frontiers in Ecology and Evolution

ORIGINAL RESEARCH
published: 11 February 2022
doi: 10.3389/fevo.2022.804523

Why Home Gardens Fail in Enhancing Food Security and Dietary Diversity

Marié J. Du Toit[1], Olivia Rendón[2], Viktoria Cologna[2], Sarel S. Cilliers[1]* and Martin Dallimer[2]

[1] Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa, [2] Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, United Kingdom

Visions of sustainable cities mostly conjure up well tended home and community gardens, where owners and residents plant fruits and vegetables that supply some of their livelihood needs. Indeed, home gardens can contribute to household food security but often fail to do so. Moreover, gardens can provide several additional ecosystem services and impact entire communities. This paper seeks to answer why these gardens often do not provide adequate services to make a substantial contribution to food security and identifies possible solutions. We undertook a case study in South Africa in a low-income former township area. The area is characterized by poverty, high levels of unemployment and food insecurity. We interviewed 140 respondents with home gardens to determine what role their own garden plays in household food security. Only 10% of households were found to be completely food secure. Of the rest, 39% experienced hunger that affected everyone in the household and 51% were at risk of hunger. Despite the fact that 72% of the respondents planted vegetables or fruits, the gardens did not contribute substantially to food security. The respondents mostly bought their food, with subsequent food shortages when they did not have enough money. The dietary diversity and consumption of vitamin A-rich fruits and vegetables were very low. The most important constraints inhibiting urban agriculture in the study area were cultural practices, such as the presence of large, bare, open spaces, or "lebala," the focus of home gardeners on ornamental species and lawns; and a reliance on purchasing of foods.

Keywords: food security, dietary diversity, home gardens, cultural practices, urban agriculture

OPEN ACCESS

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Correspondence:
Sarel S. Cilliers
Sarel.Cilliers@nwu.ac.za

Specialty section:
This article was submitted to Urban Ecology, a section of the journal Frontiers in Ecology and Evolution

Received: *29 October 2021*
Accepted: *11 January 2022*
Published: *11 February 2022*

Citation:
Du Toit MJ, Rendón O, Cologna V, Cilliers SS and Dallimer M (2022) Why Home Gardens Fail in Enhancing Food Security and Dietary Diversity. Front. Ecol. Evol. 10:804523. doi: 10.3389/fevo.2022.804523

INTRODUCTION

Food availability, accessibility and utilization are the three dimensions of food security (Jones et al., 2013). Food security is assured when "all people at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit [WFS], 1996). However, in 2020 it was estimated that between 720 and 811 million people worldwide faced hunger (FAO et al., 2021). Moreover, the report stated that "the world has not been generally progressing either toward Sustainable Development Goal (SDG) Target 2.1, of ensuring access to safe, nutritious and sufficient food for all people all year round, or toward SDG Target 2.2, of eradicating all forms of malnutrition"

(FAO et al., 2021). It has also been estimated that two billion people are deficient in micronutrients, 50 million children under the age of 5 years are dangerously thin and 790 million people have insufficient daily dietary energy intake (International Food Policy Research Institute [IFPRI], 2015). Undernutrition is associated with three million child deaths annually, which is almost half of child deaths globally (Myers et al., 2017). A diverse diet is important to ensure that the requirements for essential nutrients are met (Arimond and Ruel, 2004). As an essential nutrient, vitamin A deficiency, especially in children, is a worldwide problem but particularly so in sub-Saharan Africa, leading to malnutrition, stunted growth and even deaths as children with vitamin A deficiency are at greater risk to die from diarrhea, measles and malaria (Black et al., 2003; United Nations Children's Fund [UNICEF], 2008; World Health Organization [WHO], 2009). In their review on malnutrition and health, Müller and Krawinkel (2005) conclude that "diet-based strategies are probably the most promising approach for a sustainable control of micronutrient deficiencies."

With regards to the accessibility of foods, urban areas are often thought to have an advantage over rural areas, however, recent evidence indicate that the urban poor face distinct barriers that limit their access to healthy diets (Vilar-Compte et al., 2021). Financial barriers are a common feature of less healthy eating patterns throughout the developing world (Faber et al., 2017). A study assessing 76 low- and middle-income countries found that domestic food production, as well as inequality in income and consumption, and market conditions, plays a critical role in the food security of these countries (Thome et al., 2019). With the reality that the majority of people now reside in urban areas (United Nations [UN], 2019), the food security of urban residents needs urgent attention. The increase in severity and frequency of natural disasters coupled with the recent global scale COVID-19 pandemic exacerbated fragile food systems worldwide (O'Hara and Toussaint, 2021; Ruszczyk et al., 2021). The fragility of food systems, through dependence of cities on global resources, point strongly to the fact that cities are not as resilient as they ought to be (Gulyas and Edmondson, 2021). Many new urban residents end up living in peri-urban areas (Baud, 2000) often characterized by informal settlements or "slums" (Smit et al., 2017) which are described as spatial clusters of food insecure (Hunter-Adams et al., 2019) households without access to improved water, sanitation, sufficient living area, permanent dwellings or land tenure (UN-Habitat, 2010).

Thus, an approach that can mitigate food security issues, and potentially enhance livelihoods, is the pursuit and encouragement of urban agriculture (Orsini et al., 2013). Zezza and Tasciotti (2010) defined urban agriculture as "the production of crop and livestock goods within cities and towns." In their multi-country study, they indicated that in many countries greater household dietary diversity correlated with urban agricultural practices (Zezza and Tasciotti, 2010). Tontisirin et al. (2002) also argue that the promotion of home gardens and small livestock production can be used as strategies to address micronutrient malnutrition through increased dietary diversity. The most widespread form of urban agriculture is that based in private gardens (Lin and Egerer, 2018), which includes community, domestic and home gardens (Cilliers et al., 2018). Urban agriculture can provide many benefits or ecosystem services, such as habitat for biodiversity (Lin and Egerer, 2018), mitigation of food security (Aerts et al., 2016), contribution to human nutrition (Boeing et al., 2012), alleviation of poverty (Adeyemo et al., 2017) and improvement of human wellbeing (Othman et al., 2018). Its potential role in enhancing urban resilience is also acknowledged (Gulyas and Edmondson, 2021). Historically gardens have provided resilient food and nutrition security for garden owners during times of economic crisis and food shortages (Barthel et al., 2015; Warren et al., 2015).

