Received: 11 September 2024 | Accepted: 3 November 2025

DOI: 10.1002/uar2.70036

Urban Agriculture & Regional Food Systems OPEN ACCESS

ORIGINAL ARTICLE

Assessing the viability of hydroponics for low-income farmers in South Africa's urban agriculture sector: An urban political ecology perspective

Busisiwe Miya Noxolo[1] | **Tinashe P. Kanosvamhira**[2]

[1]Department of Geography Environmental Studies and Tourism, Faculty of Arts and Humanities University of the Western Cape, Cape Town, Western Cape, South Africa

[2]Department of Geography Environmental Studies and Tourism, Faculty of Arts and Humanities University of the Western Cape, Cape Town, Western Cape, South Africa

Correspondence
Tinashe P. Kanosvamhira, Department of Geography Environmental Studies and Tourism, Faculty of Arts and Humanities University of the Western Cape, Robert Sobukwe Road, Cape Town, Western Cape 7535, South Africa. Email: Kanostk1@gmail.com

Assigned to Associate Editor Marcus Mergenthaler.

Abstract

Urban agriculture in densely populated areas is significantly constrained by space, leading to interest in vertical farming solutions like hydroponics. This study evaluates hydroponics' viability in Cape Town's low-income urban areas as a useful supplement to most research, which focuses on cities in the Global North. Using surveys and interviews, the article assesses whether farmers believe hydroponics can address challenges, such as water scarcity and limited space. The findings highlight several perceived benefits, including improved yields, water conservation, and efficient land use allvaluable features in Cape Town's urban environment. Significant challenges remain, notably the high setup costs and limited government support. This study draws on urban political ecology to explore how broader systemic inequalities influence the adoption of hydroponics. Financial and institutional barriers are rooted in historically produced conditions of inequality, reflecting ongoing capitalist dynamics of urban development. While hydroponics has potential as a sustainable alternative, its high costs hinder broader applicability, particularly in low-income areas with unequal resource distribution. Therefore, hydroponics is not yet considered a viable large-scale alternative for addressing food security in such contexts. For hydroponics to meaningfully contribute to urban food security and sustainable agriculture in Cape Town's low-income communities, supporting actors must address systemic issues around financial feasibility and local expertise.

Plain Language Summary

Urban farming in crowded areas faces space and resource challenges, which is why new solutions like hydroponics are being explored. Hydroponics allows plants to grow without soil, using less water and space. This study looks at how hydroponic farming works in low-income urban areas of Cape Town. Through surveys and inter-

Abbreviations: NGO, Non-governmental organisation; SDG, sustainable development goals; UPE, urban political ecology.

views, the research shows that while hydroponics uses less water and space, making it a good fit for Cape Town, there are still huge challenges. These include high costs to start and a lack of local support. The study also shows how deeper problems, like financial inequality, make it harder for people in low-income areas to use hydroponics successfully. Even though it offers environmental benefits, hydroponics is not yet a practical solution for large-scale farming in these areas. To make it work, we need to address issues like affordability and local training.

1 | INTRODUCTION

Urban agriculture is the process of cultivating crops or rearing animals within or near urban areas (Kiribou et al., 2024). Its social, ecological, and economic benefits vary across contexts (Nkosi et al., 2022). In Global North states, like the United States and Canada, urban agriculture is valued for fostering community building, providing education, improving mental health, enhancing food security, and promoting environmental awareness (Gray et al., 2020). It is also widely practiced in the Global South, including in Zimbabwe, Mozambique, and South Africa (Kiribou et al., 2024; Paganini et al., 2018), where it is mainly driven by food security and economic needs (Gray et al., 2020). It is often practiced by wealthier individuals but also used by poorer communities to alleviate poverty (Matamanda et al., 2022; Mwakiwa et al., 2018). However, urban farmers often have limited access to land, especially in poorer townships, and must rely on off-plot or guerrilla cultivation (Suchá et al., 2020). Many farmers also rely on rainwater or must purchase water, adding to their challenges (Mwakiwa et al., 2018).

The Sustainable Development Goals addressing urban food insecurity are Zero Hunger (SDG 2) and Sustainable Cities (SDG 11). Sustainable urban agriculture is essential for achieving these objectives by 2030 (Azunre et al., 2019). The scarcity of resources like water and arable land necessitates innovative solutions for maintaining urban ecologies. Soilless farming is a smart agricultural technology that utilizes a nutrient solution (with or without a supportive medium such as perlite, rice hulls, or coco-peat) and thrives in controlled environments. It offers a practical approach to cultivating crops without traditional soil (Gumisiriza et al., 2023). This method is especially prudent for horticultural crops in areas with poor soil or limited space. Soilless farming methods include hydroponics, aeroponics, and aquaponics, each with distinct advantages (Campbell et al., 2014).

Hydroponics is a modern urban farming system that uses water to deliver nutrients to plants without soil. Urban hydroponics addresses critical challenges related to resource efficiency, food security, and environmental conservation. The method enhances crop yields and quality, making it ideal for urban agriculture. It addresses traditional farming challenges, such as limited arable land, by utilizing innovative spaces like rooftops and vertical farms to boost urban food production and sustainability (Treftz & Omaye, 2016). Hydroponics also increases productivity through precise nutrient control to enable faster growth and higher yields. It is also more environmentally sustainable since it reduces soil erosion, nutrient loss, and eliminates the need for chemical pesticides. Integrated pest and disease management techniques ensure healthier plants. The system also mitigates issues like air pollution and urban heat island effects. Hydroponics also fosters entrepreneurship and stimulates economic growth by creating business and job opportunities, particularly for youth. Efficient food production in limited urban spaces supports local food systems, reduces transportation distances, and encourages community involvement in sustainable agriculture (Treftz & Omaye, 2016).

