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Rooftop Agriculture in the Urban Global South: The Experience of Johannesburg²

ABSTRACT

Urban agriculture is attracting a growing international scholarship. The objective in this article is to examine the organization and contemporary state of rooftop agriculture in Johannesburg, South Africa's commercial heart and largest city. Current international scholarship on rooftop agriculture is overwhelmingly dominated by research on the experience of North American and European cities. Although urban agriculture has generated a considerable literature in the Global South and especially in Africa, only limited work exists on rooftop farming. This study draws together existing material on the South African record of rooftop agriculture. It is shown that Johannesburg hosts the largest cluster of rooftop farms which have been established mainly for social considerations with smaller numbers of projects for commercial reasons or the image-enhancement of businesses. The importance of partnerships for the establishment of projects emerges as a distinctive element of the Johannesburg inner-city experience. The challenges confronting the rooftop farming projects are investigated.

Keywords: urban agriculture, rooftop agriculture, Johannesburg, South Africa

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² The baseline analysis conducted by Warrick Allen at the University of Johannesburg is acknowledged. Thanks are due to the critical comments and suggestions for improvement made by two journal reviewers. Helpful inputs were made by Lulu White, Robbie Norfolk and Betty White in the preparation of this paper.

INTRODUCTION

It is pointed out in several recent reviews that urban agriculture is a globally prevalent practice which encompasses various forms of farming activities and that the topic has garnered a substantial international literature across several different research themes (Pradhan et al., 2023; Srinivasan & Yadav, 2023; Alkhaja et al., 2024). Tornaghi (2014) views urban agriculture as a broad umbrella term which encompasses food cultivation and animal husbandry. The scope of urban agriculture includes an array of different production forms, variously activities such as small-intensive urban farms, food production allotments, restaurant-supported salad gardens, balcony and windowsill vegetable growing, and rooftop gardens (Orsini et al., 2017; Alkhaja et al., 2024; Teoh et al., 2024). Urban agriculture supports the economic, social and environmental sustainability of cities, most especially through enhancing food security (Azunre et al., 2019). Beyond issues of food security, however, a current in recent literature on urban agriculture underscores its importance to include for self-empowerment and learning, and in constituting ways to achieve social justice (Tornaghi, 2017; Horst et al., 2024).

Over the past 20–25 years it has been observed that “urban agriculture has been variously embraced by public authorities, NGOs, research agencies, scholars, and civil society actors, across cities of both, the Global North and South” (Tornaghi, 2024, p. 285). Orsini et al. (2020, p. 1) document that in recent years urban agriculture projects “have bloomed throughout the world, finding large applications” particularly in the developed economies. Indeed, across the Global North there is occurring a surge of policy activities taking root around urban agriculture (Horst et al., 2024; Tornaghi, 2024). In the environment of the Global North grassroots initiatives as well institution-led urban agricultural projects are expanding in many cities “reshaping urban landscapes, experimenting with alternatives to the capitalist organization of urban life and sometimes establishing embryonic forms of recreating the Commons” (Tornaghi, 2014, p. 551). In the urban Global South urban agriculture is a common practice in many cities, most especially in sub-Saharan Africa (Freeman, 1991; Rogerson, 1992; Drechsel & Dongas, 2010; Masvaure, 2016; Mensah, 2023a). Debates around urban agriculture in the Global South mainly focus around poverty alleviation and its contribution to food security (Orsini et al., 2024; Teoh et al., 2024). Mensah (2023b) establishes that in the urban Global South urban agriculture can boost local economic development, assist towards the building of resilient urban settlements as well as contribute towards social inclusivity. Overall, Drescher et al. (2021) highlight the importance of urban agriculture as a fundamental element of the social-ecological resilience of Southern cities.

This international surge in urban agriculture of various kinds has generated a burgeoning literature from scholars in a range of disciplines, most importantly urban studies, planning and development studies. That said, it is argued that research questions around urban agriculture remain “a very marginal and almost unexplored field in human geography” (Tornaghi, 2014, p. 551). It is against this backdrop that the aim in this paper is to offer a modest contribution to human geographical scholarship. The objective is to examine the organization and contemporary state of rooftop agriculture in South Africa’s commercial heart and largest city, Johannesburg. Within the Global South the case of South Africa is somewhat exceptional for the existence of a rich geographical scholarship relating to