However, not all agree that urban agriculture is a silver bullet to solve urban hunger. Warren et al. (2015) found that there is substantial debate about the association between urban agriculture and food security and dietary diversity. In assessing the potential of urban agriculture for improving city resilience in the Global North, Gulyas and Edmondson (2021) proposed five factors which determine the success of urban agriculture practices namely: "its scale, the extent to which it is integrated into the urban fabric, its inclusiveness, the efficiency of food production, and human and environmental safety of practices." They go further to state that "these factors in turn depend on the amount of institutional and public support for urban agriculture, the presence of a sufficient knowledge base to guide policy and practice, communication and collaboration among different actors, and resourcefulness in finding alternative ways to use space and other resources efficiently."

Householders establish and maintain gardens for a variety of reasons. Gardeners who rely monetarily on gardens may be more likely to plant fruit and vegetables (Lubbe et al., 2011; Swanepoel et al., 2021). In contrast, higher incomes and access to urban markets may cause a garden composition shift toward ornamentals which provide aesthetic and cultural ecosystem services (Davoren et al., 2016). More broadly, for gardens as a whole, socioeconomic and demographic factors, such as education level and wealth, have been widely shown to have a positive relation to vegetation cover in human dominated ecosystems (Wang et al., 2015; Lin et al., 2017). Local agricultural traditions and preferences may also influence the composition of vegetation providing specific ecosystem services (Barau et al., 2013; Clarke et al., 2014).

The potential of food production in home gardens for enhancing food security and improving dietary diversity, combined with the debate on its efficacy prompted this study. Specifically, the well documented crisis with undernutrition and the effect of vitamin A deficiencies on populations in low-income countries need urgent attention. Clear evidence exists for beneficial effects of eating fruits and vegetables for preventing chronic diseases (Wang et al., 2014). We apply an ecosystem service approach, with a view on human wellbeing, to home gardens in a former township of South Africa. South Africa is much more developed than the rest of Africa, and yet still has issues of poverty, food insecurity, and poor health (Shisana et al., 2013; Statistics South Africa [SSA], 2016). Our study aims to answer three distinct questions: (1) what is the effect, if any, of home gardens on food security and on dietary diversity? (2) What factors characterize households with higher plant diversity? (3)

Why home gardens often do not provide adequate services to significantly contribute to food security?

MATERIALS AND METHODS

Study Site

South Africa has a rich cultural and ethnic diversity, evidenced by its 11 official languages. It is a middle-income country with around half of the population living in poverty and a fifth in extreme poverty (Statistics South Africa [SSA], 2016). There are high levels of food insecurity, especially in urban informal settlements (32.4%) and for black Africans (30.3%) (Shisana et al., 2013). Formal settlements refer to permanent, local council-organized urban residential areas with water and electricity. Whilst informal settlements are on un-surveyed land, usually in the outskirts of towns and without basic service provision (Statistics South Africa [SSA], 2004). The North-West Province has been reported to have the highest proportion (21%) and the biggest increase of households living in informal settlements nationally (45.1%) (Statistics South Africa [SSA], 2016).

We focused on Ikageng, a peri-urban suburb and former township of the city of Potchefstroom (**Figure 1**) in the North-West Province. Peri-urban refers to an inhabited area on the fringe of a city characterized by relatively high-density housing, poor services, limited commercial opportunities, few recreational green spaces and widespread poverty (Shackleton et al., 2015). Ikageng has a population of 87,701 inhabitants and 26,245 households of which 71% are in formal settlements. However, only 37.6% of households have piped water inside the home, 88.6% have electricity and 80% have a flush toilet connected to sewerage (Statistics South Africa [SSA], 2018). The apparent discrepancy between piped water inside the house and flush toilets is due to the fact that many flush toilets are in separate buildings on the yard. The toilets are connected to municipal sewage infrastructure without further proper plumbing in the homes. In Ikageng, the study site was defined by the catchment area of the Steve Tswete Health Clinic (see Cilliers et al., 2018 for a discussion on the importance of health clinic gardens), which falls into the boundaries of the local election wards 20 and 26 (**Figure 1**). These wards contain both formal and informal settlements.

The Batswana ethnic group is predominant at the study site. In rural settings their home gardens or Tswana tshimo have been described by Molebatsi et al. (2010) as a “model of sustainable resource management.” They are informally designed to contain six main micro gardens, namely food gardens (include vegetable gardens and orchards), medicinal gardens, ornamental gardens (flower beds, containers and lawns), structural species (windbreaks, fire screen, shade trees and hedges), bare open areas completely devoid of any vegetation (“lebala”) and natural areas left to grow wild (“naga”). However, as the Batswana people become more westernized and urbanized their garden design becomes more “colonial” defined by a more formal garden design with more focus on ornamentals and the absence of some of the micro-gardens (Davoren et al., 2016). Thus, this study captures the full range of gardens from traditional to modern.

Data Collection

We developed a household questionnaire to capture the (**Supplementary Table 1**) socioeconomic data, food security, dietary diversity, home garden benefits (i.e., perceived ecosystem services and uses) and ecosystem disservices, reasons for and against gardening, plants grown in the last 12 months, and garden composition. The questionnaire was developed through a series of interviews and focus groups with local experts including academics, the Director of Hospital Services, health clinic gardeners and agriculture extension workers. The questionnaire was piloted with 25 households, and questions subsequently amended for clarity and relevance, and the inclusion of photos for fruit and vegetable identification in the dietary diversity section. The questionnaire was complemented by a visual survey of the home garden, where plants and trees were identified on site where possible. Unusual species were identified post-interview based on photos and specimens. The fieldwork was conducted in winter, so self-seeding annuals and herbaceous perennials were not visible.