Despite increased adoption of hydroponics, there is still a significant gap in understanding it in practice, particularly in the Global South. For instance, the environmental efficiency of indoor hydroponics is often questioned due to high energy consumption (Romeo et al., 2018). Additionally, hydroponics may not come with benefits to urban ecology and biodiversity typically linked to traditional soil-based agriculture. Nevertheless, studies from the Global North have demonstrated benefits of hydroponics, including reducing the urban heat island effect, improving air quality, and strengthening local food security (Goodman & Minner, 2019). Similar outcomes could be achieved in the Global South with the right adaptations and support. Addressing food insecurity likely requires considering hydroponics in disadvantaged urban areas. However, hydroponics remains under-researched in low-income contexts, particularly in countries like South Africa, where challenges such as drought and land tenure further complicate urban farming (Kanosvamhira, 2019; Suchá et al., 2020).

Hydroponics offers a solution to resource limitations around water and space, which are particularly important in urban areas such as Cape Town, where water scarcity is a persistent issue. Hydroponic systems can also transform underutilized urban spaces into productive green areas that promote environmental sustainability and community well-being (Gumisiriza et al., 2023). However, the soilless nature of these systems limits some ecological benefits typically provided by traditional agricultural practices, such as soil regeneration and habitat support.

This paper investigates the viability of hydroponic farming in disadvantaged urban neighborhoods. It examines whether hydroponic farming can serve as a sustainable alternative to traditional farming methods in Cape Town and what challenges and opportunities local farmers face in its implementation. Our sampling comes from a Cape Town-based organization pioneering indoor, soil-less hydroponic techniques. The paper is structured as follows: Section 2 provides the theoretical framing, while Section 3 reviews the study area and outlines the methodology. Section 4 reviews the results, and Section 5 discusses the findings using the urban political ecology (UPE) framework. The paper concludes with key insights and recommendations for future research.

Core Ideas

- Hydroponic farming reduces water use and maximizes land in space-constrained cities.
- There is limited research on hydroponics in low-income contexts, particularly in the Global South.
- Systemic inequalities impede widespread adoption of hydroponics in Cape Town.
- High setup costs and limited support hinder hydroponic scalability in low-income areas.
- Hydroponics can potentially alleviate urban food insecurity in low-income neighborhoods.

2 | THEORETICAL FRAMEWORK

Political ecology (PE) examines the interplay of power and politics around the environment, with a focus on how knowledge, access, control, and distribution of resources are managed (Bennett, 2019). It also explores the environmental and social outcomes of the politicization of environments across different scales. PE acknowledges social relations, economic constraints, and political power structures as crucial determinants of access to and control over natural resources. It tackles questions related to wealth distribution, economic inequities, social exclusion, the role of the state, interclass relations, land ownership patterns, and the distribution of benefits and costs linked to environmental change (Robbins, 2019). The PE framework has also been adopted in urban studies as an effective toolkit for analyzing socio-environmental processes and spatial dynamics (Heynen, 2016).

UPE draws attention to power relations to examine how cities function as complex socioeconomic and environmental systems (Chen & Shin, 2019). This approach intersects with critical urban geography, which focuses on social and environmental justice and interrogates spatial analyses to uncover underlying power structures (Heynen et al., 2006). Researchers using UPE investigate how socio-environmental conditions in cities are not the result of natural processes but are intricately woven into the fabric of political and economic decisions.

One significant aspect of UPE is its focus on the political dimensions of urban environments, particularly how capitalist and neoliberal urban development schemes influence socio-environmental conditions (Swyngedouw & Heynen, 2003). This perspective is crucial for understanding the unequal distribution of resources and opportunities within urban areas. UPE scholars highlight how urban spaces are often manipulated to benefit elite groups, while marginalizing less privileged populations (Keil, 2003). This framework is particularly useful for analyzing the dynamics of urban agriculture, as it helps elucidate how policies and practices either reinforce or challenge existing power structures and socioeconomic inequalities. In recent years, UPE has evolved to incorporate insights from postcolonial, Indigenous, antiracist, queer, and feminist theories to broaden its analytical scope (Lawhon et al., 2014). In sum, this heterodox approach emphasizes the importance of understanding the embodied processes of unequal urban development.

UPE has been applied to reveal the complex negotiations and power relations involved in securing space for urban agriculture (Nyantakyi-Frimpong et al., 2016). UPE work has also considered how urban governance at various spatial levels interacts with gardening practicesss and whether these practices align with or challenge official policies and plans (Zhu et al., 2020). The application of a UPE framework enables an exploration of the socio-political dynamics shaping resource access and equity in urban environments. It has uncovered how gardeners navigate political discourses and societal norms, illuminating the symbolic and practical struggles inherent in urban agriculture (Neo & Chua, 2017). It helps us situate hydroponic farming within broader socio-political power relations, offering a nuanced perspective on the structural barriers and opportunities within urban governance.

Additionally, UPE's emphasis on the social construction of urban spaces and the production of urban nature (Tornaghi, 2014) sheds light on how hydroponic farming challenges traditional conceptions of agricultural practices. This theoretical lens enhances the findings by elucidating how hydroponics serves as both a practical response to resource constraints and a site for contesting dominant urban governance models. Our application of UPE demonstrates how power dynamics and policy decisions shape the sustainability and justice outcomes of hydroponic systems, ultimately contributing to a richer interpretation of the findings.

3 | MATERIALS AND METHODS

3.1 | Study site

Cape Town is characterized by sharp socio-economic contrasts, with affluent areas featuring opulent residences juxtaposed against impoverished regions, such as the Cape Flats. These disparities are largely a legacy of apartheid-era spatial planning, which entrenched socio-economic divisions within the city. The Cape Flats are sandy, sparsely vegetated areas on the outskirts of Cape Town that were initially designated as residential zones for manual laborers during apartheid. Post-apartheid urban migration has transformed these areas into extensive townships, housing thousands of residents, despite bearing the marks of historical segregation (Engel & Anja, 2019). These landscapes are exposed to strong southeasterly winds in summer and occasional winter flooding. They also suffer from deficiencies in social amenities, limited commercial and industrial infrastructure, and pressing issues related to food security, community development, and environmental sustainability (Lukas-Sithole, 2020).