urban agriculture. From the 1990s urban agriculture became a prominent research focus for many human geographers who were engaged actively with the issues of post-apartheid urban change and the sustainable management of urban growth (Rogerson, 1993a; May & Rogerson, 1995; Webb, 1998a, 1998b; Rogerson, 2003; Webb & Kasumba, 2009; Rogerson, 2011; Webb, 2011). Several contributions authored by geographers have interrogated the role of urban agriculture in poverty alleviation as well as elaborate its importance for urban food security and food justice (Rogerson, 1993a, 1993b, 1998; Thornton, 2008; Webb & Kasumba, 2009; Crush et al., 2011; Battersby & Marshak, 2013; Battersby, 2016a, 2016b; Kanosvamhira, 2019; Kanosvamhira & Tevira, 2020; Kanosvamhira, 2023, 2024a, 2024b). It is observed, however, that these works concentrate almost exclusively on open space and peri-urban cultivation. By contrast, the focus here is upon the issue of rooftop agriculture. The remainder of this paper is organized as follows. The next section situates the South African research within a burgeoning international scholarship on rooftop gardening. A brief discussion on research methods is then presented before turning to a review and analysis of the findings from the Johannesburg experience.

LITERATURE REVIEW

Orsini et al. (2017) pinpoint that one of the greatest unused resources of many cities is flat roofs, especially in inner-city areas and denser settlements where other growing spaces may be limited. Roofs are estimated to account for between 20-30 percent of urban land and as such represent a valuable supplement to land resources and assume a crucial role in promoting sustainability and particularly for cities with limited land availability (Chen et al., 2024). The utilization of rooftop space potentially can offer multiple benefits to cities and their residents, most importantly in terms of urban heat island mitigation, energy saving and water management. The exploitation of unused city spaces such as rooftops can contribute to overcoming barriers to the challenges of urban development (Specht et al., 2014). Rooftop agriculture—plant cultivation on the rooftops of urban buildings—has been isolated as a functional pathway variously to increase ecological services, resilience to climate change, food security as well as contributing to the social and economic inclusion of marginal communities as well as those that experience gender inequality (Orsini et al., 2017; Appolloni et al., 2021). Rooftop agriculture is defined as “a building-based form of urban agriculture that includes both protected and nonprotected practices, such as rooftop greenhouses as well as open air rooftop gardens and farms” (Appolloni et al., 2021, p. 1). Further, Appolloni et al. (2021) clarify that rooftop agriculture is a form of zero-acreage farming or building-integrated agriculture and can include both protected (greenhouses) or nonprotected (open air rooftop gardens) forms of production. The terminology of zero-acreage farming or ZFarming is used especially in European research (Specht et al., 2014; Thomaier et al. 2015; Thomaier, 2017).

Reviews by Thomaier et al. (2015), Thomaier (2017), Appolloni et al. (2021) and Beroske (2022) highlight rising global interest in rooftop gardening for addressing sustainability issues in cities. Projects for rooftop agriculture can be commercial or non-commercial in focus. Thomaier et al. (2015) classify projects for rooftop agriculture based on their main objectives and isolate five types:

(1) commercial, (2) social-educational, (3) image, (4) innovation, or (5) urban living quality. As elaborated by Appolloni et al. (2021) the category of commercial rooftop farms is usually constituted by business-oriented enterprises which target profitability. By contrast, rooftop agriculture practices which are social-educational in character or geared towards urban living qualities are often initiated without profit considerations and instead concentrate on the integration of minorities or marginal groups, the education of young people, and addressing negative aspects of urban living by the offer of recreational and community spaces for personal food production (Nasr et al., 2017). The category of image-oriented rooftop agriculture projects mainly link to hotels or restaurants which use rooftop cultivation for purposes of marketing and/or aesthetics. The final category of innovation projects in rooftop agriculture are linked to the research and development of new technologies for sustainable food production and often are associated with universities or research centres.

It is pointed out in the international reviews on rooftop gardens conducted by Nasr et al. (2017) and by Appolloni et al. (2021) that different rooftop agriculture projects apply varying strategies in terms of their growing systems, design and management which are dependent upon and link to the different objectives of projects. The commercial business-oriented projects integrate rooftop agriculture into existing food chains and apply state-of-the-art technologies and intensive systems for plant cultivation. Often such commercialized production is anchored upon soil-less techniques with inert substrates and hydroponic methods. By contrast, non-commercial rooftop projects apply often low-technology growing systems utilizing inexpensive or recycled materials in order to improve urban food production with the lowest cost of investment. Typically, for food production such projects use soil either in raised beds or directly on rooftop surfaces (Beroske, 2022). Whether commercial or non-commercial in character it is argued that rooftop gardens can support sustainable environmental benefits for cities including water runoff management, biodiversity conservation, and ameliorating urban heat island effects (Whittinghill & Bradley Rowe, 2012; Appolloni et al., 2020; Appolloni et al., 2021; Baroske, 2022; Toboso-Chavero et al., 2023).

