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RESEARCH ARTICLE

A sustainable livelihood pathway for urban carrot gardening in Ghana

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Abstract

This study investigates the adoption of carrot cultivation practices in urban areas and its impact on sustainable livelihoods. Using multistage sampling, 384 carrot farmers in the Mampong municipality were selected. The study showed that regarding farmer training, a significant positive influence is observed on farmers' ability to obtain seeds from reliable sources and measure planting depth. The adoption of good cultural and post-harvest practices among urban carrot producers is perceived positively, with high levels of satisfaction. Extension education significantly influences carrot production and livelihoods. The perceived level of sustainable livelihood resulting from carrot production practices is notably high across various capital dimensions, including natural, financial, human, social, and physical capital. Regression analysis reveals that post-harvest practices and distance to market significantly predict the sustainable livelihoods of the farmers. There is a need to invest in infrastructure such as irrigation systems and storage facilities to improve productivity and reduce post-harvest losses. The findings offer practical insights for extension workers, policymakers, and practitioners involved in urban agriculture and poverty alleviation programmes. The study's outcomes offer a valuable framework for informed decision-making in the design and implementation of urban gardening initiatives.

Keywords: Cultural practices; Post-harvest practices; Training programmes

1. Introduction

Training programmes for farmers play a vital role in enhancing agricultural practices, exerting a significant influence on both individual farmers and the wider agricultural domain. These initiatives aim to improve farmers' proficiency in farming methods (Sajeev *et al.*, 2012). They serve as pivotal channels for the dissemination of crucial knowledge and skills, arming farmers with the latest advancements and sustainable methodologies in agriculture (Noor & Dola, 2011). Empowered with this knowledge, farmers are more inclined to adopt innovations and technologies that can amplify their productivity, improve crop yields, and streamline livestock management. Furthermore, farmer training programmes often emphasise sustainability, advocating for eco-friendly practices to mitigate the environmental impact of agriculture while ensuring the long-term viability of farms (Rahmat *et al.*, 2020) Farmer training programmes serve as potent instruments in the arsenal of agricultural enhancement, nurturing a more efficient, sustainable, and resilient agricultural sector capable of addressing the world's burgeoning

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food needs (Shubham & Kumar, 2024). These programmes facilitate the advancement of teaching methodologies, leading to more effective and streamlined educational and training initiatives.

They play a multifaceted and indispensable role in bolstering agricultural skills and the comprehensive development of the agricultural domain. By empowering farmers within the agricultural community to acquire and hone crucial skills and knowledge (Sharma *et al.,* 2017) these programmes transcend mere skill acquisition to highlight the adoption of best agriculture practices. This includes the promotion of sustainable farming techniques, efficient resource management, and eco-friendly approaches (Sandhu *et al.,* 2012). Furthermore, training programmes cultivate empowerment among agricultural farmers by fostering confidence, problem-solving skills, and adaptability. This equips them to tackle intricate challenges such as climate change and market fluctuations with resilience (Elkashef, 2019). Moreover, these programmes foster a culture of knowledge exchange and collaboration, thereby amplifying their impact throughout the agricultural community. Ultimately, farmer training serves as the cornerstone of agricultural development, ensuring that individuals possess the necessary skills, confidence, and knowledge to confront evolving agricultural challenges, promote sustainability, and stimulate prosperity within the sector (Shubham & Kumar, 2024).

Rapid infrastructure expansion and escalating urbanisation put a strain on agricultural lands, leading to their conversion to housing and essential social amenities (Ayerakwa, 2017). Consequently, there's a prevalent concern that the increasing urbanisation in Sub-Saharan Africa may introduce additional hurdles to achieving sustainable methods of feeding the growing population. In response to this challenge, urban agriculture (UA) has emerged as a strategy to bolster local food security by augmenting the availability and accessibility of fresh, nutritious produce in food-insecure areas within cities (Mack *et al.*, 2017)

(Martellozzo *et al.,* 2014; Mack *et al.,* 2017; Martellozzo *et al.,* 2014). Urban farming encompasses both subsistence and commercial activities, providing sustenance for households while also generating income for urban residents (Nchanji, 2017). Transferring some food production to urban regions has the potential to reduce greenhouse gas emissions linked to food supply chains, offer fresher and more nutritious produce compared to imported goods due to shorter transport times, and alleviate strain on existing agricultural land (Kulak *et al.,* 2013; Wilhelm & Smith, 2018; Eigenbrod & Gruda, 2015).

Historically, developing nations have used urban agriculture as a means of subsistence and a supplement to household food security, while developed countries have primarily used it for recreational purposes. However, there is a growing recognition of its potential to improve food access in marginalised communities (Mok *et al.*, 2014). UA can bolster the supply of produce in urban areas, augmenting the availability of locally grown foods (Grewal and Grewal, 2012). Specifically, locating UA sites and markets in food-insecure and food desert areas can enhance access to fresh produce (Puppim de Oliveira & Ahmed, 2021). Additionally, engaging in UA activities has been associated with improvements in personal health, nutrition, and overall well-being (Kortright & Wakefield, 2011).