A survey conducted on the Cape Flats revealed that 54% of households experience food insecurity, with 30.6% facing severe food insecurity (Paganini et al., 2021). Urban agriculture has emerged as a response and is supported by municipal measures and collaborative efforts from provincial governments, non-governmental organisations (NGOs), and civil society organizations (Kanosvamhira, 2019). Non-state organizations have been instrumental in advancing urban agriculture by leveraging donor funds to subsidize inputs, enhance infrastructure, and create market opportunities for urban gardeners (Paganini et al., 2018).

There are several initiatives to improve food security and promote sustainable agriculture in the township of Langa. Established in 1927, Langa is one of South Africa's oldest townships and is predominantly inhabited by Black African people, including a large Xhosa-speaking community (Musemwa, 1993). The township is characterized by informal settlements, inadequate housing, limited access to basic services, high unemployment, and significant poverty. Langa's urban environment is also affected by anthropogenic factors, such as contamination from heavy metals and domestic waste, which negatively impact soil health and traditional in-ground farming.

One such initiative is the iKhaya Le Langa Hub, established by the Mr Price Foundation, which focuses on hydroponic farming to boost local food production and support economic development (Martin, Poulikidou & Molin, 2019). The project addresses food security while promoting economic upliftment and environmental sustainability. Despite its potential benefits, the uptake of hydroponic farming faces barriers related to social, cultural, and accessibility factors, which may affect its acceptance in the community.

3.2 | Research design

This research employed a mixed-methods approach (Creswell & Creswell, 2017), utilizing secondary data, questionnaires, and semi-structured interviews with various stakeholders involved in vertical farming initiatives in Cape Town. This included open-ended questionnaires completed by hydroponic farmers and semi-structured interviews with three hydroponic farmers, representatives from civil society organizations supporting hydroponic farming in Cape Town, and the co-founder of a South African hydroponics system. The survey of hydroponic farmers was conducted in their areas of residence in 2024.

Access to participants was facilitated through an organization managing a rooftop farm in Kenilworth, Cape Town. Farmers were randomly selected based on their availability and willingness to participate. We selected this collaborative method primarily due to accessibility and safety concerns, as the organization's established presence in Langa township allowed for secure and effective engagement. However, our reliance on the organization for access to farmers excluded individuals who established independent hydroponic systems.

A total of 20 urban farmers were identified, and open-ended questionnaires were distributed for the farmers to complete at their own convenience. This approach facilitated more thoughtful responses, as the farmers could answer the questions in a calm environment of their choice. The questionnaires were distributed by fieldworkers from the NGO, which had extensive knowledge of the study area and established trust-based relationships with the farmers. This familiarity facilitated smoother logistics and helped build trust among participants, especially in areas where external researchers might encounter security challenges. Importantly, the fieldworkers' role was confined to distribution. The research team retained control over the questionnaire's content and ensured that the NGO did not alter or modify the questions. Additionally, all data analysis was conducted solely by the research team to ensure objectivity and reliability. This approach was consistent with the co-production of knowledge methodology, which emphasizes inclusivity and mutual respect among stakeholders.

The sample of 20 targeted farmers provides valuable insights into local hydroponic farming practices but does not represent the full range of hydroponic farming in Cape Town. Our sampling strategy inherently excluded potential participants who might have independently developed hydroponic

FIGURE 1 The African grower hydroponic system.

systems. This limitation is acknowledged as a constraint on the generalizability of the findings, which predominantly reflect NGO-led initiatives.

We also conducted semi-structured interviews with key stakeholders, including the co-creator of the vertical grower, the organization that facilitated farmer training, and three of the 20 hydroponic farmers. The interviews with the co-creator of the vertical grower provided deeper insights into the product, its design, functionality, and the motivations behind its development. The African Grower (Figure 1) is a South African-made vertical hydroponic growing system designed to maximize space efficiency by stacking multiple growing pods, allowing the cultivation of 16–24 plants per unit. The pest-resilient system is suspended from a fixture and is ideal for home food production. It includes components such as growing pots, coir blocks, fertilizers, and organic boosters. The interviews with the three farmers added depth to the initial survey and discussed the technological aspects of hydroponic systems. These interviews lasted between 20 and 45 min.

Data from the questionnaires were processed in SPSS. Qualitative data from interviews and open-ended questions were transcribed and analyzed using thematic analysis, following Terry et al.'s (2017) guidelines. Initial reviews identified key themes, which were coded around the research aims; a reflexivity diary tracked this analytical process. Thematic evaluation focused on participants' experiences with traditional and hydroponic farming, as well as access to support systems. Recurring patterns and insights were organized to capture the diverse challenges and opportunities faced by farmers transitioning to hydroponic methods. Direct quotes from participants are included here to enrich the thematic analysis. This multi-method approach allowed for a holistic view of the introduction and impact of hydroponics in economically disadvantaged communities in Cape Town. All ethical procedures were followed. Data collection commenced after receiving ethical clearance from the university under certificate number HS24/2/5, ensuring the research adhered to ethical standards and guidelines.

4 | FINDINGS

The findings of this study are structured into four key areas. First, we present the socio demographic profile of respondents, including their age, gender, education, income sources, and occupations. Second, we discuss the common crops, yields, and challenges of traditional in-ground farming practices. Next, we turn to hydroponic farming dynamics to examine the motivations for adoption, experiences, and benefits (e.g., water and space efficiency). Finally, we consider local perceptions of community engagement and support for hydroponic initiatives and additional developmental needs.

4.1 | Sociodemographic data of respondents

Data were collected from 20 participants who had received training from an NGO and engaged in hydroponic farming. The participants' ages ranged from 26 to 55 and above, with the largest age group being 26–35 years old (45%), followed by those aged 56 and above (25%). The gender distribution was fairly balanced, with 55% female and 45% male participants. The farmers' primary sources of income included formal employment (35%), pension (15%), and self-employment/entrepreneurship (15%). Other sources of income included government assistance (10%), and some were unemployed (20%). Most identified their occupation as farmers (70%) or agricultural workers (15%), with the remaining 15% being professionals in unspecified fields. Most participants had between 1 and 5 years of farming experience (60%), while 20% had >10 years. The remainder had 6–10 years of experience (15%) or <1 year (5%).