The overall picture as disclosed in the major international surveys conducted by Thomaier et al. (2015) and Appolloni et al. (2021) shows the predominance of rooftop agriculture in the urban Global North and using the form of open air rooftop gardens. The largest number of project cases appear to be in North America followed by Europe. The trend was towards the multifunctionality of rooftop agricultural practices in terms of a combination of improving quality of urban living with social-educational goals and image enhancement. For Yang et al. (2024) urban rooftop agriculture, alongside photovoltaic power production, offer solutions for the food-energy nexus in Chinese cities, albeit they are in competition for limited rooftop space. Rawal and Thapa (2022) draw attention to the contrasting situation of green roofs in developed as opposed to developing countries. They point to several success stories in the Global North of concrete roofs in urban areas being transformed into productive green roofs.

Grounded in critical urban geography, urban political ecology and debates related to everyday informal life politics Turner et al. (2024) disclose the complexities surrounding rooftop gardening in the Global South. According to Quddus (2022, p. 120) across cities of the Global South rooftop gardening “may improve foodstuff demand and able to encourage a livable urban community by ensuring

local fresh and safe foods”. Indeed, the consensus is that support for rooftop agriculture is highly relevant for the building of sustainable cities (Then & Hong, 2022). Two recent studies of the record of Dhaka in Bangladesh underscore the transformative potential of rooftop gardening (Safayet et al., 2017; Giri & Karmakar, 2024). The broad picture is of limited recorded successes. The typical situation as reported from Nepal is that rooftop gardens in urban areas function at a non-commercial scale albeit “help to ensure food security and aid in ecosystem services from the local level” (Rawal & Thapa, 2022, p. 1). In Pokhara city, Nepal, roof top gardening is contributing to local food supplies as well as an enhanced ecosystem (Kumar et al., 2019). In the case of Hanoi it is elaborated that “rooftop gardeners confront pressing food safety concerns while expressing doubt in formal political institutions’ ability to address these anxieties” (Turner et al., 2024, p. 249).

Most Global South research on urban rooftop agriculture is situated in Asia rather than Africa. Recent work on Cairo provides one exception (Shaltout et al., 2024). In another contribution Wesonga (2023) flags rooftop farming as one of a range of approaches to alleviate problems of food security and malnutrition in African cities. Overall, for the small cohort of African studies Appolloni et al. (2021) report a noticeably higher proportion of projects centred on urban living quality and social-educational progress and often promoted by local authorities or NGOs.

METHODS

This study is guided by various research approaches. First, it was informed by the international literature review of the findings of existing scholarship on rooftop gardens. As is demonstrated from the above overview, the African experience of rooftop agriculture is not prominent in a literature which is dominated by Global North case studies and most especially of projects operating in cities in North America and Europe. Second, the paper draws upon the existing studies on rooftop gardening in urban South Africa and in particular focuses on the experience of Johannesburg, the country’s major urban centre (Sekonyela et al., 2024; Rogerson, 2025).

The Johannesburg discussion draws extensively from a detailed audit which was conducted of rooftop agriculture and of the production practices across the city (Allen, 2019). Results are summarized from 25 semi-structured interviews which were conducted with select key stakeholders engaged in rooftop agriculture in Johannesburg using a purposive sampling approach comprising a mix of in-person, telephonic and email communications. This material is supplemented by a review of the findings from other recent works that have addressed issues of urban agriculture in Johannesburg inner-city (Ansell, 2017; Shapurjee, 2022; Ngie & Sithole, 2023).

RESULTS

At the outset the point must be reiterated that in addressing the critical challenges of food security or of sustainable urban development in South Africa the extent and contribution of rooftop agriculture is small as compared to the expansion of open-space and peri-urban cultivation practices. Indeed, rooftop agriculture in urban South Africa is in its infancy as compared to the extensive activities which are recorded in cities such as Berlin, New York or Toronto. The discussion is organized into two

sub-sections of material. These relate first to a national profile concerning rooftop agriculture and the state of the policy environment within which the sector functions. The second sub-section shifts to focus squarely on rooftop farming in Johannesburg and deals with the organization and development of projects with a review of current challenges.