Urban agriculture can serve as a strategy to enhance the food self-sufficiency of a city, thereby bolstering resilience against disruptions in the national or global food supply chain, particularly heightened by extreme weather events and climate change-related crises (Grewal and Grewal, 2012). Urban agriculture spaces play a crucial role in cities by mitigating local air temperatures, enhancing air and water quality, managing stormwater, revitalising soils, sequestering carbon, and fostering biodiversity through wildlife habitat creation[1] (Goldstein *et*

al., 2016; Lin *et al.,* 2015; Clinton *et al.,* 2018).

Moreover, UA offers social benefits by establishing interactive spaces for urban dwellers to reconnect with their food system and natural environment, thereby improving personal health, fostering relaxation and well-being, and providing avenues for community engagement and education (Turner, 2011). While UA may not serve as a comprehensive solution to meet all the food needs of urban residents, reallocating some food production within cities can alleviate pressure on current agricultural land, enhance access to and availability of nutritious foods, and concurrently provide various other advantages to the urban landscape (Wilhelm & Smith, 2018; Clinton *et al.,* 2018).

Urban agriculture plays a significant role in enhancing food security, income generation, and livelihoods, particularly in regions with burgeoning urban populations like the Mampong municipality in the Ashanti region of Ghana. In this context, carrot cultivation holds promise as a lucrative venture for urban farmers. However, realising the full potential of carrot production necessitates the adoption of good cultural and post-harvest practices. Farmer training programmes emerge as crucial interventions aimed at equipping urban farmers with the knowledge and skills necessary to implement these practices effectively. Understanding the influence of such training programmes on the adoption of cultural and post-harvest practices, as well as their subsequent influence on sustainable livelihoods, is critical for promoting agricultural sustainability and improving the well-being of urban farmers. However, recent studies in urban agriculture[1] (Nchanji *et al.,* 2023; Nchanji, 2017; Padgham *et al.,* 2015; Mensah, 2023; Puppim de Oliveira & Ahmed, 2021) have failed to address this concern. This study addresses the lack of information in the literature.

In this study, we aim to assess the influence of farmer training programmes on the adoption of good cultural and post-harvest practices in urban carrot production, as well as their subsequent impact on sustainable livelihoods among farmers in the Mampong municipality of the Ashanti region, Ghana. Specifically, the study seeks to answer the following questions: i. How is farmer training perceived to influence the adoption of good cultural practices in urban carrot production? ii. How does farmer training influence the adoption of good post-harvest practices and their impact on urban carrot production and livelihood? iii. What are the perceived levels of sustainable livelihood capital among urban carrot farmers that result from the adoption of production practices? iv. How does the adoption of good cultural and post-harvest practices relate to livelihood outcomes among urban carrot farmers? v. What factors significantly predict the impact of urban gardening components on sustainable livelihoods among urban carrot farmers? By examining these dynamics, we seek to provide insights that can inform policy interventions, extension services, and agricultural development initiatives aimed at enhancing the productivity and resilience of urban farming communities in Ghana and similar contexts globally.

2. Materials and methods

2.1. Study Area

The research took place in the Mampong municipality, situated in the Ashanti region of Ghana. Geographically, it lies between longitudes 00 05W and 10 30W and latitudes 60 55N and 7 0 30N, covering an approximate area of 23.9 square kilometres. It shares borders with the Sekyere South District to the south, Ejura Sekyedumase Municipal to the north, and Sekyere Central District to the east. The primary towns within the municipality include Mampong, Krobo, Dadease, Asaam, Kofiase, Adidwan, and Apaah. The municipality comprises around 79 settlements, with approximately 61% classified as rural. These rural areas are predominantly located in the northern part of the municipality, characterized by dispersed communities with an

average population of less than 50 people. As per the 2021 Population and Housing Census, the population of the municipality stands at 116,632, consisting of 56,965 males and 59,667 females (source: https://ghanadistricts.com/Home/LinkDataDistrict/6582).