The initial questionnaire was developed in English, surveys were administered in the local language, Batswana. Households were systematically sampled within formal and informal settlements at regular intervals, beginning with streets closest to the health clinic. If no one was home or refused to participate at the selected household, the neighboring house was visited and so on until a participant was found. The systematic sampling approach recommenced from a successfully sampled house. To be included in the sample, households had to own, or have direct access to, a home garden from their house. For the purpose of this study a home garden was defined as a land-use form on private or communal land surrounding an individual house with a defined border (although not always physical), in which several useful plant species are cultivated together (Molebatsi et al., 2010).

Wealth indices are an effective way of measuring socioeconomic status, often outperforming expenditure data or income in explaining variations (Filmer and Scott, 2012; Smits and Steendijk, 2015). When developing our questionnaire, we used an index that has been externally validated in relevant low-income contexts (Filmer and Pritchett, 2001; Nundy et al., 2011). The wealth index is based on data on asset ownership (e.g., private or shared toilet, water tap) and household characteristics (e.g., number of rooms per person). Information on household assets was analyzed using a Principal Components Analysis (PCA), which combines the original questionnaire responses weighted by an asset’s contribution to explaining the variance and then used to calculate each observation’s score (Filmer and Pritchett, 2001; Nundy et al., 2011). **Table 1** lists all the variables used to calculate the PCA and their calculated weights. As recommended by the Department of Demographic and Health Surveys (DHS) of the United States Agency for International Development (USAID), the individual households were then divided into five wealth quintiles, i.e., from poorest to richest households (Rutstein and Johnson, 2004).

The general categories of the Common International Classification of Ecosystem Services (CICES) of the European Environment Agency were applied to classify the plant uses reported by respondents. Respondent reported uses including food, medicine, firewood (provisioning services), shade, fencing,

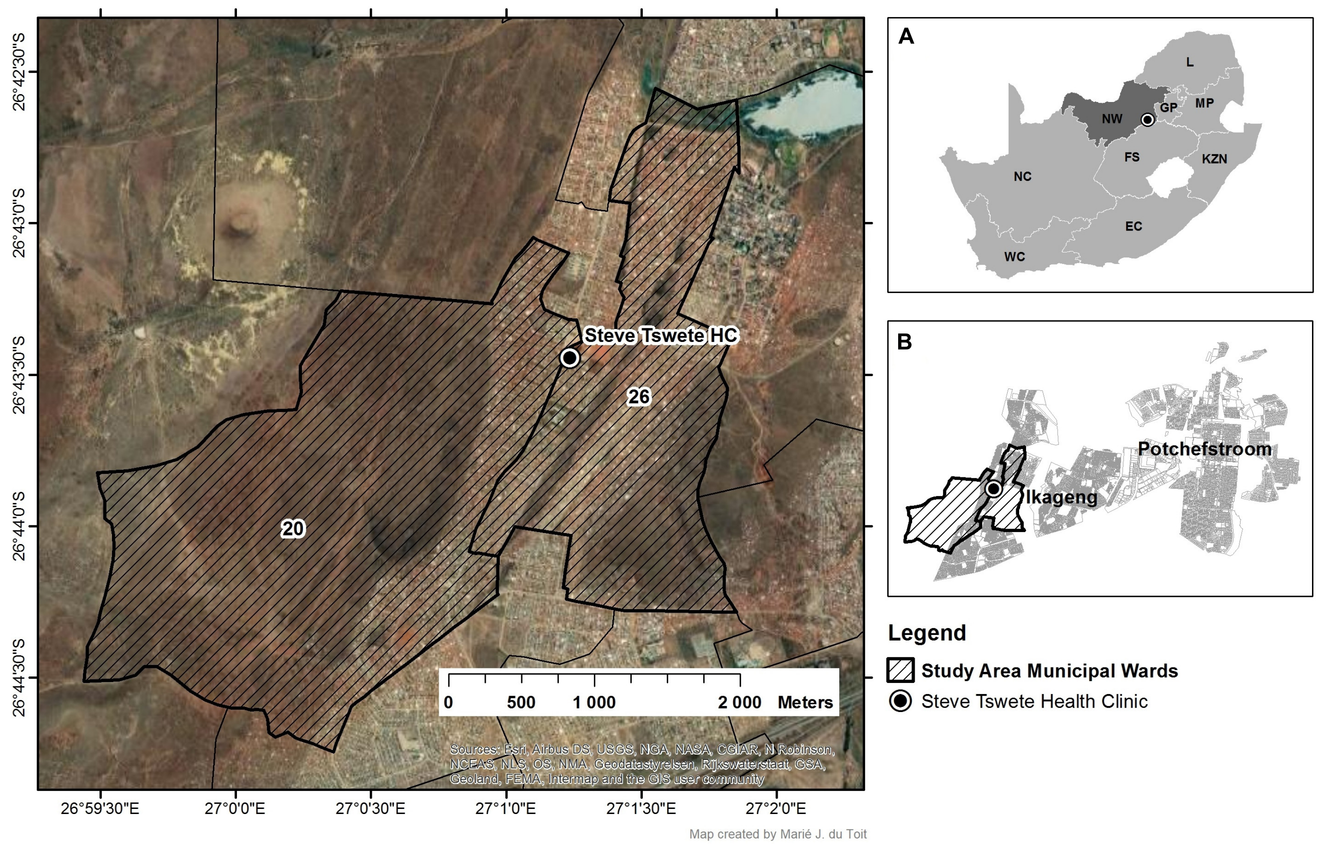

FIGURE 1 | Map of the study area indicating the two Ikageng wards in which the surveys were undertaken. The inset maps show the location of Potchefstroom in South Africa **(A)** and the location of the study area within Potchefstroom **(B)**.

windbreak (regulating and maintenance services), spiritual and ornamental (cultural services). Many species had multiple uses and were noted once for each use. The extent and composition of home gardens was also characterized according to the presence of the six tshimo micro gardens (Molebatsi et al., 2010).