The national landscape

The research revealed that rooftop farming is a relatively new phenomenon in South Africa with the first initiative launched only in 2009. The foundation date for the majority of rooftop agriculture projects occurred in the past decade. Arguably, the emergence of rooftop farming is part of a growing response to South Africa's deteriorating economic situation in the 2010s with high levels of unemployment, a chronic crisis of urban poverty, and rising concerns about food insecurity. The period 2009–2018, the years of the Presidency of Jacob Zuma, often are styled as 'South Africa's lost decade' as they were characterised by rampant industrial-scale corruption, state-capture and economic mismanagement which resulted in depressed rates of economic growth and disastrous levels of national unemployment reaching at least to 36 percent.

The national audit disclosed a total of 20 operational rooftop agricultural initiatives and with six additional projects temporarily on hold for reasons related either to renovations or issues of red tape. Of these 20 projects, 12 were greater in size than 100 m². Table 1 shows the uneven geography of rooftop agriculture in South Africa. It is evident that the largest number of operational farms are situated in the environs of inner-city of Johannesburg with two each located in the coastal cities of Cape Town and Durban (Table 1).

Table 1. The uneven geography of rooftop farming projects

City	Operational	Dormant/Non-Operational
Cape Town	2	1
Durban	2	1
Johannesburg	16	4

Source: Adapted from Allen, 2019

Table 2 shows the rationale for establishment of these 26 rooftop projects using an adapted version of the international typology of Thomaier et al. (2015) with the category 'social and educational' segmented into separate groups.

It is evident from Table 2 that the largest number of rooftop projects fall into the classification of social projects which are then followed by commercial and image improvement initiatives. Only isolated cases exist in South Africa of rooftop agriculture initiatives that relate to the categories of education, urban living quality or innovation incubator which are more characteristic features of rooftop farming as observed in cities of the Global North (Thomaier et al., 2015; Appolloni et al. 2021;

Alkhaja et al., 2024). In terms of production methods, the audit disclosed that the majority of rooftop projects are organized as soil-based, open air installations.

Table 2. Reasons for establishment of operational projects

Purpose	Description	Number of projects
Commercial	The overall aim for the farm is economic viability and profit making.	7
Image-oriented	The farm is not a source of revenue but rather offers other benefits, such as growing herbs or produce for a hotel restaurant kitchen, or corporate canteen.	6
Educational	The overall objective is to instil sustainability values within a community or educational context, these are often non-profit	1
Social	The farm can be seen as a community garden, in which tenants of a building produce crops and may eat or sell what they grow.	10
Urban living quality	The farm is used for enhancing a residential, commercial or mixed-use space, which can serve as a recreational area and is open to the public	1
Innovation incubator	Serves as a prototype and promotes novel concepts in food production	1

Turning to the national policy environment surrounding rooftop farming, this is best described as weak and undeveloped. From a policy perspective, whilst there are several city-scale initiatives to support urban agriculture, no progress has been made towards any overarching national policy towards urban agriculture development in South Africa. Policy commitments by national government towards agriculture, as driven by the Department of Agriculture, equate with sentiments about its operations only in the 'rural' environment (Kanosvamhira, 2024a). Further, in relation to policy whilst government has sought to tackle 'big policy questions' concerning challenges to food security, minimal attention has been accorded to the how and where of urban agriculture fitting into the policy framework (Rogerson, 2011). As a result, urban agriculture is viewed often as an extension of other policy and urban development mandates, a small component of much wider policy agendas regarding economic development and associated strategies. Correspondingly, the sector of urban agriculture does not receive the necessary targeted support that it would receive from policy specific directives (Rogerson, 2003; Haysom, 2015).

In South Africa policy issues pertaining to urban agriculture essentially therefore are devolved to the scale of municipal governance where often they become a component of local pro-poor initiatives of economic development programmes (Rogerson, 2011). This can be seen in the municipal level responses to urban agriculture with the City of Cape Town's Urban Agriculture Policy, the City of Johannesburg's Urban Agriculture Support Programme, or Durban's Agro-Ecology Programme. Such local initiatives each have sought to support community gardens and smallholder farms through approaches such as capacity building, skills transfer and the supply of basic tools. Arguably, therefore, South Africa's leading urban municipalities have taken up and are grappling with some of the challenges of open-space and peri-urban agriculture. Nevertheless, whilst acknowledgement is given to the practices of urban agriculture *as a whole* in municipal level responses there remains little explicit consideration for the particular issues around rooftop farming in South African policy discourse.