4.2 | Traditional in-ground farming dynamics

Most of the 20 participants (75%) reported currently practicing traditional in-ground farming, while 25% had previously done so. Here, traditional in-ground farming refers to agricultural practices that take place in the ground. A variety of crops were cultivated in-ground, with most farmers growing maize and vegetables (e.g., butternut and pumpkin). Some farmers grew other crops traditionally, including spinach, beetroot,

TABLE 1 Crops cultivated using traditional in-ground farming methods versus hydroponic methods.

Traditional in-ground farming	Hydroponics farming
Vegetables	
Cabbages, carrots, potatoes, spinach, beetroot, peas, beans, cauliflower, Swiss chard, butternut, pumpkin, lettuce.	Lettuce, spinach, spring onion
Fruits	
Tomatoes, peaches, strawberries, macadamia nuts, grapes, mangoes, granadilla	Tomatoes
Herbs	
Basil, thyme, rosemary, mint, parsley, coriander, oregano	Basil, thyme, rosemary, mint, parsley, coriander, oregano
Flowers	
Nasturtium, marigold, diosma, viola, impatiens, dianthus	Nasturtium, marigold, diosma, viola, impatiens, dianthus, pansy
Other	
Aloe, rooibos, maize	Celery

peas, beans, tomatoes, and various fruits like mangoes and granadillas. The farmers explained that they continued to practice traditional in-ground farming, particularly for larger crops that were not necessarily compatible with the African Grower system. One farmer explained, *"While the African Grower is excellent for smaller crops, certain larger crops, like maize and pumpkin, still require more space and deeper soil, which is why we rely on traditional farming methods*."

Many farmers continued to practice both methods, experimenting with the new technology before fully committing to it. However, they also listed multifaceted challenges associated with traditional in-ground farming, with pest infestation being the most frequently cited issue (affecting 15% of respondents). Other challenges included soil quality, water availability, and weather conditions, with some participants facing multiple issues simultaneously.

4.3 | Hydroponics farming dynamics

Farmers adopted hydroponic techniques for a variety of personal, practical, and ideological reasons. Many were drawn to the innovative technology, which they perceived as easier and more efficient than traditional methods due to its soil-free approach and efficient use of water and space. Others were motivated by its potential to address broader issues like food security and climate change. Some farmers identified an opportunity for personal and professional growth after hands-on experiences and training placements boosted their confidence with the method.

Motivations for engaging in hydroponic farming were primarily driven by convenience, efficiency, and alignment with personal values (Table 2). Respondents were attracted to hydroponics for its ease of use, efficient use of space and water, and modern approach to farming. Farmers noted the simplicity of the system ("*Because it makes farming look easy*"), its resource efficiency ("*It's more economical in terms of water usage and space*"), and a desire to address climate change and expand knowledge ("*I realised that climate change is on an upward curve" and "I wanted to expand my knowledge in crop production*"). The largest group of respondents (40%) had practiced hydroponics for 1 year. However, a significant portion (15%) had only engaged in hydroponic farming for 6 months. This underscores the relatively recent uptake of this method and the ongoing learning curve for many farmers.

Participants grew a range of crops using hydroponic methods (Table 1), including lettuce, tomatoes, cucumbers, flowers, and herbs like basil, thyme, and parsley. Most participants rated the overall yield of their hydroponic farming highly. Specifically, 55% rated the yield as "Much higher than expected," suggesting strong satisfaction with the productivity of hydroponic systems.

For the participants, the primary advantages of hydroponic farming were faster growth rates and reduced water usage (Figure 2). Additionally, 10% of farmers noted consistent quality and reduced pest problems as benefits over conventional methods. These perceptions align with broader work on hydroponic systems as being more efficient than traditional farming methods. One participant used the system's fast growth to germinate seedlings before transferring them to the ground. He explained: *"The African Grower is much more efficient for germinating seedlings, and once they are strong enough, I transfer them to the ground. It saves time "* This approach allowed him to maximize the potential of both the hydroponic system and traditional farming methods. Finally, farmers perceived a significant reduction in water consumption when using hydroponic systems. As one farmer explained, "*I water my plants once every two days, depending on the weather conditions*." By contrast, traditional soil-based crops generally required more frequent irrigation, often on a daily basis during warmer peri-

TABLE 2 Selected responses on why farmers engaged in hydroponics.

	Quotations from questionnaires
Respondent 1	*"I realised that climate change is on an upward curve and I wanted to make sure people had other means to farm and get food."*
Respondent 3	*"I wanted to expand my knowledge in crop production."*
Respondent 5	*"In hydroponics plants can grow quick and saves space."*
Respondent 6	*"As I said, it's very sandy in Cape Town. So, in hydroponics, it's very good because it has a lot of nutrients because we use coconut corn instead of soil".*
Respondent 9	*"Because it is the new technology."*
Respondent 10	*"It's more economical in terms of water usage and space."*
Respondent 12	*"It's a new way of farming and easy to do."*
Respondent 13	*"Less, less water less energy."*
Respondent 14	*"Uses less soil, less water and being trained in a way of farming."*
Respondent 15	*"Because in the hydroponic, there's no soil dig."*
Respondent 17	*"I was already doing ground farming, I needed something more easier."*
Respondent 18	*"Being part of new things in agriculture."*

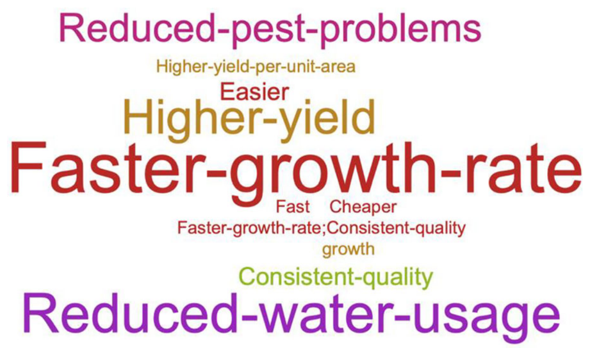

FIGURE 2 Word cloud showing the main advantages of hydroponic farming ($n = 20$).

ods, due to higher evaporation rates and reduced water-use efficiency.