Food security data were obtained using the internationally used and validated Community Childhood Hunger Identification Project (CCHIP) index (Wehler et al., 1992). This index is used by the South African National Health and Nutrition Examination Survey (SANHANES-1) (Shisana et al., 2013). The CCHIP index is based on eight occurrence questions that represent a generally increasing level of severity of food insecurity. They are related to whether the household, adults and/or children are affected by food shortages, perceived food insufficiency or altered food intake due to constrained economic resources within the household (Coates et al., 2007). For each of the questions, participants were asked about occurrences in the 30 days prior to the questionnaire (Shisana et al., 2013). A score of five or more affirmative responses out of eight indicates the presence of food shortage or "hunger" in the household. A score of one to four indicates that members of the household are at risk of hunger. A score of zero indicates that the household is food secure (Shisana et al., 2013; Walsh and van Rooyen, 2015). The frequency of food insecurity occurrence in the last 30 days was coded with the Household Food Insecurity Access Scale Score (HFIAS; Coates et al., 2007). The HFIAS score was estimated by assigning each frequency response to one of four categories: 0 = Never, 1 = Rarely (once or twice in the past 4 weeks), 2 = Sometimes (three to ten times in the past 4 weeks) and 3 = Often (more than ten times in the past 4 weeks). The HFIAS score could range between 0 and 24; the higher the score, the more food insecurity the household experienced.

Dietary diversity was calculated by a recall technique following the Household Dietary Diversity Score (HDDS) as suggested by Kennedy et al. (2010). The study was only interested in the contribution from the number of vitamin A-rich fruits and vegetables consumed (range 0–13), i.e., richness, to nutritional security. A two-level score was estimated from the data: a score of the variety or richness of vitamin A consumption (i.e., number of items eaten); and a score of the abundance of vitamin A consumption (i.e., times eaten and portion size). Vitamin A-rich fruit and vegetables at the study site included: Yellow-orange vegetables (i.e., carrot, butternut squash, Hubbard squash, pumpkin, orange-fleshed sweet potato), yellow/orange (non-citrus) fruit (i.e., mango, pawpaw/papaya, melon, apricot, peach) and dark-green leaves (i.e., spinach and wild and

TABLE 1 | The calculated wealth indexes of 15 household assets indicators sorted by category (house, main construction material, toilet facilities, and access to water) using Principal Component Analysis.

Asset category variable	Wealth index weight
House	
Rooms per person	0.42
Electricity	0.91
Main construction material	
Redbrick	0.25
Concrete	0.55
Aluminum	–0.93
Toilet facilities	
Bucket	–0.06
Pit latrine	–0.20
Working flush toilet	0.70
Not working flush toilet	0.10
Communal toilet or latrine	–0.59
Using neighbor's toilet or latrine	–0.65
Access to water	
No tap	–0.30
Tap in yard	0.37
Tap in house	0.34
Communal tap	–0.87

traditional leaves such as "morogo"). Respondents were first asked if they ever ate the listed plants and then if they had eaten them in the last 24 h, including how many times and the portion size. Therefore, the nutrition and dietary diversity results of this study only refer to the consumption of vitamin A-rich plant sources.

Data Analysis

Four Quasi-Poisson regressions were carried out to determine (a) what characterized households with more or less total number of plant species grown in their garden, (b) what characterized households with food insecurity or a high CCHIP index, (c) what characterized households with different frequencies of food insecurity (HFIAS), and (d) what characterized respondents with different Dietary Diversity Score (DDS) i.e., richness of vitamin A-rich plants consumed. The variables used in the different regressions are presented in **Table 2** and were selected based on existing literature on community and home gardens.

This study is not without limitations. We acknowledge that studies like the current study which does not include vitamin A rich foods from other sources (West and Darnton-Hill, 2008) cannot truly assess the real dietary diversity of interviewed respondents. The findings only focus on home gardens as a source of vitamin A-rich plant consumption and as such the contribution of animal foods for respondents who prefer it instead of eating fruits and vegetables was not recorded. Furthermore, although the study covers 1 year of garden cultivation, seasonal variation in garden produce was not considered in the study design.

RESULTS

Respondent and Household Characteristics

The overall sample consisted of 140 households with respondents who self-identified as the home gardener. Results were included in **Table 3**. The sample was close to an equal balance between men and women, which was an interesting finding as the literature often reports a high proportion of women as urban small-scale farmers (Orsini et al., 2013). Just over half of respondents were Batswana. The next most common ethnic groups were Sotho and Xhosa. Levels of education were low, with two thirds only completing high school. Half of respondents were in a relationship, where cohabiting was predominant. There was a high level of unemployed respondents, with only 11% working full time. There was a high level of households with one or more unemployed persons and just over a third had one or two people employed full time. Households reported a median of 4 family members. Households were distributed quite evenly across the wealth index quintiles.

Just over half of houses were made of concrete block, followed by red brick or aluminum. Houses had a median of five rooms including add-on structures in backyards. Most houses had a water tap, in either their yard or house, an electricity connection and a functional flush toilet. Although most households had access to basic services, there were some houses without electricity, having to borrow a neighbor's toilet or without access to water (**Table 4**).

Home Garden Composition and Ecosystem Services

Most households (91%) had a garden with vegetation, while the rest (mainly in informal settlements) only had bare open space (i.e., lebala). More specifically, 93% of households had bare open space, 61% had ornamental beds, 60% had fruit, 58% had lawn, 48% had shade trees, 41% vegetables, 31% had medicinal plants, 25% had hedges and 4% had natural areas. The largest overall micro garden cover was bare open space in 81% of households and the largest vegetated micro garden cover was lawn (38%). Average vegetable area per household was 11 m^2, ranging from 0.01 to 98 m^2. A total of 87 plant species were recorded (**Supplementary Table 2**), of which 30 provided shade, 26 were vegetables, 23 fruits, 21 medicinal, 12 for firewood, and 8 for spiritual use. Only vegetables and fruit grown in the last 12 months were recorded.