In the absence of specific policy directives governing its operations, the activity of rooftop farming therefore is most directly relevant to property owners in South Africa (Allen, 2019). It is in this space that rooftop farming exists with a need for cohesive partnerships to be forged between building

owners and farmers for the establishment of projects. Sometimes such partnerships emerge out of a need for large corporates in South Africa to fulfil Corporate Social Responsibility/ Investment (CSR/CSI) obligations, whether enforced through government legislation, or under pressure from company stakeholders. The development of rooftop farming is thus underpinned often by how large corporates may wish to leverage it either to meet Sustainable Development Goals or to undertake social obligations through community development and job creation schemes. The latter are for the legislative fulfilment of Black Economic Empowerment (BEE) criteria, controversial government mandated policies which have been introduced in the post-apartheid period to redress the effects of apartheid and reduce white-ownership of the South African economy (Ponte et al., 2007; Southall, 2007; Tangri & Southall, 2008; Francis & Valodia, 2021). Beyond CSI initiatives another critical impetus is that linked to projects which involve social housing, an important thread in the experience of rooftop agriculture in South Africa's major city.

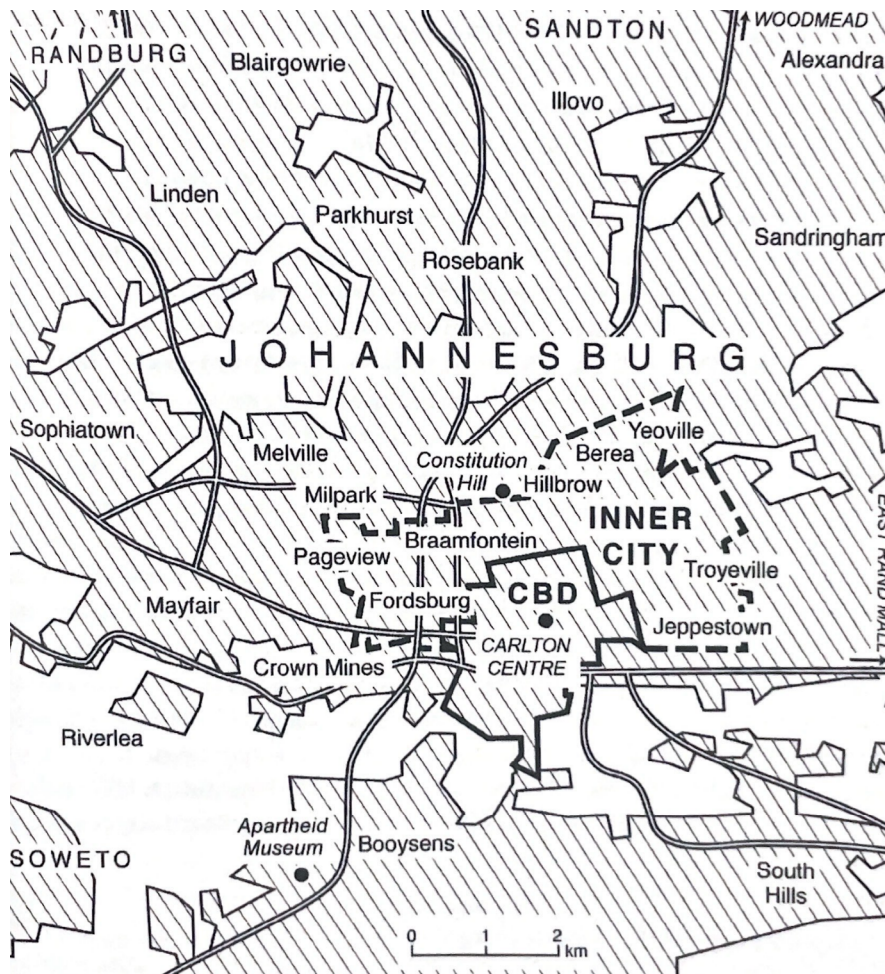
The Johannesburg record

The record of the operation of rooftop agriculture in Johannesburg is that of the city with the greatest cluster of initiatives for rooftop food production in South Africa. The inner-city of Johannesburg is the location for the majority of rooftop farms, a space which has experienced radical change over the past 30 years with dramatic physical and economic decline and readjustment (Figure 1). The location of most of the city's rooftop farms is the environs of the CBD including the surrounds of the Carlton Centre, the former commercial and retailing hub of Johannesburg. This geographical concentration of rooftop farming in Johannesburg inner-city must be understood against the background of the precipitate decline and attempts to revive of what was formerly the economic heart of South Africa's most important city.

