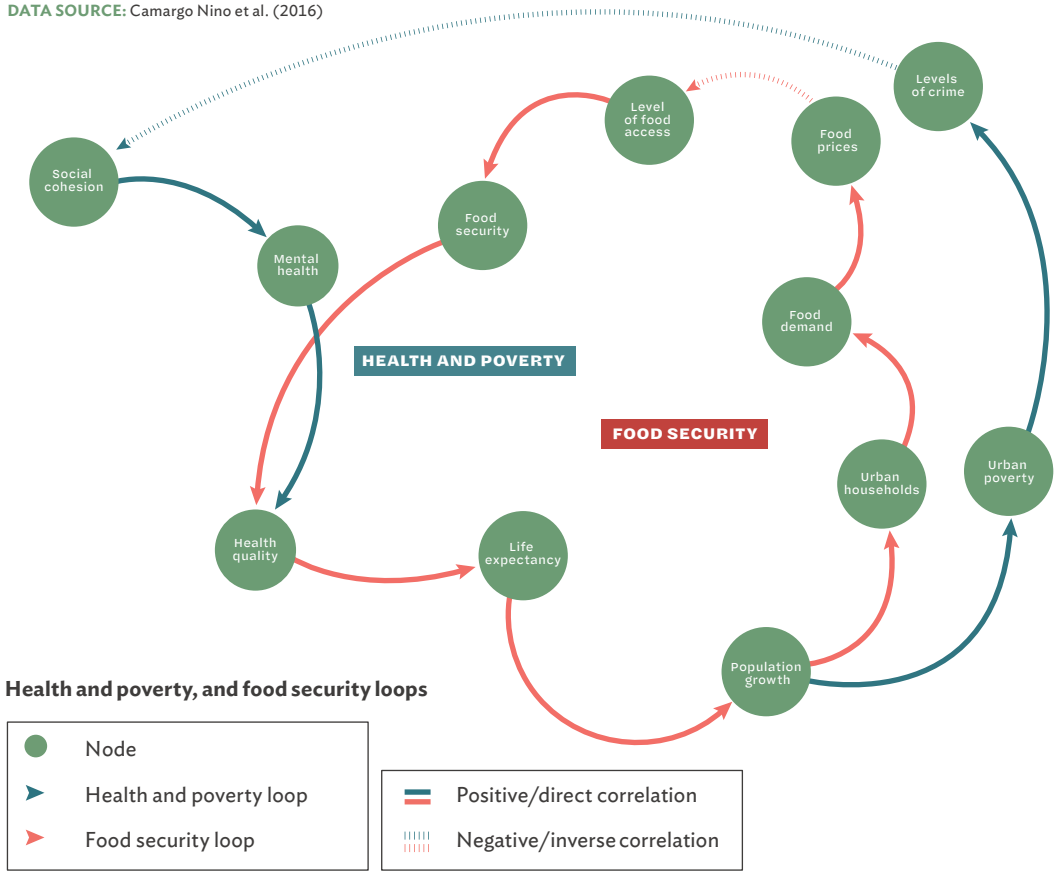

Figure 8: Overall CLD with emphasis on health and poverty, and food security loops

DATA SOURCE: Camargo Nino et al. (2016)

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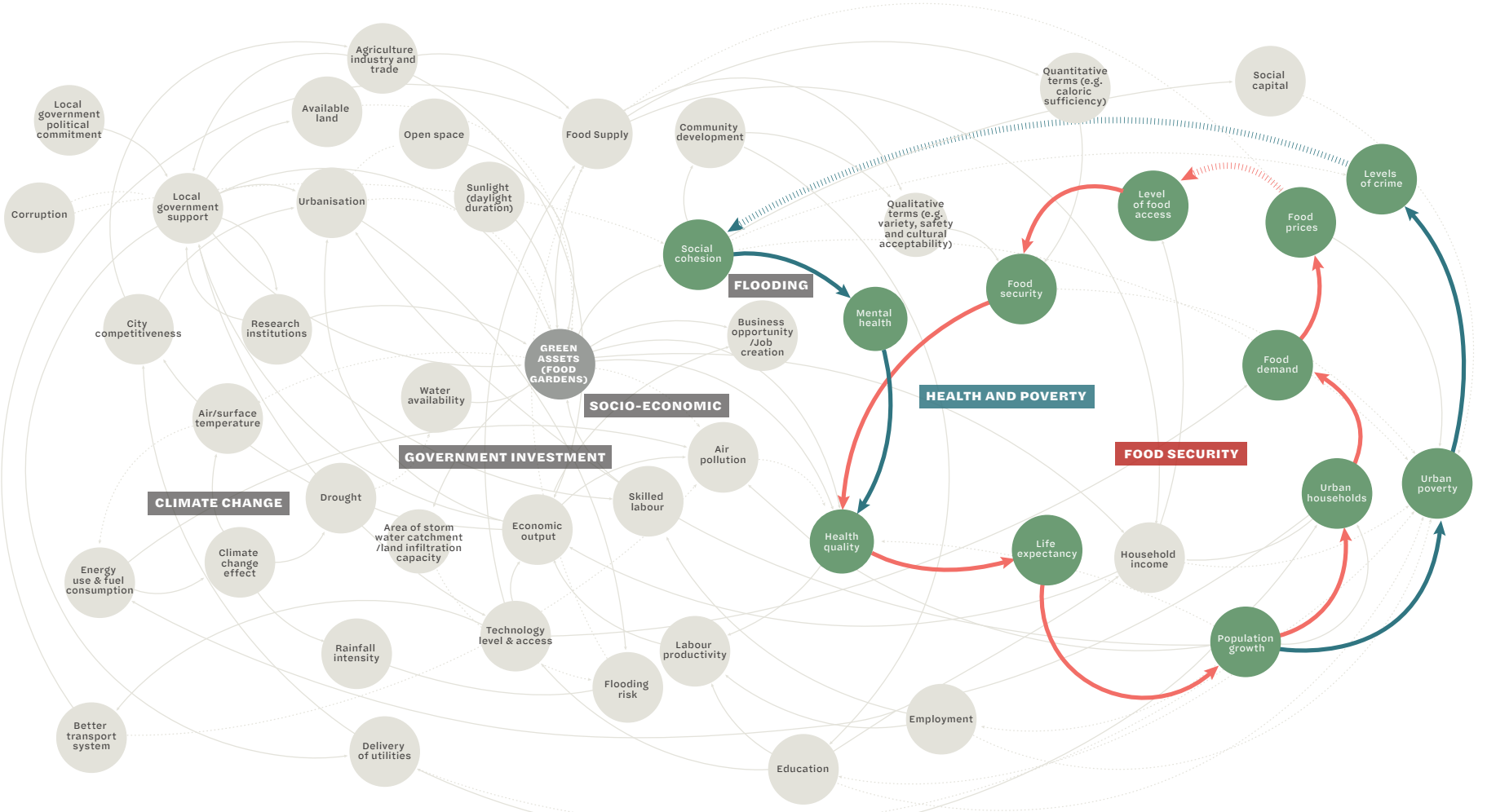