2.2. Research Design, Population, Sample and Sampling Procedure

The study used a descriptive correlation survey design approach. The population comprised all carrot farmers in the municipality. Since the actual population size of the carrot farmers is not known, the study employed the Cochran formula to determine the sample size (Cochran, 1997). The formula is given as; $n_0 = \frac{z^2pq}{e^2}$, where n_0= the sample size, Z = is the selected critical value of the desired confidence level, p = the estimated proportion of an attribute that represents the population, q = 1 – p, e = the desired level of precision (i.e., the margin of error). The z score for the 95% confidence level selected is 1.96. Thus, p = 0.5, q = 1 – 0.5 = 0.5 and e = 0.5. Therefore, $n_0 = \frac{(1{\cdot}96)^2(0{\cdot}5)(0{\cdot}5)}{(0.05)^2}$, n_0 = 385. Therefore, the sample size for the study was three hundred and eighty-five (385) carrot farmers in the municipality. The selection of respondents followed a multi-stage sampling procedure. In the first stage, the municipality was purposively selected because, in the municipality, the Ministry of Food and Agriculture has embraced the "backbone approach" proposed by the Global Program Development Oriented Emergency and Transitional Aid. This approach aimed to train urban gardeners specializing in carrot cultivation. The "backbone approach" operates on the principle of strategically using urban gardening to mitigate vulnerabilities and employing practical interventions, such as the sustainable livelihood pathway, to enhance livelihood assets. Again, the municipality was chosen because it is among the leading producers of carrots in Ghana. Hence the farmers in the municipality were ideal for the study. In the second stage, the municipality was divided into six (6) clusters. Finally, from each of the clusters, communities and farmers were selected using the simple random sampling method, proportionate to their size as indicated in the Ministry of Food and Agriculture office list. The sampled communities and the corresponding number of respondents were as follows: Mampong (50), Krobo (45), Dadease (35), Kofiase (39), Adidwan (32), Apaah (38), Nkwanta (41), Bobin (37), Hiamankyene (29), and Owuobourho (38).

2.3. Data Collection

We employed a structured interview schedule for data collection, comprising solely closed-ended questions aimed at measuring the variables central to our study. To assess the reliability of these questions, we utilized Cronbach's alpha test, yielding a score of 0.73, indicating the questionnaire's validity. Before actual data collection, we pre-tested the questionnaire on 30 carrot farmers in Kofiase to evaluate its validity. This pre-test helped identify any ambiguities in the questionnaire, allowing us to make the necessary adjustments. The researchers conducted the main data collection between July and August 2021, with the assistance of two national service personnel from the Department of Agriculture Economics and Extension Education at Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), Mampong, Ashanti, Ghana. Through extension agents from the municipal agriculture department, we contacted selected communities and participants. Each participant provided informed consent, and we maintained confidentiality throughout the data collection process. We tested hypotheses at a significance level of 0.05 alpha, focusing on significant differences and relationships. Finally, we analysed the collected data using the Statistical Package for Social Sciences (SPSS) version 21.

2.4. Data analysis

To assess how farmer training affects the adoption of good cultural and post-harvest practices, as well as the perceived sustainable livelihood capital of carrot farmers stemming from these practices, we employed a five-point Likert scale. This scale was 1.00 -1.44= very low; 1.45-2.44= low, 2.45-3.44=moderate, 3.45-4.44=high, and 4.45 - 5.00 = very high. Descriptive statistics (means, and standard deviations) were used to analyze the findings. Correlational coefficients (Point Biserial, Spearman rho and Pearson) were run to assess the relationship between farmer training on the adoption of good cultural and post-harvest practices on carrot production and livelihood. To assess the best predictors of urban gardening components on sustainable livelihood ordinary least square (OLS) regression analysis involving the stepwise entry method was employed. The regression equation used was

$Y = a + \beta_7 X_7 - \beta_5 X_5 + \ldots. \varepsilon$

$Y = a$ if $\beta_2 = \beta_8 = \beta_{12} = 0$

Where, dependent variable (Y) = urban gardening, a = constant ε = Error term, X_n = sustainable livelihood.

3. Results and Discussion

3.1. Demographic Characteristics of Farmers

Table 1 outlines the demographic characteristics of the surveyed farmers, providing key insights into their profile. The mean age of the farmers is 48.9 years, reflecting a moderate degree of age variation with a standard deviation of 11.04. Farmers, on average, possess 2.2 acres of farmland, showcasing considerable variability in farm sizes as indicated by the standard deviation of 2.04. In line with the findings of the study, Abunyewa *et al.* (2019) reported the age and farm size of carrot farmers to be 3.06 years and 1.99 acres respectively. Gender distribution is relatively balanced, with 54.43% being male and 45.57% female. Regarding education, the majority have received formal education (55.84%), while 44.16% have non-formal education. In terms of distance to the market, a significant proportion (76.56%) have farms located within 3 kilometres of a market, whereas 23.44% have farms situated more than 3 kilometres away.

Table 1. Demographic Characteristics of the Farmers

Variables	Mean	Std Dev.	Frequency	Percentage (%)
Age (years)	48.9	11.04	-	-
Farm size (acres)	2.2	2.04	-	-
Gender	Male		209	54.43
	Female		175	45.57
Level of education	Formal education		215	55.84
	Non-Formal education		169	44.16
Distance to market	< 3km to market		294	76.56
	>3km to market		90	23.44