During the 1980s the economic and physical condition of inner-city Johannesburg started to exhibit signs of socio-economic stagnation and decline as businesses abandoned the area and relocated to Johannesburg's wealthy northern suburbs (Turok et al., 2021). The exodus occurred of commercial office and retail activities, formerly situated in the CBD, to new decentralized nodes in Rosebank and Sandton (Figure 1). This capital flight resulted in a loss of jobs in the inner-city and the movement of (majority white) middle-income residents from the inner-city suburbs into Johannesburg's wealthier residential areas. It was evident that the central area was becoming a blighted space as a consequence of a cumulative downward spiral (Rogerson, 2020). Murray (2011, p. 88) documents that by the 1990s that "the once thriving central city of Johannesburg had become synonymous with unregulated street trading, poor urban management, abandoned and badly maintained buildings, unauthorized squatting, overcrowding, neglected public spaces and general disorderliness". By 1994, the year of democratic transition in South Africa the historical downtown core of Johannesburg lay in ruins, with decaying high-rise office properties, commercial establishments closed-down, and crumbling buildings invaded by homeless squatters (Moyo, 2020). The former core of a vibrant metropolis, Johannesburg

inner-city had “sunk into a state of suspended animation, transformed into a derelict and dangerous place during the day and a virtual ghost town at night” (Murray 2011, p. xiii).

Figure 1. The location of Johannesburg inner city



Since the new millennium these deteriorated physical and environmental conditions “have prompted the City of Johannesburg to implement programmes and activities which target renewal or regeneration of the inner city” (Moyo, 2020, p. 202). One of the most significant agencies for revival is the public benefit organization, Johannesburg Inner-City Partnership (JICP) which was established in 1996 and works with inner-city stakeholders to create a clean, safe and welcoming inner-city, part of broader urban regeneration initiatives. Many of the rooftop farming initiatives originated from partnerships established between different inner-city stakeholders consolidated in the JICP, the central role of which is to forge collaborative relationships between government, the private sector and community groups. One manifestation of this partnership was the establishment in 2017 of The Urban Agriculture Initiative (UAI), a non-profit social enterprise incubated by the JICP to drive the development of urban agricultural projects in the city, including of rooftop projects with a social focus (Urban Agriculture Initiative, 2020). The stated aims of the UAI are to localise food systems, to generate new economic activity and contribute to the greening of unused spaces (Urban Agriculture Initiative, 2020). The UAI initiative encouraged various property companies to utilise their rooftop spaces for urban agriculture initiatives (Ngie & Sithole, 2023). Ansell (2017) argues that components

of green infrastructure, agriculture and landscaping potentially intersect in planning for rooftop gardening in Johannesburg.

The interviews disclosed that the 20 rooftop farms in Johannesburg were established variously for social reasons, business motivations or image-enhancement considerations. The largest share—nine in total—relate to social motivations, seven for entrepreneurial or profit considerations, and four projects which are best categorized as image-related. It was revealed in the stakeholder interviews that production methods of projects split equally between a group that uses hydroponics and another group that uses soil-based mediums for food production; two projects apply a mix of these approaches. Of note is that Johannesburg is the only South African city which has examples of soil-less hydroponic projects in operation and that all these hydroponic projects are profit-motivated. Of the 20 rooftop farms 16 were operational and four were dormant, the reasons for which will be explored as part of the discussion around the challenges of rooftop farming.

From the interviews it was evidenced that the majority of Johannesburg rooftop farms driven in their establishment by social considerations are associated with property companies that own multiple buildings in the city. A group of rooftop farms in inner city Johannesburg relate directly to corporate social responsibility programmes (linked to Black Economic Empowerment) for social upliftment with support for initial project start-up costs (such as soil and containers). The largest share of social initiatives for rooftop gardens, however, are associated with non-profit companies which have been initiated by the municipal government in order to provide social housing. Allen (2019) documents in further detail the range of these initiatives and shows that a leading role is played by the Johannesburg Housing Company (JHC). It was observed that JHC owns 29 buildings and manages an additional five properties providing in total 4300 rental units and shelter for nearly 20 000 people in low-income brackets. Likewise, the Johannesburg Social Housing Company was established by the City of Johannesburg to provide and manage affordable rental housing and contribute towards reducing the city's severe housing problems. Both these entities (and others) have engaged in programmes which include the establishment of farms at the top of several of their buildings. For the JHC—which is responsible for six socially-driven farms—these initiatives were initially part of recycling awareness programmes designed to encourage tenants to be environmentally-friendly. The JHC conceived of the rooftop gardens in 2011 as a greening strategy to be anchored on encouraging environmentally-friendly lifestyles; this aligned also with motivations for enhanced food security.