Government investment, socio-economic and job creation loops

Several sources have confirmed that urban agriculture practice provides a basis to boost the local economy. Ackerman et al. (2014) identify that food gardens have positive effects on communities through job creation and increasing household income as food expenditure is reduced. This is also shown by Feenstra et al. (1999), who highlight that food gardens increase community self-sufficiency, employment creation, distribution of local fresh produce and preserve land for farming. In addition to job creation, the job availability through urban agriculture is highly seasonal, indicating that the employment market is fragmented and requires sound policy support (Nugent, 2009). With economic growth, the government could receive more income to invest in the City's development, but, at the same time, it also fosters trends of urbanisation as the increase of basic service and utility delivery improves (GCRO, 2011). The inflow of people increases competition for land for urban farming. These government and socio-economic relationships are presented in Figure 9 with their interaction in the broader system presented in Figure 10.

Figure 9: Government investment, socio-economic and job creation loops

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DATA SOURCE: Camargo Nino et al. (2016)

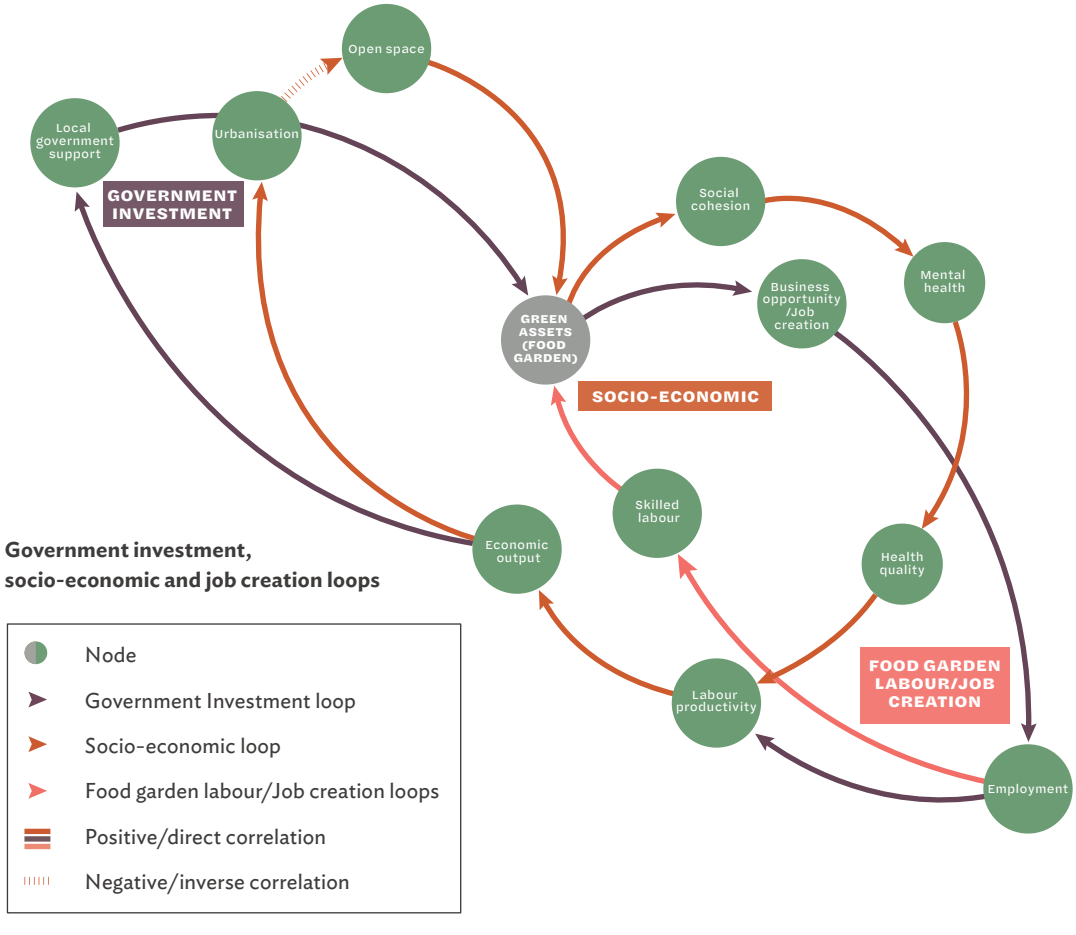

Figure 10: Overall CLD with emphasis on government investment, socio-economic and job creation loops

DATA SOURCE: Camargo Nino et al. (2016)