Source: Field Survey, 2021

3.2. Perceived Influence of Farmer Training on the Adoption of Good Cultural Practices

Table 2 reveals notable insights into the impact of farmer training on various aspects of carrot production among urban carrot producers. According to Table 2, the highest mean ($\bar{x}$ = 4.98, SD = 0.12) was observed for "Ability to obtain seeds from a reliable source". This suggests that farmer training has had a positive impact on farmers' ability to access seeds from a trustworthy source. It implies that the training programmes have been effective in enhancing the farmers' capacity to secure seeds from dependable sources. This finding highlights the efficacy of training initiatives in enhancing farmers' capacity to secure high-quality seeds, thus promoting

sustainable production practices. The statement with the lowest score, "Ability to measure planting depth" ($\bar{x}$ = 4.11, SD = 0.65), suggests that training programmes focusing on good cultural practices have been effective in assisting carrot farmers in improving their ability to measure planting depth. The overall rating of the application of good cultural practices amongst urban carrot producers was very high with fewer variations as shown by the standard deviation ($\bar{x}$=4.53, SD= 0.58). This implies that these urban carrot gardeners know the importance of cultural practices such as mulching, manure and fertilizer application, watering, weeding, and pest, and disease control and therefore diligently practice them in their production protocols. This observation is in line with (Crush & Caesar, 2017) who asserted that proper mulching improves the growth, yield, and water conservation in carrot production. Appropriate pest and disease control will invariably extend shelf life, maintain freshness, wholesomeness, and quality, and substantially reduce marketing costs and losses (Crush & Caesar, 2017).

From Table 2, extension education on good cultural practices influenced positively, the production of carrots and subsequently, the livelihoods of urban gardeners. This is in line with the observation of Carney (1998) that, working with people, supporting them to build upon their strength and potential, while at the same time helping them acknowledge the effect of policies, external shocks, institutions, and trends edify them to improve their livelihood assets. The findings highlight the significance of tailored farmer training programmes and extension education initiatives in promoting sustainable agricultural practices, enhancing productivity, and improving the socio-economic well-being of urban farming communities. Policymakers and practitioners should prioritize the implementation of such programmes to facilitate knowledge dissemination and skill development among farmers, thereby fostering resilient and prosperous agricultural systems within urban landscapes.

Table 2. Perceived Influence of Farmer Training on the Adoption of Good Cultural Practices for Carrot Production

Perception statements	Mean	Std. Dev
Ability to identify source of water	4.60	0.77
Ability to measure land before cultivation	4.70	0.86
Ability to space the crops	4.60	0.57
Ability to prepare beds	4.95	0.20
Ability to get seeds from a reliable source	4.98	0.12
Ability to perform early planting	4.45	0.59
Ability to thin out	4.33	0.62
Ability to do mulching	4.92	0.77
Ability to measure planting depth	4.11	0.65
Ability to irrigate uniformly on the beds	4.95	0.27
Ability to fertilize soil	4.31	0.55
Ability to remove stumps	4.59	0.62
Ability to remove weeds	4.30	0.58
Ability to identify disease-resistant variety	4.45	0.80
Ability to control pest	4.63	0.56
Ability to use the right tool for harvesting	4.41	0.79
Ability to treat seeds before planting	4.85	0.55
Overall rating of Cultural practices	4.53	0.58

Source: Field Survey, 2021. Scale: 1.00-1.44=very low (VL), 1.45-2.44= low (L) 2.45-3.44=moderate (M), 3.45-4.44=high (H), 4.45-5.00=very high (VH)

3.3. Farmer Perceived Level of the Adoption of Good Post-Harvest Practices

From the results of Table 3, "Ability to reduce market losses" ($\bar{x}$=4.92, SD=0.27) had the highest mean indicating a widespread perception among respondents of being well-equipped to mitigate market losses effectively. This indicates that respondents perceived a very high ability to reduce market losses. Farmers, on average, feel well-equipped to manage and minimize losses in the market, indicating a positive influence on the strategies or practices introduced through training programmes. This suggests a positive influence of training programmes on equipping farmers with strategies to manage and minimize losses, highlighting the efficacy of interventions in this regard. "Ability to control storage diseases" ($\bar{x}$=2.05, SD=0.77) had the lowest mean. This indicates that, on average, respondents reported a relatively low perceived ability to control storage diseases. The findings indicate that there is room for improvement in the farmers' ability to control storage diseases. This highlights the need for targeted interventions, education, or strategies aimed at bolstering farmers' skills and knowledge in this specific area to enhance disease control measures. The overall rating of the adoption of post-harvest practices amongst urban carrot gardeners was very high ($\bar{x}$= 4.71, SD=0.44) with minimal variations in responses as indicated by the SD. This implies that respondents perceived the adoption of good post-harvest practices such as sorting, grading, processing, packaging, storage, and transportation to be a positive influence on the production of carrots.