The principal agency responsible for operating projects is a JHC subsidiary company (Makhulong A Matala) which functions as an NGO provider of community development services. The goal of this agency is to enhance the quality of life of building tenants with the development of rooftop gardens and using recycled waste for food production. This project runs alongside its other initiatives which include improving playgrounds and internet facilities for school learners. The rooftop farms grow produce out of plastic containers or old tyres and with soil covered by straw as the growth medium. The farmers that maintain the rooftop gardens are all tenants in the JHC buildings and assisted both by volunteers and a service provider that provides skills advice as well as recommendations on what crops to plant. The farmers are afforded opportunities to attend training workshops before given the responsibilities for tending the farm. The rooftop farms are engaged with producing a range of

different crops such as spinach, cabbage, peas, beans, sweet potatoes, onions, mint, rosemary and basil. Several farms use shade netting in order to safeguard crops from birds and pests as well as seeking to maximise the use of as much roof space as possible. The core focus for project participants is to have access to fresh produce but with any excess production sold to generate an income through the hosting of regular market days and produce sales to other building tenants.

A second group of rooftop farms in Johannesburg which are not directly profit-oriented are those supplying fresh ingredients for use (and cost offsets) in hotels, restaurants or the canteens of leading corporates in the city. For example, at the Saxon Villa hotel, located outside the inner-city in the wealthy area of Sandton in Northern Johannesburg (Figure 1), a soil roof farm has been established on top of one of the hotel's undercover parking complexes. The entire rooftop has been covered by soil and used to produce ingredients to supply the hotel restaurant. Produce includes specialist ingredients such as a variety of herbs, 20 different types of tomatoes, broad beans, Jerusalem artichokes, peas, beans and an assortment of heirloom marrows, spinach, beetroots and turnips. In this case the rooftop garden is an adjunct to the chef's demand for specialist ingredients that set apart the hotel's cuisine from other upmarket restaurants in the city. At the Troyeville Hotel the farm is situated on a rooftop terrace accessible to the public. This farm is mixed in its production methods. As Allen (2019: 138-9) elaborates, it "consists of two vertical growing walls, which is the hydroponic component, and then several pots and upcycled polystyrene prawn packaging containers that are used to grow parsley in soil". A third example of an image-related rooftop farm is that which is on the top of the offices of one of South Africa's largest banking concerns. The farm produce is used to supply the company's canteen as well as provide fresh food to staff.

The third group of Johannesburg rooftop farms are those which are profit-oriented and mainly use hydroponics. Of note is the distinctive role played in the establishment of these enterprises by a business innovation enterprise which functions as an incubator for entrepreneurs. In particular, this enterprise targets capacity building for youth entrepreneurs drawn from what in South Africa are designated as 'previously disadvantaged' (ie. black) communities in the apartheid era. Capacity building is given in the form of training for establishing a business start-up and with mentorship on how to run a business. The work of this business innovation enterprise (titled WIBC or 'Wouldn't It Be Cool') is directed to ensure that initiatives for corporate social responsibility are closely aligned with objectives for Black Economic Empowerment. It focuses broadly on a range of initiatives around urban agriculture including for rooftop farming. In one pilot project to demonstrate the possibilities of creating a sustainable business model around rooftop farming the production focus is basil, a high value crop that is produced using hydroponic methods. Support for the wider roll out of such entrepreneurial rooftop farming projects came from the Kickstart entrepreneurship support programme which is funded by the international brewing conglomerate SAB Inbev (formerly South African Breweries). Support consists of a skills upgrading programme in which individuals receive a five month training course on how to maintain and operate a hydroponic farm. The course further includes components on business management and issues around establishing a market, which products to sell, and how to develop market linkages (Allen, 2019). Essentially, the WIBC business innovation enterprise seeks to produce urban farmer graduate entrepreneurs to be part of the agri-business value chain. Graduates

from the five month training programme are encouraged to network and form business relationships with each other, thereby to construct a cohesive market system that might support urban agriculture (including rooftop farms) across Johannesburg. This thrust is the result of frustration with previous failed initiatives in urban agriculture and rooftop farming which were the result of the absence of the development of market linkages.