The vegetables and fruit grown was used for consumption in all households but some was at times sold (a mean 9% of vegetables, range 4–17%; and 6% of fruit, only one instance) or gifted to friends and neighbors (mean 23% of vegetables, range 5–60%; 37% of fruit, range 8–67%). All vegetable and fruit growers recognized the food benefits (provisioning services) from their garden but only 11% of respondents mentioned any other benefits from their garden vegetation: relaxation and aesthetics (cultural services) and shade, wind protection and dust protection (regulating services). Just 4% of respondents

TABLE 2 | The explanatory variables used in the four Quasi-Poisson regressions to determine the characteristics of the respondents and their households, with their expected sign and justification.

Variable name	Description	Expected sign	Justification
Female	Gender of respondent: 1 = female, 0 = male	Positive	Women have been found to be more involved in urban agricultural practices (Magidimisha et al., 2013)
Age	Age of respondent	Positive	Younger adults are less involved in gardening than older people (Dunnett and Qasim, 2000)
Low education	Education level of respondent: 1 = primary school completed or less, 0 = high school or higher	Negative	Respondents with at least some high school education (≥ 8 years) were more likely to be food secure (Faber et al., 2017)
Employed per household	Proportion of people employed per household	Negative	Reflects less time available to garden (Kornrich and Roberts, 2018)
Wealth	Wealth quintile of household: 1 = lowest, 5 = highest	Positive	Assets, such as type of dwelling, have been found to be significant for food security (Walsh and van Rooyen, 2015). Individuals with access to resources, labor or financial means are capable of effecting change in their urban environment, e.g., increase species richness (Davoren et al., 2016).
Children present	1 = Children under 18 years old are present in the household; 0 = no children present	Positive	Households with children are more likely to want to provide for their children and sacrifice for them (Walsh and van Rooyen, 2015)
Batswana language	1 = Batswana home language; 0 = other home language	Positive	Individuals' food intake is influenced by the beliefs and behaviors of the different ethnic and cultural groups (Wentzel-Viljoen et al., 2011). Batswana people are known for the Tswana tshimo or micro gardens (Molebatsi et al., 2010).
Informal settlement	0 = Formal settlement; 1 = Informal settlement	Negative	Informal settlement households have no garden area or resources to grow vegetables and/or fruit (Cilliers et al., 2013)
Know health clinic garden	Know about the existence of their local health clinic garden	Positive	Health clinic gardens have a positive influence on home gardening (Cilliers et al., 2018)
Grew vegetables and fruit	1 = Has grown vegetables and/or fruit in last 12 months; 0 = has not	Positive	Households growing vegetables and/or fruit have higher food security (Drechsel and Dongus, 2010; Zezza and Tasciotti, 2010)
Dietary diversity	Dietary Diversity Score (DDS)	Positive	Households growing vegetables and/or fruit have higher dietary diversity (Johns and Eyzaguirre, 2006)
Total vitamin A	Consumed Vitamin A (RE mcg per 100 g) from fruit and vegetables in last 24 h	Positive	Vitamin A–rich food sources were significantly higher for food secure households, pointing toward a more frequent dietary intake of vitamin A–rich foods in the food secure households for both plant and animal sources of vitamin A (Faber et al., 2017).

mentioned negative effects, e.g., allergy to a plant. However, when queried directly about plant usage, respondents reported growing plants for medicine (34%), firewood (29%) and spiritual uses (19%; e.g., wild garlic to repel snakes, indigenous *Aloe* species for funeral cleansing).

A quasi-Poisson regression to determine what characterized the number of plant species grown at each household explained 30% of variance (**Table 5A**). Older gardeners grew more plant species, female gardeners grew more plant species than men, and the number of species grown increased with wealth. Specifically, wealth quintiles 2, 3, 4, and 5 were all significantly higher than wealth quintile 1. Wealth quintile 3 was significantly higher than 2, but there was no difference between 3, 4, and 5. So there is a threshold around wealth quintile 3 above which respondents with higher wealth did not increase the number of species grown.

A total of 72% households had grown vegetables and/or fruit in their garden and 12% had vegetables planted by the municipality (i.e., with or without their consent). The most frequently grown vegetable was spinach (35%) and fruit was peach (54%). The main reasons for growing vegetables and fruit were to use available land (53%), lack of money to buy vegetables (25%), to gift to neighbors (9%), and other minor reasons (13%). Contrastingly, the main reasons for not growing (more) vegetables and fruit in their garden were bad, rocky or muddy soil (40%), limited or no land (28%), lack of money (19%), lack of gardening skills/knowledge (6%), and other minor reasons (7%).

Food Insecurity and Home Gardens

Only 10% of households were found to be completely food secure. Of the rest, 39% experienced hunger that affected everyone in the household (38% experienced it in the last 30 days) and 51% were at risk of hunger (37% experienced it in the last 30 days). Thus, over a third of households are food insecure and over half of households are at risk of becoming food insecure. The CCHIP Index ranged from 0, being food secure, to 8, being food insecure, with a median of 3. The average number of days in the last 30 days in which a food insecure condition was experienced was 6.5 days for adults and 2.3 days for children. The survey also indicated parents going without food to feed children as a coping strategy to deal with food insecurity. The HFIAS score for frequency of food insecurity occurring in the past 30 days had a median of 4 with a range between 0 and 22 (out of 24 maximum).

A quasi-Poisson regression to determine what characterized households with food insecurity found that respondents with

TABLE 3 | The socioeconomic characteristics of the respondents of 140 households who self-identified as the home gardener.

Variable	Median or percentage	*SD*	Range
Female	55%		
Age	44	15	20–96
Education level	2% Post-school 60% High school 27% Primary school 11% No education		
Home language	55% Batswana 24% Sotho 19% Xhosa 2% Others		
Family members	4	2.48	1–18
Marital status	31% Single 31% cohabiting 21% married 17% divorced, widowed, separated		
Employment status	44% Unemployed 21% retired 16% work part-time/temporarily 11% work full-time 8% housewives/unable to work		
At least one family member unemployed	68%		
At least one family member employed (respondents could select more than one option as needed)	38% full-time 40% part-time		
Wealth index quintiles (Q)	14% Q1 29% Q2 16% Q3 21% Q4 20% Q5		

TABLE 4 | House characteristics of the respondents of 140 households who self-identified as the home gardener.