Table 3. Perceived Influence of Farmer Training on the Adoption of Good Post-Harvest Practices for Carrot Production

Perception	Mean	Std. Dev
Ability to separate broken produce from unbroken produce	4.91	0.27
Ability to separate big from small produces	4.89	0.31
Ability to do proper handling	4.27	0.66
Ability to preserve the produce	4.85	0.55
Ability to reduce market losses	4.92	0.27
Ability to do transportation	4.89	0.31
Ability to regulate storage temperature	4.85	0.55
Ability to control growth of storage pathogens	4.91	0.27
Ability to preserve produce quality	4.89	0.31
Ability to use the by-products	4.85	0.55
Ability to retain the freshness for a longer time	4.91	0.27
Ability to discard spoiled carrot	4.89	0.31
Ability to do the washing	4.91	0.27
Ability to preserve the taste of carrot	4.89	0.31
Ability to control storage diseases	2.05	0.77
Ability to detect early storage disease	4.85	0.55
Ability to use appropriate washing tools	4.91	0.27
Ability to apply ideal storage temperature	4.85	0.55
Ability to regularly check storage produce	4.91	0.27
Overall rating of post-harvest practices	4.71	0.44

Source: Field Survey, 2021. Scale: 1.00-1.44=very low (VL), 1.45-2.44= low (L) 2.45-3.44=moderate (M), 3.45-4.44=high (H), 4.45-5.00=very high (VH)

According to Kitinoja and Kader (2002), proper packaging and packing offer effective protection for produce and ensure adequate ventilation during handling, cooling, transport, and storage. The findings presented in Table 2 demonstrate that extension education focusing on sound post-harvest practices yields a favourable impact on carrot production. This impact holds the potential for assisting impoverished urban gardeners in achieving sustainable and lasting livelihood

improvements, along with tangible enhancements in measured assets. The Sustainable Livelihoods (SL) approach, as elucidated by Carney (1998) and the United Nations Development Program (2017), seeks to empower economically disadvantaged individuals by employing poverty indicators defined, contextualized, and operationalized by the individuals themselves. The findings stress the importance of targeted interventions and education initiatives aimed at enhancing post-harvest practices among urban carrot producers. By addressing perceived shortcomings in disease control and optimizing strategies to minimize market losses, policymakers and practitioners can contribute to the resilience and sustainability of urban farming communities, ultimately fostering lasting livelihood improvements and poverty alleviation.

3.4. Perceived Influence of Farmer Training on Cultural and Post-Harvest Practices

Table 4 presents perceptions of the total production process among respondents based on cultural practices, post-harvest practices, and the overall production process. The mean scores for cultural practices (4.54) and post-harvest practices (4.72) indicate high to very high levels of satisfaction. This positive outlook can be attributed to the effectiveness, efficiency, or perceived benefits of these practices, as rated by the farmers. These positive perceptions present an opportunity for stakeholders in agriculture to leverage and build upon existing strengths to further enhance productivity and the overall quality of the production process. By acknowledging and amplifying successful practices, stakeholders can facilitate knowledge sharing and promote sustainable agricultural practices within the industry. The overall contribution of both cultural practices and post-harvest practices to the Total production process is very high ($\overline{x}$=4.62, SD= 0.20) with marginal variations in responses. This implies that farmers perceived extension training on good cultural and post-harvest practices to be helpful enough and therefore adopted and applied the practices at a high level to help them achieve a positive livelihood. Research conducted by Badami and Ramankutty (2015) affirms that households in urban regions participate in self-sustained food production for a variety of purposes, encompassing personal consumption and generating income through surplus sales. The acknowledged advantages of urban gardening, spanning nutritional, health, and economic realms have prompted the endorsement of this practice as a constructive endeavour with the potential to assist economically disadvantaged segments of society, particularly the urban poor (Ayerakwa, 2017). The findings accentuate the importance of capitalizing on farmers' positive perceptions and leveraging effective practices to promote sustainable agriculture and improve livelihoods, particularly in urban settings. Policymakers and practitioners should prioritize initiatives that support knowledge sharing and capacity building to foster resilient and productive farming communities.

Table 4. Total Production Process

Perception	Mean	Std. Dev
Cultural practices	4.54	.58
Post-harvest practices	4.72	.44
Total production process	4.63	.56

Source: Field Survey, 2021. Scale: 1.00-1.44=very low (VL), 1.45-2.44= low (L) 2.45-3.44=moderate (M), 3.45-4.44=high (H), 4.45-5.00=very high (VH)

3.5. Farmers' Perceived Level of Sustainable Livelihood Capital

Table 5 presents the farmers' perceived level of sustainable livelihood resulting from the adoption of carrot production practices. Based on the findings, the general perception of sustainable livelihood concerning natural capital is very high ($\bar{x}$ = 4.77, Std. Dev = 0.58). This suggests that farmers recognize the influence of adopting carrot production practices on the accessibility of natural resources, thereby contributing significantly to the enhancement of their livelihoods. The conscientious and sustainable utilization of natural resources, as exemplified by practices like urban gardening, directly affects the reservoirs of natural capital. This approach serves as a tool for enhancing the availability of vital resources that underpin health and well-being, rooted in the continued functionality of intricate ecosystems (Steinbrink and Niedenführ, 2020). The overall impact of financial capital on livelihood was very high ($\bar{x}$=4.75, SD=0.39) indicating that farmers believe adopting carrot production practices has a significant impact on their financial well-being. It contributes significantly to increasing revenue, creating investment opportunities, accumulating savings, and enhancing overall profitability. Financial capital encompasses the monetary resources that individuals harness to realize their livelihood goals. Its availability in the form of cash or equivalent assets enables the pursuit of diverse livelihood strategies (Steinbrink and Niedenführ, 2020). A sustainable approach to resource management, exemplified by practices like urban gardening, extends the continuity of financial streams derived from natural capital (such as yields from urban gardening). This, in turn, fosters a consistent influx of funds and the accumulation of accessible reserves (savings) in a more dependable manner (van Dijk, 2011).