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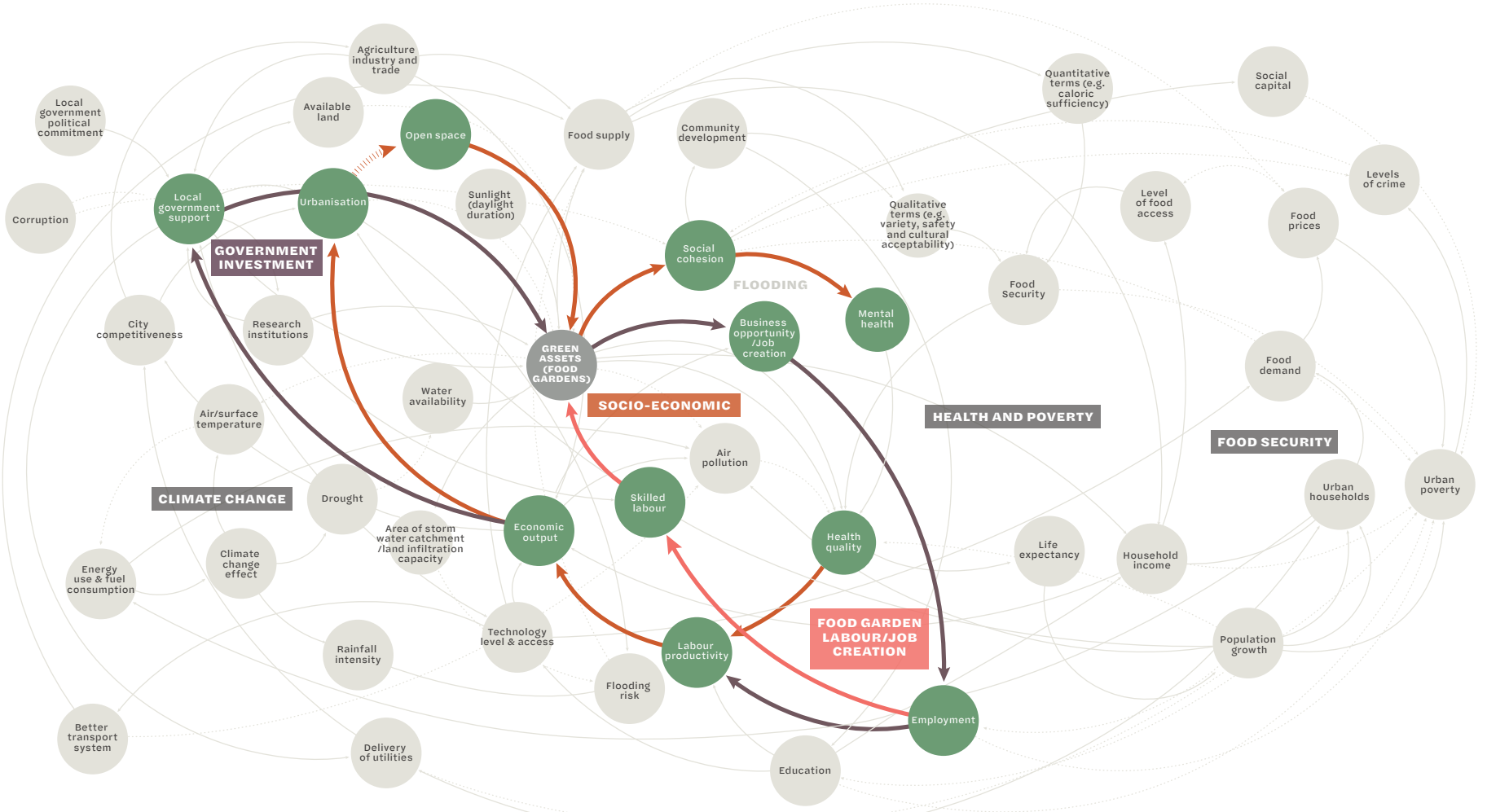

Surveys and semi-structured interviews

The survey results from the initial engagement with urban agriculture stakeholders provided practical insights into the operation and challenges for food gardens in Johannesburg. The effect of both internal and external factors is prevalent in the survey responses, which confirms that broader system dynamics, as well as individual garden functionality, must be considered by policy-makers. Primarily, climate and land were reported to be affecting the sustainability of gardens in terms of dryness and frost, as well as increasingly infertile soils. In areas with poor solid waste management, gardens often become sites of illegal dumping. Farmers also reported that a lack of water and electricity (i.e. technology constraints and access to inputs) are limiting factors. Johannesburg's climate, with its harsh winters, further limits farmers who cannot access the necessary equipment, such as tunnels or greenhouses, to extend the growing period.

Many of the gardens surveyed are non-commercial and function within severe budget constraints, affecting the operation and growth of production of these gardens. This is evident in responses relating to the labour force, where food gardens clearly do not have the capacity required to absorb labour and contribute to improving unemployment in the city. The productivity of food gardens is further impacted by the common practices of sharing and donating food in communities, as well as paying garden employees in garden produce in lieu of money. This study found that more than half of the gardens were donating their food to the community, and that the food gardens are known as hubs to gain regular access to, and exchange, food. While this enables food gardens to act as important poverty alleviation tools, the ultimate sustainability of individual gardens is compromised by these practices. Where networks of food gardens and local markets can be established, gardens may be able to both improve commercial performance while still performing important social functions. Where some food gardens may grow beyond the limit of consumption for those working in the garden, surplus fruit and vegetables, as well as seeds and other inputs, may be shared with food gardens in other communities or sold into local food markets if they exist (Corrigan, 2011).

Information from interviews with two urban agriculture initiatives in Johannesburg helps to derive lessons for how food gardens could be promoted and supported within a wider green infrastructure approach. The first was the Siyakhana Initiative,[3] a food garden and social entrepreneurial enterprise that has become a platform for research and capacity-building. The second was Izindaba Zokudla,[4] an action-research project that aims to create opportunities for urban agriculture in the Soweto food system. Izindaba Zokudla has become a networking and knowledge sharing platform for developing urban farmers. Key informant interviews provided both high-level and practical guidance for better management of food gardens in Johannesburg as follows.

The capacity of the City's food gardens to make a dent in food security is limited, mostly due to the productivity levels that can be attained (Izindaba Zokudla, personal communication, 11 April 2018). One of the most productive individual food gardens within the Izindaba Zokudla programme is the Bambanani organic farm in Bertrams, which produces approximately 50 kg/m^2/year. This is a low yield rate compared to some of the intensive and more technologically advanced farm production rates in the country, which can reach up to 600 kg/m^2/year (Izindaba Zokudla, personal communication, 11 April 2018). This suggests that while food gardens are not productive enough to make a dent in food security, they could be viewed as a feasible vehicle for increasing food access and diet diversity, as well as reducing the cost of food by supplementing the household's food basket. Similarly, the employment potential of food gardens is limited (Siyakhana, personal communication, 13 April 2018). However, when food gardens are considered as another asset within the broader green infrastructure network, they provide an additional application for potential green jobs. This employment

3 http://www.siyakhana.org/about-us/about-us/

4 http://www.designsocietydevelopment.org/project/izindaba-zokudla/

potential depends on the allocation of support and operational budget to green assets. For food gardens, the operational budget could extend to ensuring that gardens are equipped with the components that most benefit productivity and functioning.

The availability of land for the expansion of urban food gardens is a major limiting factor (Izindaba Zokudla, personal communication, 11 April 2018). Many food gardens are projects of churches, schools or hospitals where gardens can be constructed on 'private' but accessible land (Cilliers et al., 2017). In the informal economy, there is minimal ownership of land, and little security of tenure for urban farmers. Increasingly, informal food gardens are constructed under powerlines and vacant land under other hard infrastructure that will not be further developed (Izindaba Zokudla, personal communication, 11 April 2018). The concept of 'green servitudes' (such as biodiversity corridors and open space networks) becomes useful here, where the maintenance of the green infrastructure network provides space and land availability for the development of assets like food gardens. The expansion of the green infrastructure network could also benefit from the rising demand for organically produced food. In addition, organic farming could be undertaken in ecologically sensitive areas (such as on the periphery of wetlands) as a means of ensuring these areas remain vegetated and continue to provide ecosystem services. Organic farmers must mimic natural processes in their farming techniques to reduce their impact and receive organic accreditation.