Table 3 illustrates the comparative analysis of land usage between traditional in-ground farming and hydroponics. Hydroponic farmers use much smaller areas, with 65% of them requiring just 1–10 square meters. In contrast, traditional farming demands much larger spaces, with 25% of respondents needing 11–100 square meters and 20% requiring up to 10,000 square meters. This space efficiency makes hydroponics particularly well-suited for land-scarce urban areas like Cape Town. It allows crop cultivation to occur in underutilized urban spaces, such as rooftops. However, as one key informant noted, this efficiency comes with trade-offs, including the need for specific infrastructure and recurrent energy costs.

Hydroponic farming entailed different financial costs and savings from traditional farming. Traditional farming costs included seeds, fertilizers, pesticides, and labor, whereas hydroponic farming expenses were centered around equipment, nutrient solutions, and maintenance. Participants were almost evenly divided on whether hydroponic farming was more profitable than traditional methods over time: 45% believed hydroponics was more profitable, while 40% chose traditional farming. This variability reflected individual circumstances and operational efficiencies.

The choice of farming methods was influenced by factors like market demand and crop type, along with available resources and climate conditions. Farmers listed the start-up cost for hydroponic systems at approximately 1399 ZAR (approximately $74.25 USD). Many received a subsidized

TABLE 3 Comparative land area needed for farming methods.

Land area category	Traditional in-ground farming	Hydroponic farming
1–10 square meters	5% (1 respondent)	65% (13 respondents)
11–100 square meters	25% (5 respondents)	30% (6 respondents)
101–1000 square meters	5% (1 respondent)	0% (0 respondents)
1001–10,000 square meters	20% (4 respondents)	0% (0 respondents)
N/A	5% (1 respondent)	5% (1 respondent)

Abbreviation: N/A, not applicable.

start-up kit but knew that upscaling would require purchasing additional tunnels and connectors.

4.4 | Community engagement and support

The survey revealed that only 35% of respondents were aware of community engagement initiatives promoting hydroponic farming in their area. For instance, African Grower provided training and resources (e.g., a 1.5 × 1.5 m tunnel and hydroponics system) to the Langa community to facilitate their entry into hydroponic farming. Other area organizations also promoted hydroponic practices and supported individuals by supplying the necessary equipment and creating market opportunities for their produce. These initiatives collectively advanced hydroponic farming and fostered local engagement.

However, most respondents (70%) expressed dissatisfaction with the support from local authorities and organizations. One respondent lamented, *"Currently, there is a lack of support; we need more substantial backing from local bodies to make hydroponic farming viable, particularly in accessing land for scaling up."* This sentiment was echoed by another key informant, who indicated that farmers may not fully benefit from hydroponics due to land tenure challenges:

> They may have been cultivating the land for years, but they do not necessarily hold a lease or own the property. This leaves them quite vulnerable. Their arrangement with the land is often seasonal, making it difficult to commit to a hydroponic setup, which requires upfront capital costs and other infrastructure investments. The returns on such investments take time to materialise, and the farmer may not have the luxury of that kind of time

Conversely, 20% of respondents felt that adequate support was available and were positive about the existing support structures.

Several key needs emerged when participants were asked about additional support or resources that could benefit hydroponic farmers. One participant proposed, *"purchasing African Growers and distributing them in the community, and supporting the farmers by buying their produce or opening a channel for them to sell their own produce."* Another suggested, *"Enhanced plant yield is crucial, as hydroponics offers a greater yield with less water."*

Financial support was frequently mentioned, with one respondent noting, "Funding from the government to buy the hydroponic system would make a significant difference." Additional needs included "dryers for preserving food," "grant funds for seeds," and "material or equipment support." Respondents also requested support in accessing local markets since "connecting with potential buyers could help farmers sell their produce." Another farmer highlighted the importance of government assistance, stating, "If projects like these could get support from the government, hydroponic farming could be more accessible to more people."

The farmers were optimistic about the future of hydroponic farming in Cape Town and often envisioned integrating it into urban life through networks of rooftop farms supplying fresh produce. As one participant explained, *"I see a massive market where more and more buildings will have rooftop farms in order to supply fresh vegetables to the community."* They called for *"involving the young and old in the community to farm in the spaces,"* highlighting the potential for inclusive participation to enhance hydroponic farming's impact.

Respondents also identified several crucial policy interventions that could promote hydroponic farming in economically disadvantaged neighborhoods. There was a need for infrastructural support, with one respondent advocating for *"Assistance with space, that is, open areas, water, and fencing."* Another respondent called for *"targeted policy interventions, government and stakeholders [to] help foster the growth of hydroponic farming in economically disadvantaged neighbourhoods."* Other suggestions included educational initiatives *"and exposure even in social media,"* and increased funding for "*the locals in getting them hydroponic systems to farm at the backyards."*

However, this technology was not easy to adopt (which is why African Grower decided to manufacture a less complex vertical grower system). The co-founder of African Grower indicated that *"You still need to ensure that the system is user-friendly, so it can be legally adopted and utilised effectively. If the system is too complex, it may become problematic, requiring substantial investment in training, monitoring, and evaluation."* These recommendations allude to a multi-faceted approach that could overcome the barriers to widespread adoption and ensure that hydroponic farming can thrive in economically challenged areas.

5 | DISCUSSION

Hydroponics is a vital approach for fostering sustainable urban farming (Gumisiriza et al., 2023). An UPE lens allows us to explore the interplay between socioeconomic inequalities, urban space, and sustainable agricultural practices, offering a nuanced understanding of hydroponic farming's complexities. UPE focuses on the interplay between socio-environmental processes and political dynamics, showcasing how urban environments are shaped to favor certain groups (Heynen et al., 2006). This framework helps contextualize the viability and challenges of hydroponic farming as a sustainable alternative.