Extant research on the performance of rooftop farming in Johannesburg points to the existence of a number of challenges that impact the sector and its participants (Ansell, 2017; Allen, 2019; Shapurjee, 2022). The first, already alluded to, is the weakness of the policy environment concerning urban agriculture in general and then the almost complete absence of policy frameworks for support of rooftop gardening. This weakness of policy support even extended to the municipal levels. The interviews conducted with stakeholders underscored issues of general disinterest and lack of engagement by the municipal authorities. The responsible department was styled by one interviewee as “one of the most unorganised, unmotivated and unengaging departments”. The damning critique continued as follows: “it’s almost like a fronting scenario where they just want to do something to look like they are doing something. But they don’t have a genuine interest or intention to take this into something sustainable” (cited in Allen, 2019, p. 145).

A second set of challenges relate to issues of weather and that of climate change. Projections point to far reaching impacts for the city of climate change in terms of warming trends and increased levels of humidity (Nana et al., 2019). For rooftop farmers the impact of wind and extreme heat events are issues of greatest concern. It has been observed that in Johannesburg wind is most problematic for hydroponic farms as the growing tunnels are mainly made of shade cloth or plastic sheeting which can buckle under high wind conditions. The threat of hail damage to crops is also of concern in Johannesburg summers. Arguably, climate change is one of the major stressors on urban development in Africa and therefore a risk factor for rooftop farmers (Hetz, 2016). The impacts for crops of extreme temperatures during summer months are heightened as none of the hydroponic projects applies air conditioning. Three, the situation has been exacerbated in recent years by power shortages in the South African electricity network and regular episodes of loadshedding in Johannesburg. Unstable power supplies have contributed to crop failure (Ngie & Sithole, 2023). As hydroponics requires electricity to circulate water, without a power source plants have dehydrated and died, one of the factors leading to the non-operational status of at least one rooftop project. Four, problems are highlighted by the implementing agencies concerning the poor or unreliable participation of tenants in farmer training programmes in social projects. Participation by tenants was often irregular and inconsistent. The research by Shapurjee (2022) at the Coronia Gardens Berea project also discloses the problematic issues of limited involvement and engagement in an inner-city rooftop farm. This finding underlines the important point of the need to address limited resident awareness of the potential benefits of engagement with urban agriculture projects including for rooftop farming.

Finally, another vital constraint in Johannesburg relates to projects that were geared to financial viability. The challenge concerns market access difficulties which resulted in some rooftop projects failing to be operational due to the absence of established market linkages. It was evidenced in the stakeholder interviews which were conducted in Johannesburg that, notwithstanding the activities

of The Urban Agriculture Initiative, only a handful of rooftop farmers that were engaged in business-oriented ventures were able to sell excess stock through the Johannesburg Fresh Produce Market.

CONCLUSIONS

Across the international experience, urban agriculture has emerged as a crucial strategy for ensuring sustainable food access (Alkhaja et al., 2024). Questions surrounding the role of urban agriculture and sustainable cities continue to attract a growing literature in the Global North albeit with only a small contribution observed from geographers (Tornaghi, 2014; Turner et al., 2024). One component of this Global North scholarship is debates around the practice and merits of rooftop farming (Appolloni et al., 2021). In the urban Global South, whilst there is a rich and vibrant literature on open-space and peri-urban agriculture, including from human geographers, there is a paucity of material about the state of rooftop agriculture.

It is against this backdrop that this paper contributes to an emergent scholarship for the urban Global South concerning rooftop farming. More specifically, it addresses a knowledge gap by contributing a state-of-the-art overview on rooftop agriculture in urban South Africa where the leading cluster of initiatives exists in and around inner-city Johannesburg. Although a range of different motives underpin the appearance of this cluster of projects the most significant relate to social considerations for improving the access of lower-income groups to fresh food. The importance of partnerships for the establishment of projects emerges as a distinctive element of the Johannesburg experience. Further monitoring and research is needed of the progress of rooftop agriculture in South Africa's major cities and in particular of evaluations of resource efficiency and sustainability actions. In addition, for geographers an enhanced understanding of the ramifications of climate change for rooftop agriculture sector is a matter of special interest. Furthermore, in terms of looking to the future, the development of policies that might support adaptation to climate change are of critical significance for enhancing the prospects of the rooftop farming sector in urban South Africa.

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