Planners might also consider expanding the network of food gardens around transport nodes to facilitate access to food through informal and small-scale traders who conduct business at these locations. If urban agriculture can be based on ecological design, and better approximate a closed loop system, this improves the viability of the market created and used by local actors. This is to say that where food gardens are promoted as local food sources, support is needed to establish a market for composting, seed savings and exchange, and water harvesting, which all maintain the environment for inputs as well as enable secondary economic inputs (Malan, 2015). In this way, the planning for a broader green infrastructure network might be better aligned with transport-oriented development and the planning of hard infrastructure.

An operating budget and access to suitable land and inputs are necessary to scale urban agriculture to a level where social and economic benefits are realised. This impacts the capability of food gardens to work as instruments for poverty reduction and, therefore, is a key insight for policy-makers and implementers. Food gardens will only provide the provisioning services that underpin socio-economic benefits if agricultural inputs, extension services and technical assistance are accessible.

Practitioners in the food system have suggested that the City engage in differentiated involvement, where the Department of Economic Development provides high-level and strategic engagement, while Johannesburg City Parks and Zoo engage at ground level (Siyakhana, personal communication,

While food gardens are not productive enough to make a dent in food security, they could be viewed as a feasible vehicle for increasing food access and diet diversity

13 April 2018). To facilitate this, it may be useful to house the Food Resilience Unit more centrally in the local government structure to better enable interdepartmental engagement. Increasingly, food systems researchers and practitioners are calling for greater focus on the economic development role of food gardens (Izindaba Zokudla, personal communication, 11 April 2018). To facilitate the development of local markets and opportunities for food gardens, many practitioners suggest that the level at which the City engages should be higher. This is to say that the City should play a facilitation and strategic role to enhance and expand the urban agriculture network.

Several cases justify this approach, for example, the Dube garden in Soweto, adjacent to the South West Gauteng TVET College. This garden received direct donations of infrastructure and equipment from the City, but there has been very little progress or success at this garden, owing to the lack of knowledge and access to the broader urban agriculture network, and the lack of training and skills of the farmers. Investing in the creation of local markets is important, especially in the Johannesburg food system, where urban farmers who resort to delivering to large supermarkets receive lower prices for their produce (Izindaba Zokudla, personal communication, 11 April 2018). There is also an opportunity to create markets and networks for 'intermediate' technology, such as hand ploughs and other equipment that would support small-scale agriculture and associated local supply chains (Izindaba Zokudla, personal communication, 11 April 2018).

Municipal structures, like the City of Johannesburg, could consider a community reinvestment model through a local economic development focus, where food gardens are established and maintained to act as a food resource in communities (Izindaba Zokudla, personal communication, 11 April 2018). The 'infrastructure' provided by the City would involve awareness raising and the creation of communication channels to allow actors in the food systems to be connected. Resources such as mobile apps and WhatsApp groups act as logistical infrastructure to facilitate the local benefit of the community by local spend, enabled by the City (Izindaba Zokudla, personal communication, 11 April 2018).

Data from the interviews and surveys informed the development of a summary strengths, weaknesses, opportunities and threats (SWOT) analysis highlighting the internal and external factors that impact food gardens in the city (see Table 2).

Multi-criteria decision analysis

The multi-criteria decision analysis (MCDA) exercise was completed iteratively after the development of the initial framework of challenges and issues facing the promotion and functioning of food gardens in Johannesburg. The MCDA enabled the insights from the initial survey to be validated by experts in urban agriculture and food gardens. The MCDA supports the CLD analysis by identifying the key issues the City is facing. The pressing issues facing food gardens in Johannesburg are summarised (in no particular order) in Table 3.

Ranking was allocated to specific issues after the process of pairwise comparison was combined and quantified into a relative score for each issue. The priority of issues differed between the experts according to the varying experience and focus in this space (summarised in Table 4). In some ways, this MCDA helps to direct potential policy interventions toward appropriate actions at relative scales or levels. The challenges highlighted by the community food garden expert that are required to expand and improve food gardens in Johannesburg are practical in nature and relate to water scarcity and lack of access to farming inputs, loss of land due to urbanisation, as well as limited skills and capabilities of the farmers. In addition, the challenges prioritised by the school garden expert highlight the health crisis and food insecurity as the predominant challenges, possibly because these broader issues affect early childhood development and are thus more visible in the school context. The academic expert prioritised crime, unemployment and poverty in addition to the health crisis, which reflect how broader development challenges impact urban farming on the ground. This indicates that food gardens should be promoted as one instrument in a broader and more holistic programme of policy actions.

Table 2: Summary SWOT analysis for urban food gardens in the City of Johannesburg