Socioeconomic inequalities shaped the environmental practices and resource access of a diverse group of hydroponic farmers from economically disadvantaged areas in Langa (Chen & Shin, 2019). Many of the farmers turned to hydroponics due to challenges with traditional in-ground farming, such as pest infestations, poor soil quality, and water scarcity. This underscores how urban environments often leave marginalized populations to deal with environmental and socio-economic challenges (Swyngedouw & Heynen, 2003). Thus, conventional methods are inadequate for addressing urban issues like water scarcity and land constraints. As UPE understands, these challenges are rooted in systemic inequalities and power dynamics, not simply technical shortcomings.

The participants expressed diverse motivations and experiences with hydroponic farming as a tool to reshape urban agriculture to meet socio-environmental challenges like climate change, food insecurity, and resource scarcity. UPE focuses on urban responses to ecological crises (Swyngedouw, 2015). Hydroponic technology is a potential solution to urban environmental degradation and resource scarcity. Participants highlighted hydroponics' efficiencies around water and space, important features in drought-prone Cape Town, where water scarcity is a pressing issue (Paganini et al., 2018). In areas like the Cape Flats, residents typically depend on rainwater collection and municipal supplies (Olivier, 2018). Global research suggests that soilless farming can reduce water usage by up to 90% compared to traditional methods (De Bon et al., 2010).

UPE also prompts us to critically examine how technology intersects with existing urban power dynamics. Technological innovations intersect with broader socio-political and economic contexts, creating both opportunities and challenges for urban farmers. Hydroponic farming requires a substantial initial investment in equipment and nutrient solutions, creating barriers for economically marginalized urban dwellers. Although the farmers were provided significant subsidies (a start-up kit), more investment was required to upscale and maintain the system. Such uneven distribution of urban environmental benefits can perpetuate social and spatial inequalities (Gustafson et al., 2014).

The reliance on NGO-promoted commercial hydroponic systems incurred high costs and limited accessibility for economically disadvantaged farmers. While these systems are resource-efficient, their initial expenses and inconsistent economic returns (Gumisiriza et al., 2023) pose significant adoption challenges. Stakeholders should incorporate alternative hydroponic practices that are more cost-effective than the pricey commercial systems. UPE's framework contextualizes these challenges within capitalist urban development, which can either facilitate or hinder sustainable practices, depending on prevailing economic and political conditions (Heynen, 2014). These findings underscore the need to address systemic barriers and promote equitable access for hydroponics to realize its full potential in resource-constrained urban settings.

Perceptions of community engagement and support for hydroponic farming initiatives revealed both opportunities and critical gaps in local support systems. Various organizations provided valuable training and resources, but farmers frequently found the support from local authorities insufficient. This reflects UPE's critique of how power dynamics shape environmental practices, resource allocation, and access to technology (Lawhon et al., 2014). There is an urgent need for more inclusive and robust frameworks to bridge the gap between the support offered and farmers' expressed needs. Addressing these shortcomings is particularly vital in urban contexts, where sustainable agricultural practices are key to enhancing food security and resilience.

In Cape Town, civil society actors, including NGOs, support urban agriculture initiatives (Engel & Anja, 2019), bridging the gap between farmers' needs and existing support systems by leveraging local knowledge and advocating for policies. However, their role as intermediaries between farmers and policymakers demands careful scrutiny. While NGOs often address gaps left by state inaction, their programs should encourage community-led models that prioritize local capacity building and sustainable empowerment. An over-reliance on NGOs for market access undermines farmer autonomy and hinders the development of sustainable, community-led agricultural initiatives. Most marketing of produce is currently facilitated by third parties (Paganini & Lemke, 2021). Farmers should move away from this NGO dependence and establish their own retail and market access networks that allow them to retain greater control over their produce and reduce their vulnerability to external influences.

Farmers' calls for improved support, particularly regarding land access, financial resources, and state intervention, highlight structural challenges. Insufficient support reflects a broader failure in urban governance to prioritize marginalized populations, hindering the equitable adoption of sustainable agricultural practices (Heynen, 2014). While community initiatives make meaningful contributions, the unequal distribution of state resources perpetuates inequalities in access to agricultural technologies, further marginalizing disadvantaged communities.

The scaling of hydroponic farming presents both opportunities and challenges that require the attention of policymakers and community stakeholders. Integrating hydroponics into broader urban food systems, such as school feeding programs or rooftop farming projects, could significantly enhance its impact (Treftz & Omaye, 2016). However, achieving this scale requires policies that incentivize hydroponics adoption, provide subsidies for equipment, and facilitate knowledge transfer to promote widespread uptake and equitable access. Community-based initiatives, including cooperatives and local networks, could also play a crucial role in democratizing access to hydroponic technologies through resource pooling and collective action.

Following UPE's principle of radical incrementalism, we advocate for transformative change through small, locally driven initiatives (Lawhon et al., 2014). Respondents' optimism about hydroponics reflects UPE's emphasis on grassroots innovations reshaping socio-environmental conditions. However, realizing this vision requires overcoming significant barriers through more supportive policies and infrastructural investments in underprivileged neighborhoods. Key policy interventions, including support for space, resources, and financial aid, must follow UPE's call for targeted measures to address systemic inequalities and foster sustainable practices (Keil, 2003).

UPE offers a productive framework for analyzing the viability and challenges of hydroponic farming in Cape Town. It provides valuable insights into the interactions between socio-environmental conditions, power dynamics, and technological innovations, shedding light on the potential and limitations of hydroponics as a sustainable alternative to traditional farming. The findings emphasize the need to address systemic barriers and promote equitable, sustainable urban agriculture, mainly through education and government funding.