The respondents expressed a very high perception of human capital ($\bar{x}$ = 4.87, SD = 0.33), suggesting that farmers believe the adoption of carrot production practices significantly enhances their skills, knowledge, labour capabilities, and leadership potential. This enhancement, in turn, equips farmers to pursue diverse livelihood strategies and successfully attain their livelihood objectives. Investing in education and training, exemplified by programmes like urban gardening extension services, as well as acquiring skills through engaging in various occupations, can collectively boost human capital. However, it's crucial to note that neither of these factors alone is adequate for achieving positive livelihood outcomes; rather, they act as complementary elements in the pursuit of such outcomes (De Haan, 2017). According to Horner (2019), who placed a focus on education and skills, improving human capital is not simple or quick, especially for peasants who are exposed to shocks and dangers. Nevertheless, human capital is significant since it is both the aim and the subject of development.

Table 5 displays a notably very high overall rating for social capital ($\bar{x}$=4.60, SD=0.40), with respondents demonstrating relatively consistent responses, as indicated by the low standard deviation (SD). This suggests that farmers perceive the impact of carrot adoption on their livelihoods in terms of social capital to be highly influential. This social capital is instrumental in garnering support from associations, individual farmers, households, and friends, thereby facilitating the achievement of positive livelihood outcomes. Vicol (2018) defines social capital within the context of the sustainable livelihoods framework as the social resources leveraged by individuals to pursue their livelihood objectives. These resources stem from networks, connections, participation in formal groups, and relationships founded on trust, reciprocity, and exchanges. Furthermore, van Dijk (2011) underscores the effectiveness of social capital in enhancing the management of shared resources, such as the natural capital of urban gardening, as well as the upkeep of communal infrastructure, like the physical capital essential for urban gardening. The comprehensive evaluation of

physical capital yielded a notably very high score ($\bar{x}$ = 4.87, SD = 0.34). This emphasizes the farmers' shared perception of the substantial influence of adopting carrot production practices on their physical capital.

Table 5. Farmers Perceived a Level of Sustainable Livelihood by Adopting Carrot Production Practices

Natural Capital	Mean	Std. Dev
Capacity to add onto farm size for production	4.89	0.31
Capacity to improve on the land fertility	4.54	0.68
Capacity to practice crop protection	4.73	0.65
Capacity to increase yield	4.25	0.61
Capacity to collateralize crop	4.85	0.55
Overall rating	4.77	0.58
Financial Capital	Mean	Std. Dev
Capacity to increase revenue	4.92	0.28
Capacity to make investments	4.89	0.31
Capacity to save	4.18	0.49
Capacity to access credit facilities	4.85	0.55
Capacity to make profit	4.93	0.28
Overall rating	4.75	0.39
Human Capital	Mean	Std. Dev
Capacity to acquire knowledge	4.89	0.31
Capacity to apply managerial skills	4.86	0.55
Ability to access extension service	4.92	0.28
Ability to access labour	4.89	0.31
Capacity to exhibit leadership skills	4.88	0.31
Overall rating	4.87	0.33
Social Capital	Mean	Std. Dev
Ability to own a membership to the association	4.86	0.55
Ability to have support from the association	4.91	0.27
Ability to have aid from other individual farmers	4.89	0.31
Ability to care for the household	4.69	0.55
Ability to have assistance from friends	3.65	0.40
Overall rating	4.60	0.48
Physical Capital	Mean	Std. Dev
Ability to build a storage room	4.85	0.55
Ability to buy irrigation equipment	4.86	0.56
Ability to purchase gear for controlling weeds	4.84	0.57
Ability to buy means of transportation	4.92	0.28
Ability to buy tools for harvesting	4.87	0.31
Overall rating	4.88	0.45

Source: Field Survey, 2021. Scale: 1.00-1.44=very low (VL), 1.45-2.44= low (L) 2.45-3.44=moderate (M), 3.45-4.44=high (H), 4.45-5.00=very high (VH)

This impact is substantial, as it aids farmers in acquiring fundamental infrastructure and essential producer goods necessary for bolstering livelihoods, enhancing productivity, and facilitating more effective functioning. As outlined by the United Nations Development Program (2017), infrastructure, often constituting a public good, and producer goods, typically owned by individuals or groups, represent pivotal forms of physical capital that play a pivotal role in enhancing livelihoods. However, the state of existing infrastructure or its absence can either positively or adversely affect household livelihood pathways. These findings highlight the multifaceted benefits of adopting carrot production practices across various capitals, highlighting the importance of holistic approaches to sustainable livelihood

development. Policymakers and practitioners should prioritize initiatives that support sustainable resource management, skill enhancement, social capital formation, and infrastructure development to promote resilient and prosperous farming communities.