	Strengths	Weaknesses
Internal factors	• Food gardens are a tool for contributing to poverty alleviation and hunger reduction, especially in poor areas where the produce from gardens is donated and shared within communities. • Food gardens provide sites for farming and business skills development, especially where the youth and unemployed are included. • Food gardens promote social integration, mental health improvement and self-esteem building (one garden accommodates people with disabilities to work in the garden as part of their therapy). • Food gardens provide access to fresh food, organic vegetables and nutrition diversity, usually at a more affordable price than commercial outlets. • Food gardens are sites of innovation (e.g. systems designed to recycle water for garden use in droughts can be applied to other household uses, resulting in improved climate resilience in vulnerable communities). • With adequate support and inputs, food gardens are a relatively accessible foundation for entrepreneurship and business development. • Food gardens provide ecosystem benefits to the urban environment by reducing the carbon footprint of food production, increasing urban biodiversity and encouraging behaviour change around sustainability.	• Currently, food gardens have a low capacity to address unemployment because there are very few of them, and their size and scale of production limits employment opportunities and food security impact. • Many gardens suffer from a lack of inputs and technical support. • Location of gardens in unproductive land is affecting the sustainability of the garden (dryness, frost, infertility). • Many gardens have a limited capability to address pests and insects. • Many gardens have a limited labour force. • In general, there is a lack of knowledge and equipment to enable communities to start food gardens independently. • Food gardens require a long time (years) to become efficient. It takes three to five years to set up a food garden to demonstrate its success.
	Opportunities	**Threats**
External factors	• All gardens received donations and grants from the City of Johannesburg, NGOs, donors and private funding, which indicates that funding partnerships and opportunities exist for urban agriculture. • There is good networking, cooperation and communication among people involved in food gardens. • Partnerships with the academy, private sector and community cooperatives exist for technical support. • There is a major opportunity to create food selling networks that expand the demand for food sourced from urban agriculture. • There is a growing young population in the GCR providing the opportunity to establish food gardens in schools and creches, integrating the practice of urban agriculture into communities from a young age. • There is a culture of swopping and sharing food from food gardens, indicating that knowledge-sharing networks may also be possible around food gardens. • At present there are few gardens and therefore few competitors in the urban agriculture market, which could encourage entry. • Innovative technology (e.g. hydroponics) is increasing, providing opportunities to enhance urban agriculture despite unfavourable urban conditions. • The City of Johannesburg has an urban agriculture policy as part of the food security initiative, which provides a positive foundation on which to improve supportive urban agriculture policy. • In South Africa, racial inequality around land access is a growing political focus which could have positive impacts on urban agriculture and inclusivity.	• There are limited budgets (both public and household) to invest in food gardens. • Climate change: high temperatures and dry spells/ drought lead to lack of water. • People find it difficult to work long and hard hours for limited pay and low productivity. • There are low incentives for entrepreneurship and innovation. • There is a gap in policy-making between the strategic plans and their implementation. • Urban farmers do not have access to the internet, technology or equipment. • There are restrictive conditions to meet in order to receive technical and financial support for food gardens from the government. • There is difficulty in accessing food markets for urban agriculture producers. • The urban food culture does not always demand the products that are available from urban agriculture (due to the shift to fast food and meat-based products). • There is discontinuity in political support due to government leadership transitions and political cycles. • Urban agriculture contends with many other development priorities in the GCR. • There is no clear strategy to integrate the informal economy.

Table 3: Current issues and challenges for food gardens in the City of Johannesburg

General issues	Food garden related issues
Social disintegration	Unskilled labour
Health crisis	Lack of access to sufficient amounts of clean water
Unemployment and poverty	Food insecurity
Urbanisation and population growth	Insufficient land availability for growing food
Air pollution and urban heat island effect	Land condition (infertile, sloping, etc.)
Flooding	
Crime	

Table 4: Summary of ranked priority issues in the City of Johannesburg based on expert judgements

Top five priority issues		
School food garden expert	Academic	Community food garden expert
1. Health crisis	1. Crime	1. Lack of access to water
2. Lack of access to water	2. Unemployment	2. Urbanisation
3. Food insecurity	3. Health crisis	3. Unskilled labour
4. Access to food	4. Poverty	4. Insufficient land
5. Crime	5. Food insecurity	5. Land condition

The findings above are aggregated to support the relationship in the previously developed CLD. Major improvements to the CLD are primarily developed from interviews with stakeholders where the structural boundaries of a modelled system could be established. The final CLD (Figure 11) integrates this contextual basis to strengthen and enrich both the relationships and the variables which are relevant to urban agricultural challenges and dynamics in Johannesburg.

Figure 11: Final CLD for urban food garden policy issues in Johannesburg

DATA SOURCE: Camargo Nino et al. (2016)

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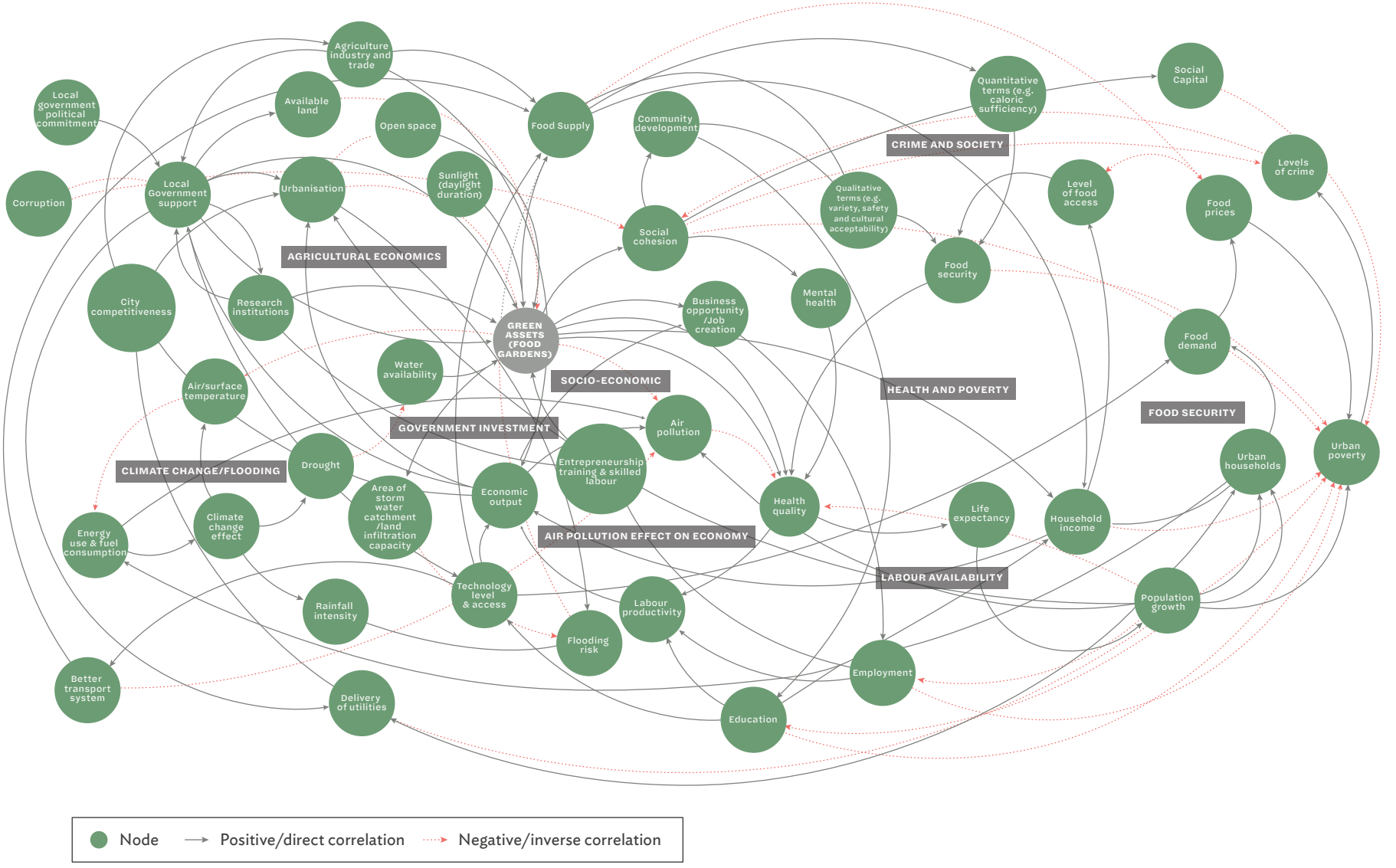