6 | CONCLUSION

This study assessed the viability and sustainability of hydroponic farming as an alternative to traditional agriculture in Cape Town. It examined the challenges and opportunities faced by local farmers and analyzed socioeconomic and environmental aspects of hydroponic farming compared to traditional in-ground farming. Hydroponic farming responds to pressing challenges for urban farmers in Cape Town, such as water scarcity, space limitations, and economic sustainability. We outlined local farmers' experiences with the benefits of hydroponics, including improved resource efficiency and faster growth, while also identifying challenges, such as financial constraints and inconsistent support from local authorities. This study fills a critical gap in the literature by offering empirical insights into hydroponic farming in economically disadvantaged urban areas. Examining the practical experiences of Cape Town's hydroponic farmers offers a nuanced understanding of the system's adaptability and effectiveness in this specific urban context.

The NGO-driven support structures reviewed here provided essential short-term assistance but may inadvertently undermine farmer autonomy and the long-term sustainability of local food systems. Heavy reliance on subsidies and aid may hinder farmers' efforts to achieve self-sufficiency and economic independence. This dependency could limit the potential for hydroponic systems to evolve into more resilient, locally controlled models of food production, raising important questions about the sustainability of food systems reliant on external interventions rather than organic, community-driven growth.

To enhance the sustainability of hydroponic farming in Cape Town, local authorities and organizations should offer increased support, including financial aid, resource provision, and market access. Policy interventions should focus on reducing setup costs, providing infrastructure, and promoting community engagement through education and training. Additionally, fostering stronger collaboration between support organizations and farmers could help address knowledge and resource gaps, encouraging wider adoption of hydroponics.

Future research should consider the long-term economic impacts of hydroponics compared to traditional farming, explore scalability in various urban contexts, and examine the socio-economic factors influencing uptake. Additionally, studying community involvement and support structures will provide valuable insights into promoting sustainable hydroponic practices.

6.1 | Limitations of the Study

We acknowledge several limitations of a small sample size, inherent in the case study approach, which restricts the generalizability of the findings to broader urban contexts. Additionally, our reliance on NGO connections for participant selection may have introduced sampling bias by excluding independent farmers. Despite these constraints, the study offers valuable insights and a critical foundation for future research on hydroponic farming in urban contexts.

AUTHOR CONTRIBUTIONS

Busisiwe Miya Noxolo: Formal analysis; methodology; writing–review and editing. **Tinashe P. Kanosvamhira**: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; software; supervision; visualization; writing–original draft; writing–review and editing.

ACKNOWLEDGMENTS

We would like to acknowledge the organizations and the farmers who generously shared their experiences and time during the interviews. We would also like to thank the three expert reviewers for their critical insights, which improved the quality of this manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author, Tinashe P. Kanosvamhira. The data are not publicly available due to containing information that could compromise the privacy of research participants.

ORCID

Busisiwe Miya Noxolo https://orcid.org/0009-0008-1096-5662
Tinashe P. Kanosvamhira https://orcid.org/0000-0002-6745-1151

REFERENCES

Azunre, G. A., Amponsah, O., Peprah, C., Takyi, S. A., & Braimah, I. (2019). A review of the role of urban agriculture in the sustainable city discourse. *Cities*, *93*, 104–119. https://doi.org/10.1016/j.cities.2019.04.006

Bennett, N. J. (2019). In political seas: Engaging with political ecology in the ocean and coastal environment. *Coastal Management*, *47*(1), 67–87. https://doi.org/10.1080/08920753.2019.1540905

Bon, H., Parrot, L., & Moustier, P. (2010). Sustainable urban agriculture in developing countries. A review. *Agronomy for Sustainable Development*, *30*, 21–32. https://doi.org/10.1051/agro:2008062

Campbell, B. M., Thornton, P., Zougmoré, R., Van Asten, P., & Lipper, L. (2014). Sustainable intensification: What is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability*, *8*, 39–43. https://doi.org/10.1016/j.cosust.2014.07.002

Chen, Y.-L. & Shin, H. B. (Eds.). (2019). *Neoliberal urbanism, contested cities and housing in Asia*. Palgrave Macmillan. https://doi.org/10.1057/978-1-137-55015-6

Creswell, J., & Creswell, J. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Engel, E., & Anja, E. (Eds.). (2019). *Farming in cities: Potentials and challenges of urban agriculture in Maputo and Cape Town*. SLE.

Goodman, W., & Minner, J. (2019). Will the urban agricultural revolution be vertical and soilless? A case study of controlled environment agriculture in New York City. *Land Use Policy*, *83*, 160–173. https://doi.org/10.1016/j.landusepol.2018.12.038

Gray, L., Elgert, L., & WinklerPrins, A. (2020). Theorizing urban agriculture: North–south convergence. *Agriculture and Human Values*, *37*(3), 869–883. https://doi.org/10.1007/s10460-020-10015-x

Gumisiriza, M. S., Ndakidemi, P. A., Nampijja, Z., & Mbega, E. R. (2023). Soilless urban gardening as a post covid-19 food security salvage technology: A study on the physiognomic response of lettuce to hydroponics in Uganda. *Scientific African*, *20*, e01643. https://doi.org/10.1016/j.sciaf.2023.e01643

Gustafson, S., Heynen, N., Rice, J. L., Gragson, T., Shepherd, J. M., & Strother, C. (2014). Megapolitan political ecology and urban metabolism in southern Appalachia. *The Professional Geographer*, *66*(4), 664–675. https://doi.org/10.1080/00330124.2014.905158

Heynen, N. (2016). Urban political ecology II: The abolitionist century. *Progress in Human Geography*, *40*(6), 839–845. https://doi.org/10.1177/0309132515617394

Heynen, N., Kaika, M., & Swyngedouw, E. (2006). Urban political ecology. Politicizing the production of urban natures. In N. Heynen, M. Kaika, & E. Swyngedouw (Eds.), *In the nature of cities. Urban political ecology and the politics of urban metabolism* (pp. 1–19). Routledge. https://doi.org/10.4324/9780203027523

Kanosvamhira, T. P. (2019). The organisation of urban agriculture in Cape Town, South Africa: A social capital perspective. *Development Southern Africa*, *36*(3), 283–294. https://doi.org/10.1080/0376835X.2018.1456910