3.6. Relationship Between Farmer Training on The Adoption of Good Cultural and Post-Harvest Practices on Carrot Production and Livelihood

Table 6 presents the Pearson product-moment correlation matrix for the relationship between livelihood and adoption of good cultural and post-harvest practices in urban carrot production. The correlation coefficient (r) was interpreted according to the guidelines recommended by Davis (1971) which is scaled as 1.0=Perfect, 0.70 - 0.9=Very High, 0.50 - 0.69=Substantial, 0.30 - 0.49=Moderate, 0.10-0.29=Low and 0.01 - 0.09=Negligible. From Table 5, there was a significant relationship between livelihood and two (2) of the independent variables at 0.01 alpha level namely post-harvest practices (X_7) and Level of education (X_3).

There was a positive and very high significant relationship between the adoption of post-harvest practices (r=.855) and the livelihood of farmers at 0.01 alpha level. This implies that the more urban carrot farmers adopt and apply the post-harvest practices, the higher their livelihoods. This finding suggests that as farmers adopt post-harvest practices, there is a substantial positive impact on their livelihoods. Such practices may contribute to increased efficiency, reduced losses, or improved product quality, ultimately influencing the economic well-being of farmers. However, there was a negative and low significant relationship between the level of education (r = -.290) and the livelihood of farmers at 0.01 alpha level. This implies that the more formally educated the carrot farmer is the less they are willing to adopt and apply the urban gardening practices for a higher livelihood. While education is often seen as a positive contributor to socioeconomic well-being, the negative correlation in this context might prompt a closer examination of the specific factors at play. It could be that farmers with higher levels of education are engaging in different types of activities or facing challenges that impact their livelihoods differently.

Table 6. Correlation Matrix of Farmer Training on the Adoption of Good Cultural and Post-Harvest Practices on Carrot Production and Livelihood

Independent variables	Correlation Coefficient (r)	Sig (p)	Type of correlation	Strength of relationship
Gender (X_1)	.087	.348	Point Biserial	Negligible
Age (X_2)	.054	.563	Biserial	Negligible
Level of education (X_3)	-.290**	.001	Spearman's rho.	Low
Farm Size (X_4)	-.008	.931	Biserial	Negligible
Distance to market (X_5)	-.155	.091	Biserial	Low
Cultural Practices (X_6)	.124	.181	Pearson	Low
Post-Harvest practices (X_7)	.855**	0.000	Pearson	Very high

Source: Field Survey, 2021.

Understanding this relationship is crucial for crafting effective interventions that consider the diverse needs and circumstances of farmers. Again, the adult learner knows what they want, how they want it and when they want it and therefore will only be motivated to learn and adopt technologies, they deem profitable, triable, compatible and with a higher relative advantage over the previous practice in their own pace. Rogers (1995) proposed that educational initiatives targeted at adult farmers should be designed to empower them to make autonomous decisions for addressing challenges in their agricultural endeavours, thereby fostering

problem-solving skills. Understanding the complex relationship between education, adoption of agricultural practices, and livelihoods is crucial for designing effective interventions that empower farmers and promote sustainable agriculture. Policymakers and practitioners should leverage these insights to develop targeted educational programmes and support mechanisms that cater to the diverse needs and contexts of farmers, ultimately fostering resilient and prosperous farming communities.

3.7. Collinearity Diagnostic Test

The Variance Inflation Factor (VIF) demonstrates the extent to which multicollinearity inflates the variance of the coefficient estimate. While tolerance values closer to 1 suggest no collinearity and zero (0) indicates a significant multicollinearity issue, VIF values close to 10 are cause for concern (Bosompem *et al.,* 2013). From Table 7, there was no evidence of multicollinearity among the variables, as indicated by the VIF test. The assumption of residual autonomy was upheld, as the Durbin-Watson test for the models yielded a value of 1.7, falling within the acceptable range of 1.89–2.03 (Panda *et al.,* 2021).

Table 7. Collinearity Diagnostic Test

Independent Variable	Tolerance	VIF	Durbin Watson
Gender (X1)	.973	1.028	1.7
Age (X2)	1.000	1.000	
Level of education (X3)	.901	1.009	
Farm Size (X4)	.997	1.003	
Distance to market (X5)	1.000	1.000	
Cultural Practices (X6)	.972	1.029	
Post-Harvest practices (X7)	.080	1.004	

Source: Field Survey, 2021.