Spatial analysis

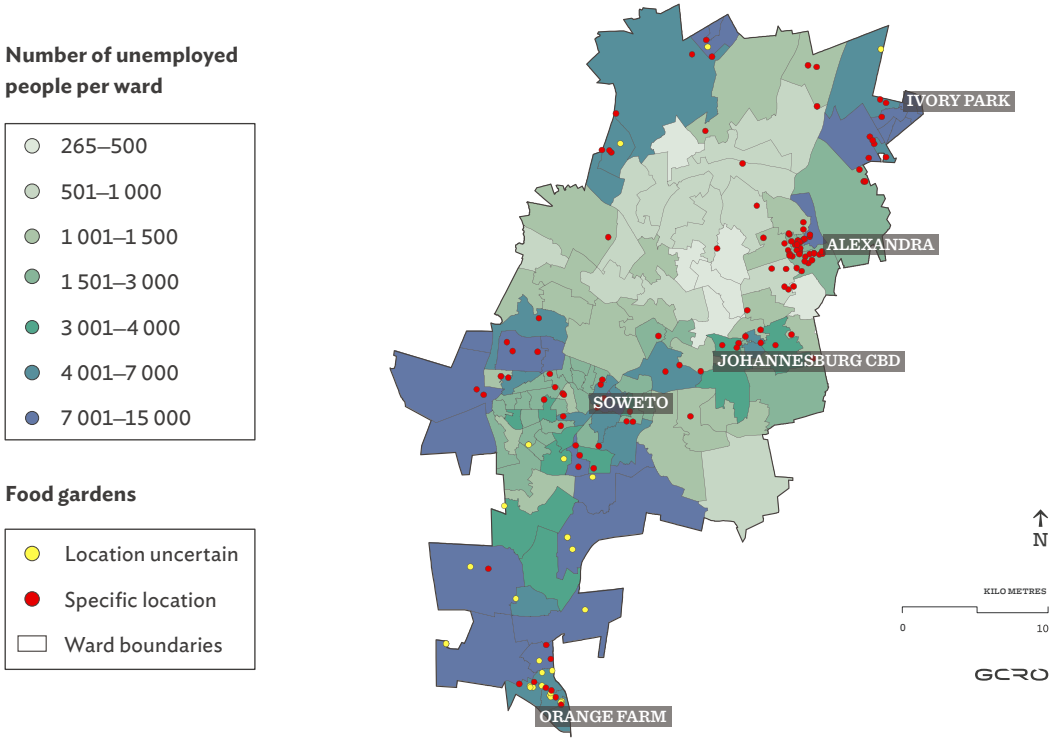
The spatial analysis considered the location of food gardens against urban dynamics — including the level of unemployment and food demand — to understand the potential benefits and the association between food gardens and such challenges in communities in the GCR. The following sub-sections describe these relationships, which highlight the spatial distribution of food gardens and their potential socio-economic impact in these locations. The analysis indicates the areas where policy interventions could focus. Major trends show that the wards with a medium unemployment level have the largest number of food gardens, and the wards with the highest unemployment rate have few food gardens. Also noteworthy is the fact that the wards with higher food demand have fewer food gardens. Lastly, the analysis seems to indicate that different areas create food gardens for different purposes. The implications for decision-making with regards food gardens in the GCR's green infrastructure network are discussed under each category of the spatial analysis.

Unemployment

Figure 12 visualises the level of unemployment per ward and the location of food gardens. This map reveals that the wards with the highest unemployment rate do not have many food gardens. The wards with moderate unemployment have the largest number of food gardens. Provisioning services are important in contexts where households will benefit from the 'free' supplementing of their food basket or fuel provision (Adegun, 2017). Given that interviewees mentioned that food garden businesses could contribute to addressing food security concerns and to creating new jobs, investing in food gardens in the wards with high unemployment rates might help to tackle those challenges.

Figure 12: Food garden location against unemployment per ward in the City of Johannesburg

DATA SOURCE: Camargo Nino et al. (2016)