Variable	Median or percentage	*SD*	Range
House material	55% Concrete 24% red brick 21% aluminum		
Number of house rooms	5	1.93	1–10
Water access	48% Water tap in yard 36% water tap in house 13% communal tap 3% no tap		
Electricity	86%		
Toilet access (1% missing data)	64% Functional flush toilet 16% broken flush toilet 8% communal toilet 7% neighbor's toilet 4% pit latrine		

low education had a higher CCHIP index, indicating they were more food insecure (**Table 5B**). While households with a higher proportion of employed persons and with the highest wealth quintile were more food secure. More specifically, wealth quintiles 4 and 5 were significantly different from quintiles 1, 2, and 3 but were the same to each other. Growing vegetables and/or fruit showed a negative relationship to food insecurity although it was only significant at 90% level, indicating a suggestion of a correlation between growing food and vegetables and increased food security.

A Quasi-Poisson regression was also estimated to determine what characterizes the frequency of household food insecurity (HFIAS score). Food insecurity is more frequent for respondents with low education and is less frequent for households with a higher proportion of employed persons per household. These results are similar to those in **Table 5B** for presence of food insecurity and are thus included as **Supplementary Table 3**.

Dietary Diversity and Home Gardens

Respondents reported consuming on average eight (range 4–11) vitamin A-rich vegetables and fruits. Carrot, spinach, peach and apricot were the most frequently consumed in their lifetime. When asked about consumption in the last 24 h, on average 1 plant was consumed (range 0–4) and 51% of households had not eaten any of the vitamin A-rich vegetables and fruits. The most frequently consumed vegetables and fruit in the last 24 h were spinach, Hubbard squash and carrots. These findings evidence a very low consumption and dietary diversity of vitamin A-rich vegetables and fruit.

A Quasi-Poisson regression did not find evidence of explanatory factors for the Dietary Diversity Score (DDS) i.e., richness of vitamin A-rich plants consumed (**Supplementary Table 4**). It is likely that wealth, and other variables, are not significant as this study does not cover all possible food sources of vitamin A, i.e., animal products.

TABLE 5 | Quasi-Poisson regressions for: **(A)** Total number of plant species grown per household (1 missing value) and **(B)** household food insecurity (CCHIP) (2 missing values).

	A) Number of species grown	B) Household food insecurity
Variable	Estimate (S.E.)	
(Intercept)	–0.222 (0.405)	1.864 (0.213)***
Low education	0.301 (0.181)	0.242 (0.114)*
Employed per household	–0.003 (0.003)	–0.010 (0.003)***
Wealth 2	0.748 (0.327)*	–0.198 (0.181)
Wealth 3	1.345 (0.327)***	–0.139 (0.213)
Wealth 4	1.028 (0.340)**	–0.533 (0.224)*
Wealth 5	0.988 (0.335)**	–0.529 (0.211)*
Female	0.326 (0.145) *	
Age	0.012 (0.006)*	
Children present	–0.242 (0.165)	
Know health clinic garden	0.166 (0.169)	
Grown vegetables and fruit		–0.256 (0.152).
Informal settlement		–0.097 (0.203)
Batswana language		–0.001 (0.115)
Dietary Diversity Score		0.013 (0.095)
Total vitamin A		–0.000 (0.000)

*Significance codes: 0.0001 = "***"; 0.001 = "**"; 0.01 = "*"*

DISCUSSION

Potential of Gardens to Reduce Food Insecurity and Increase Dietary Diversity

Two of the main causes for food insecurity in South Africa are weak support networks and inadequate and unstable household food production (Shisanya and Hendriks, 2011). Food insecurity has been found to be significantly more prevalent in urban than in rural areas of South Africa, as well as in informal settlements vs. formal settlements (Walsh and van Rooyen, 2015). Thus, there is a belief that home gardens have the potential to contribute substantially to household food security (Cilliers et al., 2018). However, the presence of a home garden does not guarantee food security of the adults or children of a household. As our results indicated that despite 72% of the respondents growing fruit or vegetables only 10% were completely food secure. The garden composition results indicated that planting of fruits and vegetables were not the highest priority in the home gardens. Bare open spaces "lebala" and then a lawn occupied most of the space in the gardens. Even the maximum vegetable area was much lower than the 230 m^2 recommended by Trainer (1995) as the minimum area required to feed one individual. This provides indirect evidence of the shortfall of home gardens toward household food security. Faber et al. (2017) reported that the frequency of household consumption of vegetables and fruit was lowest in food insecure households, mostly due to financial constraints.

The questions asked in the survey on food security all revolved around money to buy food. Together with the results from the garden survey, findings indicated that respondents mostly rely on money to buy food, rather than producing their own food. Moreover, the main reasons for growing vegetables and fruit did not include food production. Respondents stated that they mainly did it to use the available land (53%) or due to a lack of money to buy vegetables (25%).

At the study site, food insecurity figures are similar to those reported by Walsh and van Rooyen (2015) for the neighboring Free State Province in South Africa. However, our findings show a much higher incidence of food insecurity than the national averages, which are 68.5% for informal and 44.6% for formal settlements (Shisana et al., 2013). The results on parents going without food to feed their children as a coping strategy is similar to findings in other studies (e.g., Walsh and van Rooyen, 2015).

Home gardens in our study were not found to be making a substantial contribution to vitamin A consumption of households or food security. Contrastingly, Faber et al. (2017), have found a more frequent dietary intake of vitamin A–rich foods in food secure households for both plant and animal sources of vitamin A. Other studies in Sub-Saharan Africa have shown the importance of gardens to increase nutrient uptake and diversification (Johns and Eyzaguirre, 2006) and traditional leafy vegetables can considerably increase iron and vitamin A in the diet (Van Jaarsveld et al., 2014). It seems that these benefits are more commonly observed in rural areas growing more vegetables and fruit (Faber et al., 2010). It is important to note that the Dietary Diversity Score is based on a single day's food intake, which usually has a day-to-day variation, particularly for non-staple foods, and availability across seasons has an effect (Faber et al., 2017).