3.8. OLS Regression of Urban Gardening Components on Sustainable Livelihood

A seven (7) factor linear regression model made up of X_1= Gender, X_2= Age, X_3= Level of Education, X_4= Sizes of land, X_5= Location, X_6= Cultural practices, and X_7= post-harvest practices was projected to clarify the variation of urban gardening components on sustainable livelihood using the OLS regression. Table 8 shows the OLS regression of the level of urban gardening components on sustainable livelihood. The components of urban gardening that predicted the operationalization of sustainable livelihood were post-harvest practices and distance to market which explained 74.9% of the influence of urban gardening on livelihood as shown by the R-squared (R^2) column. Individually, post-harvest practices (X_7) gave (73.0%) explanation and distance to market contributed (18.0%) as exemplified in the adjusted R-Square change (AdjR^2 Change) column.

The primary and most influential predictor, post-harvest practices (X7), accounted for a substantial (73.0%) portion of the explanation for the impact of urban gardening on livelihood. This highlights that the proper execution of post-harvest activities such as sorting, grading, processing, packaging, packing, storage, transportation, and marketing of carrots directly affects farmers' livelihood and the essential activities for sustaining their way of life. This information is critical for urban gardening initiatives and interventions, as it emphasizes the importance of focusing on and optimizing post-harvest practices to maximize positive impacts on livelihoods. It suggests that improvements or innovations in how crops are handled and processed after harvest can significantly contribute to enhancing the overall success and sustainability of urban gardening initiatives. Furthermore, an 18.0% contribution to the overall prediction of sustainable livelihood is attributed

to distance to the market. This emphasizes the role of distance to market in poverty alleviation especially in developing nations (Food and Agricultural Organization, 2012). It stresses the significance of the proximity to the market in shaping the sustainability of livelihoods in the studied context. A shorter distance to the market may imply easier access to sell produce, reduce transportation costs, and potentially enable farmers to engage in more frequent and efficient market transactions. On the other hand, a longer distance may pose challenges that impact the economic viability of urban gardening activities. It has the potential to improve the lives of urban households involved in agriculture, thereby extending its positive effects to the surrounding cities. This extension of benefits includes increased access to nutritious food, supplying fresh fruits and vegetables to urban residents, lowering food expenses through reduced purchases, and boosting the income of farming households through surplus sales. Additionally, it plays a pivotal role in generating employment opportunities for vendors of farm products derived from urban and peri-urban cultivation spaces (Badami & Ramankutty, 2015; Ayerakwa, 2017).

Table 8. OLS Regression of Urban Gardening Components on Sustainable Livelihood

Predictors	Step of Entry	Beta(β) (unstandardized)	R^2	Adj R^2	AdjR^2 Change	S.E. E	F. Change	F. Sig*
X_7	7	.498	.730	.728	.730	.12608	314.107	.000
X_5	5	-.052	.749	.744	.018	.12224	8.406	.004

Source: Field Survey, 2021.

4. Conclusion and recommendations

The study provides a comprehensive examination of the adoption of carrot cultivation practices in urban areas, with a focus on its impact on sustainable livelihoods. It identified key demographic characteristics of farmers, revealing a balanced gender distribution, and varied education levels. The findings highlight the positive perception of farmers regarding the adoption of good cultural and post-harvest practices, indicating a strong awareness and implementation of these techniques. The study also emphasized the influence of farmer training on the adoption of these practices, showcasing their vital role in enhancing livelihoods. Furthermore, the research delved into the various dimensions of sustainable livelihoods, including natural, social, physical, financial, and human capital. Farmers perceived a high level of impact on these capitals, underlining the multifaceted benefits of adopting carrot production practices. The study demonstrated the importance of post-harvest practices and distance to market in predicting sustainable livelihoods, shedding light on the critical factors influencing the success of urban gardening initiatives.

The study contributes to the existing literature by addressing a critical gap in understanding the actual and potential contributions of urban gardening, specifically carrot cultivation, to sustainable livelihoods. The findings provide valuable insights for extension workers, farmers, and researchers, offering a framework for informed decision-making in the context of urban agriculture. The implications drawn from our study align with the self-efficacy theory, asserting that an individual's capabilities influence a range of factors including choices, efforts, resilience, and achievements. Practically, the study highlights the importance of tailored extension programmes focusing on good cultural and post-harvest practices for urban farmers engaged in carrot cultivation.

The study strongly recommends the advocacy and implementation of targeted training programmes for urban farmers, specifically centred on Good Agricultural Practices encompassing both cultural and post-harvest

techniques. Emphasis should be placed on comprehensive training covering aspects such as site selection, land management, pest control, and efficient post-harvest handling. Given the demonstrated positive correlation between the adoption of post-harvest practices and livelihoods, special attention should be devoted to enhancing these practices. Governments and organizations are urged to allocate resources for investing in training and extension services tailored to urban farmers, aiming to elevate the standards of both cultural and post-harvest practices. This strategic investment holds the potential to not only boost the quality and quantity of food production but also significantly enhance the livelihoods of urban farmers by directly impacting income generation and ensuring food security.

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