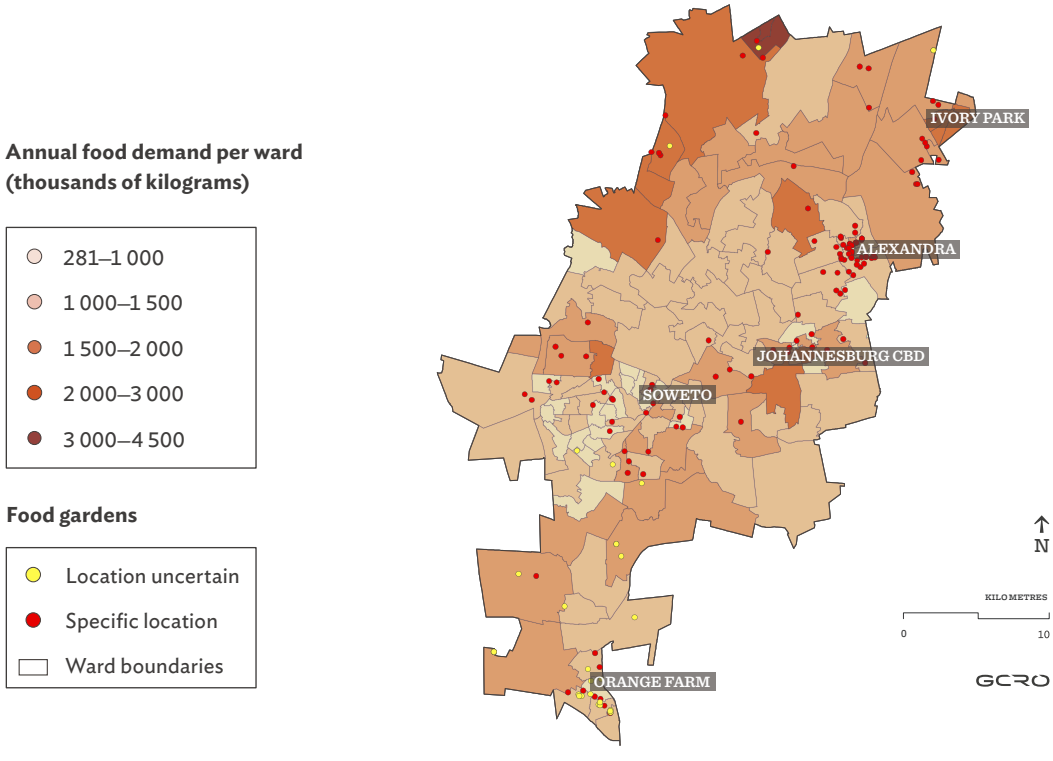
Food demand

In calculating total food demand in Johannesburg, a household consumption approach was used. Figure 13 shows the locations of food gardens and food demand per ward. The wards with an annual food demand of 2 000–3 000 kg and higher only have a few food gardens while the ward with the highest figure has four food gardens. The wards with the highest food demand also have high unemployment. Therefore, there may be potential for and benefits to operating food gardens as urban agriculture businesses in these wards. As discussed previously, food gardens and their associated provisioning services assist in supporting social development and poverty alleviation goals in Johannesburg. Supporting the expansion of food gardens in these target areas constitutes a multifunctional green infrastructure approach contributing towards poverty alleviation, job creation, food access and urban greening.

The wards with the highest food demand also have high unemployment

Figure 13: Food garden location against food demand per ward in the City of Johannesburg

DATA SOURCE: Camargo Nino et al. (2016)



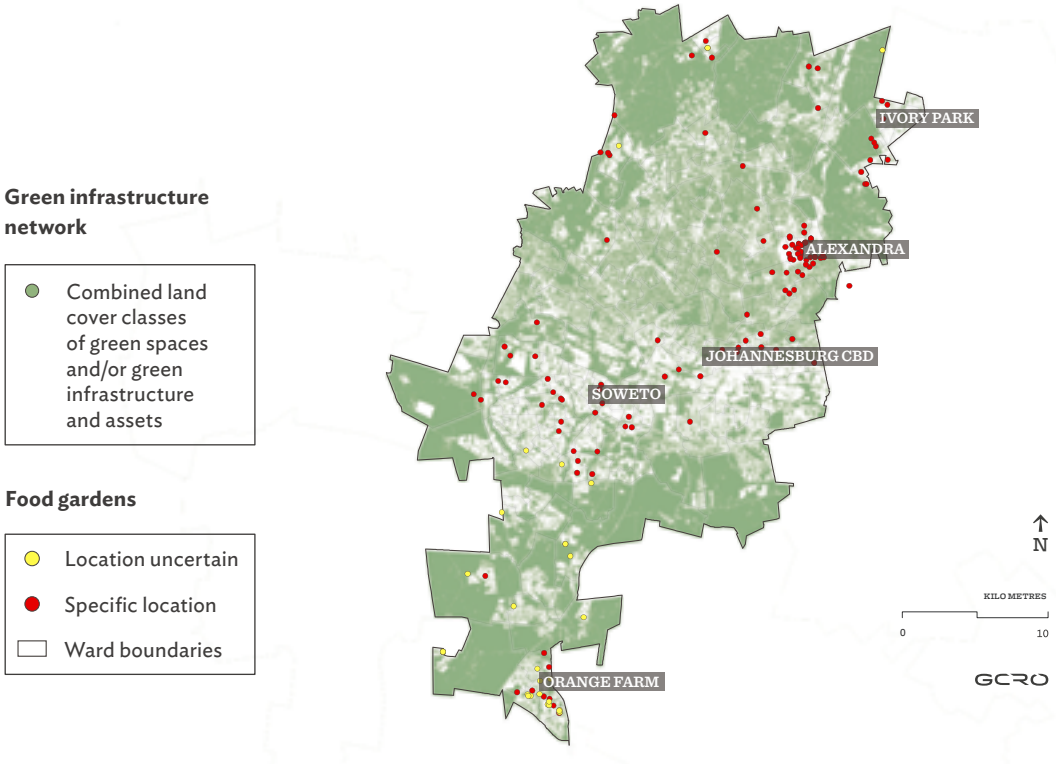
Green infrastructure network

Figure 14 shows how food gardens are distributed throughout the green infrastructure network in the GCR. Green infrastructure and assets cover 57% of the surface area of the City of Johannesburg (based on 2014 land cover data). Green infrastructure in the context of Johannesburg is comprised of land use subcategories such as: natural, cultivated, peri-urban (smallholdings), planted landscapes, school grounds and wetlands. Natural land uses account for 55% of green infrastructure in the region, followed by peri-urban land uses. Only 2% and 3% respectively are accounted for by the development of school grounds and recreation. Food gardens are a key green asset, especially in wards where other types of green infrastructure are sparse. If urban agriculture can receive greater support in the City of Johannesburg, food gardens can play a vital role in strengthening the green infrastructure network by providing key social and ecosystem services where other green assets are less prevalent.

Food gardens are a key green asset, especially in wards where other types of green infrastructure are sparse

Figure 14: Food gardens in the green infrastructure network in the City of Johannesburg

DATA SOURCE: GeoTerra Image (2014) 2.5 m Land Cover, 72 classes; Camargo Nino et al. (2016)



Results summary

The results of the various analyses have confirmed that food gardens are multifunctional green assets because they deliver a range of ecosystem services in the City of Johannesburg. The provisioning services supplied by food gardens play an essential role for many communities in the City, and food gardens further contribute to the critical supporting and regulating services provided by the broader green infrastructure network. Ultimately, the delivery of these ecosystem services is well aligned to the social services and infrastructure development needs outlined in municipal service delivery goals. These findings justify investment in management and operational resources in food gardens within the broader green infrastructure network in the GCR.