Garden Composition and Perceptions

The study could not identify characteristics that fully explained the number of plant species grown in the gardens. Of the variance explained, wealth, gender and age were the most important. The study site gardens can be described as transitional gardens (high lawn and bare open space areas) which are between traditional (mainly useful plants with large areas of bare open space and natural areas with wild vegetation) and European colonial gardens (mainly ornamental and lawn with practically no bare open space) as described by Davoren et al. (2016). There was a predominance of large areas of bare open space, lawn and ornamentals, with smaller areas of utilitarian plants such as those with a spiritual use. Both bare open space, a traditional garden cover, and lawn, a more colonial garden cover, are in conflict with growing more utilitarian plants. Several authors have mentioned that crops and plants are strongly related to local culture and traditions (e.g., Orsini et al., 2013). Bare open spaces have important cultural significance as it indicates the tidiness of the household (Cilliers et al., 2009) and are immaculately swept daily (personal communication). It also offers another key service as it is used for safety, however, it means that many households are trading off the opportunity to grow food items by leaving all or a large area of their yard as an open space. These transition gardens are also retaining traditional spiritual use plants (such as wild garlic) and giving up traditional food plants. Other studies also reported that households in urban or peri-urban areas of South Africa have a predominance of ornamental plants over food and medicinal plants (Mosina et al., 2014). The transitional gardens evidences how socioeconomic status overrides cultural preferences as peri-urban residents gain access to resources needed to effect change in their gardens (Davoren et al., 2016).

Garden composition at the small scale was also similar to other studies. For instance, van Vuuren et al. (2020) and Nemudzudzanyi et al. (2010) also reported the presence of spiritual-relevant plants. Likewise, the most predominant plants found coincided with those reported by Walsh and van Rooyen (2015) in Free State Province, South Africa. Home gardens can contribute to human wellbeing beyond just health (via food). When the reported ecosystem services are linked to human wellbeing (Smith et al., 2013) we find that home gardens also contribute to spiritual and cultural fulfillment, connection to nature (via relaxation and aesthetics), social cohesion (via gifted vegetables and fruit), and living standards (via sold vegetables and fruit). It is also important to note the wellbeing contribution of having bare open space to safety and security, as it was associated with not providing vegetation for snakes or criminals to hide in near the house (Molebatsi et al., 2010).

Authors, such as Clarke et al. (2014), have hypothesized that the higher number of ornamental species and decreased edible cover in suburban and peri-urban gardens is attributed to luxury investments. These are due to the desire to imitate European colonial gardens that provide a certain status. However, the findings point to these luxury or "status" investments happening in low wealth households at risk of or food insecure, and with low dietary diversity, especially regarding vitamin A consumption. The way in which gardens are transitioning from Tshimo to European colonial gardens is influencing the ecosystem services of food production (and its associated wellbeing) that households could derive from their home gardens.

Acknowledgment of the value of an ecosystem service may vary with the role and perception of the stakeholder and the ecosystem service considered (de Groot et al., 2010). There is a clear mismatch between the participants' perceived ecosystem services from their garden (and thus the wellbeing they derive from it) and those observed by researchers. This has been reported by other authors regarding the relationship between biodiversity of green urban spaces and psychological wellbeing (Dallimer et al., 2012; Gaston et al., 2013). A key benefit from trees that users of urban green spaces highlight in sub-Saharan Africa is their role in providing shade (Guenat et al., 2019). However, few participants perceived such benefits from their garden trees and hedges, perhaps partly explaining why there were so few of these beneficiary plants. Similarly, many participants perceived that they had insufficient space as part of their properties to allow them to maintain a garden, and thus grow food or other beneficial plants. This is probably linked to a lack of gardening knowledge regarding required space for crops. This perception is a crucial barrier to the generation of ecosystem services from home gardens as participants decide not to plant at all. It is vital to overcome these awareness and knowledge deficiencies as a first step to get households' "buy-in" into urban gardening.

Why Home Gardens Fail

Several studies indicate that despite unemployment or low incomes with related food insecurity, the main source of food consumed is food that is purchased with a low reliance on self-production (e.g., Acquah et al., 2014; Crush and Caesar, 2014; Ngema et al., 2018; Garekae and Shackleton, 2020; Lowe et al., 2021). Moreover, in Windhoek, Namibia, 51% of the respondents indicated that buying food is much easier than growing food, with 46% indicating that they are not interested at all in growing food (Crush et al., 2018). In this study, gardens consisted mainly of large bare open spaces, lawns, and ornamentals with very small vegetable gardens and areas with fruit trees. The main function of the garden was not for food production. Moreover, the main reasons given for growing fruit and vegetables were to use the land available (53%) and due to a lack of money to buy vegetables (25%). When asked why they did not grow (more) vegetables and fruits the reasons included bad, rocky or muddy soil (40%), limited or no land (28%) and a lack of money (19%). The reliance on home gardens when respondents do not have money to buy food and the explanation that a lack of money constrained them from not planting more vegetables is a major conundrum for expanding urban agriculture. As evidenced by the studies mentioned above, if more money were provided, householders would be more likely to use this for buying food than to expand their vegetable gardens.

Gardens are often used to improve the status of the householder. For instance, in a Chinese study on suburban and peri-urban gardens, Clarke et al. (2014) suggested that gardens with high ornamental species richness and decreased edible cover can be attributed to luxury investments. Moreover, a South African study indicated that especially young people have negative feelings toward urban agriculture stating that it is "not modern" and that they were "not interested" (Thornton, 2008). Fruit and vegetables are also not the only source of food for urban dwellers with many preferring and supplementing their diets with animal products (Reynolds et al., 2015). This preference for animal products can also impact the success of gardening endeavors.