Keil, R. (2003). Urban political ecology. *Urban Geography*, *24*(8), 723–738. https://doi.org/10.2747/0272-3638.24.8.723

Kiribou, R., Bedadi, B., Dimobe, K., Ndemere, J., Neya, T., Ouedraogo, V., & Dejene, S. W. (2024). Urban farming system and food security in sub-Saharan Africa: Analysis of the current status and challenges. *Urban Agriculture & Regional Food Systems*, *9*, e70007. https://doi.org/10.1002/uar2.70007

Lawhon, M., Ernstson, H., & Silver, J. (2014). Provincializing urban political ecology: Towards a situated UPE through African urbanism. *Antipode*, *46*(2), 497–516. https://doi.org/10.1111/anti.12051

Lukas-Sithole, M. (2020). Greening Nyanga: Developing a community park in a complex urban environment in Cape Town, South Africa. *Acta Horticulturae et Regiotecturae*, *23*(2), 96–100. https://doi.org/10.2478/ahr-2020-0019

Martin, M., Poulikidou, S., & Molin, E. (2019). Exploring the environmental performance of urban symbiosis for vertical hydroponic farming. *Sustainability*, *11*(23), 6724. https://doi.org/10.3390/su11236724

Matamanda, A. R., Mandebvu-Chaora, C., & Rammile, S. (2022). The interplay between urban agriculture and spatial (In) justice: Case study analysis of Harare, Zimbabwe. *Land Use Policy*, *115*, 106029. https://doi.org/10.1016/j.landusepol.2022.106029

Musemwa, M. (1993). *Aspects of the social and political history of Langa township, Cape Town, 1927–1948*. http://hdl.handle.net/11427/21707

Mwakiwa, E., Maparara, T., Tatsvarei, S., & Muzamhindo, N. (2018). Is community management of resources by urban households, feasible? Lessons from community gardens in Gweru, Zimbabwe. *Urban Forestry & Urban Greening*, *34*, 97–104. https://doi.org/10.1016/j.ufug.2018.06.013

Neo, H., & Chua, C. Y. (2017). Beyond inclusion and exclusion: Community gardens as spaces of responsibility. *Annals of the American Association of Geographers*, *107*(3), 666–681. https://doi.org/10.1080/24694452.2016.1261687

Nkosi, D. S., Moyo, T., & Musonda, I. (2022). Unlocking land for urban agriculture: Lessons from marginalised areas in Johannesburg, South Africa. *Land*, *11*(10), 1713. https://doi.org/10.3390/land11101713

Nyantakyi-Frimpong, H., Arku, G., & Inkoom, D. K. B. (2016). Urban agriculture and political ecology of health in municipal Ashaiman, Ghana. *Geoforum*, *72*, 38–48. https://doi.org/10.1016/j.geoforum.2016.04.001

Olivier, D. W. (2018). A cropping system for resource-constrained urban agriculture: Lessons from Cape Town. *Sustainability*, *10*(12), 4804. https://doi.org/10.3390/su10124804

Paganini, N., Hansmann, J., Mewes, A., Reich, V., Reigl, M., & Sander, L. (2021). *Covid-19 lockdown and the impact on local food systems: Food security and nutrition in South Africa's marginalised communities–a food justice perspective from the Cape Flats and St. Helena Bay*. SLE.

Paganini, N., & Lemke, S. (2021). "There is food we deserve, and there is food we do not deserve." food injustice, place and power in urban agriculture in Cape Town and Maputo. *Local Environment*, *25*(11–12), 1000–1020.

Paganini, N., Raimundod, I., & Lemke, S. (2018). The potential of urban agriculture towards a more sustainable urban food system in food-insecure neighbourhoods in Cape Town and Maputo. *Economia Agro-Alimentare*, *3*, 401–423.

Robbins, P. (2019). *Political ecology: A critical introduction*. John Wiley & Sons.

Romeo, D., Vea, E. B., & Thomsen, M. (2018). Environmental Impacts of urban hydroponics in Europe: A case study in Lyon. *Procedia CIRP*, *69*, 540–545. https://doi.org/10.1016/j.procir.2017.11.048

Suchá, L., Schlossarek, M., Dušková, L., Malan, N., & Šarapatka, B. (2020). Land tenure security and its implications for investments to urban agriculture in Soweto, South Africa. *Land Use Policy*, *97*, 1–10.

Swyngedouw, E. (2015). Depoliticized environments and the promises of the Anthropocene. In *The international handbook of political ecology* (pp. 131–146). Edward Elgar Publishing. https://doi.org/10.4337/9780857936172

Swyngedouw, E., & Heynen, N. (2003). Urban political ecology, justice and the politics of scale. *Antipode*, *35*(5), 839–1042. https://doi.org/10.1111/j.1467-8330.2003.00364.x

Terry, G., Hayfield, N., Clarke, V., & Braun, V. (2017). Thematic analysis. In C. Willig & W. S. Rogers (Eds.), *The SAGE handbook of qualitative research in psychology* (pp. 17–36). SAGE Publications Ltd.

Tornaghi, C. (2014). Critical geography of urban agriculture. *Progress in Human Geography*, *38*(4), 551–567. https://doi.org/10.1177/0309132513512542

Treftz, C., & Omaye, S. T. (2016). Hydroponics: Potential for augmenting sustainable food production in non-arable regions. *Nutrition & Food Science*, *46*(5), 672–684. https://doi.org/10.1108/NFS-10-2015-0118

Zhu, J., He, B. J., Tang, W., & Thompson, S. (2020). Community blemish or new dawn for the public realm? Governance challenges for self-claimed gardens in urban China. *Cities*, *102*, 102750. https://doi.org/10.1016/j.cities.2020.102750

How to cite this article: Noxolo, B. M., & Kanosvamhira, T. P. (2026). Assessing the viability of hydroponics for low-income farmers in South Africa's urban agriculture sector: An urban political ecology perspective. *Urban Agriculture & Regional Food Systems*, *11*, e70036. https://doi.org/10.1002/uar2.70036