Photograph by **Jay Groat**



Photograph by **Kamogelo Lebotse**



Recommendations

Recommendations

This paper has shown how food gardens can be considered as multifunctional green assets in the Gauteng City-Region (GCR). They can provide a range of ecosystem services to the urban environment in addition to providing several socio-economic benefits. While there are conflicting views on whether these gardens can contribute to food security, they do offer other undeniable benefits. Gardens contribute to diet diversification and the provision of important micronutrients which are not present in the cheap staple foods so widely available in Johannesburg's food system. It is common for food gardens to be used for informal means of income generation or as a food source for unemployed people. This demonstrates that food gardens are important for building resilience as they can act as a resource during times of shock. Ultimately, the maintenance of food gardens can only contribute to specific issues within the broader urban food security challenge: (1) they are a resource during times of shock (either to supplement income, or to provide food when there is limited income); (2) they make some contribution to dietary diversity; and (3) they contribute to diversifying sources of food by providing alternatives to formal suppliers such as supermarkets as well as to more informal traders.

The performance of urban agriculture is strongly related to the performance of green infrastructure in general, as ecological integrity influences the economic productivity of food gardens and their effectiveness in poverty alleviation (Malan, 2015). Therefore, by maintaining an ecosystem focus, as is central to a green infrastructure approach, local markets and shorter supply chains could be practically implemented to support urban agriculture efforts in the GCR. Establishing these markets will require targeted practical support to food garden managers and farmers. For example, the procedure to gain access to land is unclear in Johannesburg and the Johannesburg Property Company is slow at processing applications. There is scope to facilitate agreements permitting the productive use of underutilised land in lieu of ownership. Farmers' organisations are going to be key in coordinating the changes necessary to implement urban agriculture in Johannesburg (Malan, 2015).

The food system itself is variously shaped, constrained and enabled by a large number of policies not directly concerned with food security, particularly by industrial policy, land use policies and spatial development frameworks, and transport, environmental and hygiene policies. Many of these are located in the local sphere of government (Kroll et al., 2016). Therefore, efforts to improve urban agriculture need a more sophisticated understanding of urban food systems (Ruysenaar, 2012), and urban food policy needs to establish a more realistic understanding of the limitations of food gardens. What is required, therefore, is a democratisation of food systems governance in the GCR towards greater systemic resilience, environmental sustainability, equitable participation and public health (Candel, 2014; Kroll et al., 2016).

It is important to consider that food gardens can do these things only on a localised community scale, and only for the households who can interact with the gardens themselves. While this motivates the production and creation of more food gardens to enable a greater reach of these impacts, it is important to consider that the productivity of a food garden can only ever assist on a localised household scale, and the proliferation of more food gardens will not relieve the GCR's entire food security challenge. Community food gardens can only provide resilient nutrition security to those who interact with them, such as workers or customers. That the urban poor will survive by managing their own community food gardens, and that this will eradicate hunger and poverty in the GCR is a pipedream. The nature of food security involves *enough* food and *access to* food (Malan, 2015). Promoting gardens as the answer to urban food and

nutrient security is unwise and, rather, gardens should be considered an important component to be included in a well-planned, comprehensive programme. Given the policy momentum and traditional understanding and acceptance of food gardens, they should be maintained and expanded to incrementally contribute to green infrastructure goals and to make small, local contributions to improved nutrition.

The literature and policy review, as well as the multi-method modelling of food gardens in Johannesburg, informs the following recommendations for the governance and decision-making with respect to urban agriculture in the GCR's green infrastructure network.

Strengthen the productivity of food gardens for poverty alleviation. Increasing both the number of food gardens and their productivity provides direct benefits towards increasing community food security. According to the interviews and CLD analysis, food availability plays a poverty-alleviation role. As productive food gardens may also provide employment opportunities for local people, the provisioning services of food gardens may be harnessed for broad social development goals.

Locate the Food Resilience Unit in a central, cross-cutting government department. Currently the Food Resilience Unit sits in the City of Johannesburg's Department of Social Development, where the consideration of food gardens and urban agriculture is framed both too vaguely and narrowly for the purposes of education and broader food security (Kroll & Rudolph, 2015). As such, information on food and food garden expansion efforts are not formulated in terms of the multifunctional potential of these green assets. Therefore, food gardens are not considered as a potential mechanism to achieve social, economic and environmental outcomes, nor are these outcomes linked to municipal service delivery. Housing the Food Resilience Unit in a central department would enable interdisciplinary approaches towards establishing food gardens for community cohesion, food provision and education, while also creating a central database of food gardens, including their location, type, size and other key data.

Promoting the use of evidence-based policy. As demonstrated by the CLD and spatial analysis, the use of spatial data combined with economic and social indicators provides a robust policy design for maximising the potential of food gardens. Given the benefits of productive food gardens in increasing community food supply and potentially providing employment at a small scale, integrating the spatial distribution of food gardens with more socio-economic indicators is essential for generating better quality data for food garden monitoring in the GCR. Improved data, when analysed in a systematic way, also enables policy-makers to direct their strategies in a more effective manner. This would also require addressing the limitations around the quality and availability of data for such analyses.

Food gardens can provide a range of ecosystem services to the urban environment in addition to providing several socio-economic benefits

Enable simultaneous institutional and technical assistance within funding programmes. Challenges on the ground level require diversifying the support offered for the improved operation of food gardens. Funding injections need to be accompanied by capacity-building and skills development to ensure effective support for food gardens. Increasing awareness about funding and technical partnerships available to urban farmers would also aid the development of food gardens.

Improve land use policy support to ensure food gardens have an allocation within land use management. Food gardens have been framed as multifunctional green assets in order to argue that they should be incorporated more rigorously into green infrastructure planning and land use policies. The multifunctionality of food gardens reinforces their value as part of the green infrastructure network and within land use policies. Both national and local government should enact strategies to protect land access for current food gardens, particularly land with sufficient access to water supply and electricity networks, as demonstrated in the strengths, weaknesses, opportunities and threats (SWOT) analysis. Integration of urban food gardens into development strategies can also be expanded by utilising open space and rooftop structures.

This paper has built the argument that food gardens are a multifunctional element of the green infrastructure network in the GCR. It is worth maintaining and investing in food gardens because they contribute to a number of development imperatives in Gauteng. Food gardens enhance food security by broadening the range of locally produced food sources that improve the potential to help the poor access fresh food. Food gardens also enhance the green infrastructure network in the GCR by strengthening the provision of a range of ecosystem services. Productive food gardens provide economic opportunities particularly in areas with minimal access to retail outlets and where unemployment is high. Lastly, as part of the green infrastructure network, food gardens also contribute to addressing climate change and building disaster resilience through flood management and carbon capture. This research contributes to the growing literature on urban agriculture and green infrastructure and provides insights for integrated planning in the GCR.

Food gardens should be maintained and expanded to incrementally contribute to green infrastructure goals and to make small, local contributions to nutrition security



Photograph by **Anaya Katlego/Unsplash**

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