Home and community gardens also often cannot produce all year round or supply enough for household needs. A survey on urban farmers working in community gardens in Emfuleni, South Africa showed that 86% of the participants agreed that they could supply fresh vegetables to their own families from the garden. However, 41% indicated that it was not enough to feed their families (Modibedi et al., 2020). Moreover, 54% of the respondents stated that they could not rely on daily supplies of vegetables due to unreliable production. Further challenges affecting successful urban agriculture include land tenure insecurities, land use conflicts, water accessibility, weak regulatory frameworks to support urban agriculture (Puppim de Oliveira and Ahmed, 2021), limited space in urban areas (Lowe et al., 2021), and insufficient resources to maintain or start a garden (Bannor et al., 2021). Moreover, the safety of food produced using urban wastewater, planting crops or rearing livestock or poultry on polluted soils and indiscriminate use of pesticides, are crucial issues that impact acceptance and consumption of urban agricultural products (Bannor et al., 2021; Gulyas and Edmondson, 2021). These health concerns cause people to prefer to buy food from supermarkets (Wertheim-Heck et al., 2019).

Strategies for Successful Adoption of Urban Agriculture

Social grants have been endorsed as a way to ensure that food security problems are addressed, and for many it is their sole source of income. On its own, grants are inadequate to eliminate food insecurity and to date, in South Africa, has not significantly reduced malnutrition (Chakona and Shackleton, 2019; Waidler and Devereux, 2019). The main reasons for this are the fact that food prices continually increase but the grant amount does not, moreover grants are not solely used to buy food (Chakona and Shackleton, 2019; Waidler and Devereux, 2019). Therefore, urban agriculture has a crucial role to play as "safety net" and secondary food supply (Zimmerer et al., 2021) and ensuring local food supplies in times of crises such as the COVID-19 pandemic where global supply chains were severely affected (Gulyas and Edmondson, 2021). To promote urban agriculture, cooperation is needed with government entities on multiple levels as well as stakeholder participation in decision-making (Obosu-Mensah, 2002; Puppim de Oliveira and Ahmed, 2021). Moreover, viable agricultural land should be protected by acknowledging its role as a citizen-led urban green strategy and through relevant policies and the inclusion of urban agriculture in mainstream urban planning and development (Cilliers et al., 2020; Bannor et al., 2021; Steenkamp et al., 2021). Strategies should also focus on planting food with high nutritional value, combining it with poultry and livestock, and striving for gardens with high diversity specifically focusing on the richness and abundance of species to ensure year-round production (Lowe et al., 2021). Educating householders on optimal gardening practices and providing adequate support can greatly enhance the success of urban agriculture toward reducing food insecurities. However, in areas such as South Africa where cultural practices have a major influence on garden design, it is imperative to understand and find possible solutions for how cultural practices and optimal food production can coexist without residents losing their cultural identity. The excellent review of Gulyas and Edmondson (2021) on urban agriculture in the Global North proposed factors that we feel are universal for low- and middle-income countries as well and addressing these will greatly improve the value and contribute on urban agriculture to urban food security. These factors are: "the scale, the extent to which it is integrated into the urban fabric, its inclusiveness, the efficiency of food production, and human and environmental safety of practices."

CONCLUSION

The problem of reduced dietary diversity and food security is, of course, influenced by more than just home gardens (e.g., access to vegetables and fruits at shops, tastes) and needs to be dealt with a holistic approach that includes home gardens. Households need to be provided with the skills, resources and knowledge to be able to grow fruit and vegetables (e.g., soil improvement, space management) for food availability. The conflict of maintaining certain traditional cultural practices (e.g., bare open space, spiritual plants) and the loss of other traditional garden attributes (e.g., vegetable and fruit growing) with regards to the imitation of European colonial gardens (e.g., large lawns) that limit garden benefits needs to be further studied and managed. Further research could explore which ecosystem services and wellbeing benefits are more important to households and why. This could inform how to best manage culturally significant bare open space areas and also growing vegetables and fruits for food, income and social cohesion.

Low- and middle-income countries, like South Africa, have the potential to enhance peoples' food security and dietary diversity by encouraging the growing of fruit and vegetables in urban home gardens. However, there are many limitations to this, ranging from a lack of awareness of other garden benefits, lack of gardening skills and knowledge, cultural loss of utilitarian gardens and imitation of ornamental European garden styles, and an over reliance on purchasing of foods. The current protracted COVID-19 pandemic has shown that global supply chains can be vulnerable to disruption (Xu et al., 2020) and that low levels of self-sufficiency can have negative consequences for food security when food systems fail (Garnett et al., 2020; Reardon et al., 2020). The threat of global climate change further impels scientists and decision-makers to find more sustainable and resilient local food system pathways (Ghadge et al., 2019). Despite our findings of a weak contribution of home gardens to underpinning food security and dietary diversity, it is still worth trying to find ways to overcome the challenges constraining effective urban agricultural practices.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the Faculty of Health Sciences, North-West University in Potchefstroom (NWU-00064-16-S1). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MD, SC, and OR conceived and designed the study. OR performed the data collection. OR and VC analyzed the data, with help from MD. MJD created the map. MJD, OR, and VC wrote the manuscript. All authors contributed to the final draft and gave final approval for publication.

FUNDING

OR was supported by a Postdoctoral Fellowship for Early Career Researchers in South Africa funded by the Department for Science and Technology Republic of South Africa, the Newton Fund and the National Research Foundation of South Africa. MD was supported by a NERC Knowledge Exchange Fellowship (Grant No. NE/R002681/1).

ACKNOWLEDGMENTS

We thank the School of Biological Sciences, NWU for hosting OR and engaging students, especially Ancia Cornelius and Dennis Komape in the research; and the Faculty of Health Sciences, NWU for support with ethics approval and consumed Vitamin A estimations. We also thank the Ikageng agriculture extension worker, the Steve Tswete health clinic groundskeeper and head nurse, and study participants for sharing their time and knowledge.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2022.804523/full#supplementary-material

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