**Discover** Sustainability

Research

# Characterization of urban agriculture and farmers' climate change adaptation: the case of Urban Wa, Ghana

**Godwin K. Naazie**[1,2] · **Isaac Agyemang**[1] · **Anthony M. Tampah-Naah**[3]

Received: 13 November 2023 / Accepted: 19 March 2024
Published online: 04 April 2024


**Abstract**
Urban agriculture in sub-Saharan Africa has the potential to significantly improve urban food security and feed the underprivileged when promoted. In Ghana, urban agriculture has several characteristics that distinguish it from traditional farming practices. However, climate change poses a significant threat to urban agriculture, as changing weather patterns can lead to droughts, floods, and extreme weather events that damage crops and animals. This study explored the characteristics of urban food crops and livestock production in the Wa township, Ghana. Mixed methods of data collection and analysis were employed. A sample of 362 urban households was administered survey questionnaires supplemented with 12 key informant interviews. Descriptive and content analysis were carried out, with the results presented in tables, graphs, and narratives. The study found that amidst climatic stressors, urban agriculture is characterized by the production of animals such as chickens, sheep, and goats and crops like maize, yam, beans, cabbage, and pumpkin. Land is acquired through purchasing, though other farmers obtain land from relatives and friends. There is a very strong relationship between residential class and the type of urban farming (Cramer's $V = 0.291 > 0.25$) and a moderate relationship between residential class and land acquisition type (Cramer's $V = 0.108 > 0.10$). The study concludes that urban farming is characterized by mixed farming coupled with crop diversification, which has implications for climate change adaptation measures. To adapt urban agriculture to climatic stressors, the study recommends that the Ministry of Food and Agriculture (MoFA) should streamline agricultural policy interventions in urban agriculture to promote agriculture intensification.

**Keywords** Urban agriculture · Urban agriculture characteristics · Climate change adaptation · Ghana

## 1 Introduction

In sub-Saharan Africa (SSA), urban agriculture is essential for solving issues of environmental sustainability, food security, and poverty reduction [1]. Urban agricultural production supplements food production in rural areas [2]. With a large percentage of the population living in cities and the region rapidly becoming more urbanized, urban agriculture has become an essential tactic to guarantee access to wholesome food and improve livelihoods [3]. Urban agriculture typically operates on a small scale, often for domestic purposes and self-consumption [4]. This indicates that urban agriculture

✉ Godwin K. Naazie, balkonpoge1988@gmail.com; Isaac Agyemang, iagyemang@ubids.edu.gh; Anthony M. Tampah-Naah, atampah@ubids.edu.gh | [1]Department of Environment and Resource Studies, Faculty of Integrated Development Studies, Simon Diedong Dombo University of Business and Integrated Development Studies, (SDD-UBIDS), P.O. Box WA64, Wa, West Africa, Ghana. [2]Department of Mathematics and Natural Sciences, College of Arts and Sciences, William V.S. Tubman University, P.O Box 3570, Harper, MD, Republic of Liberia. [3]Department of Geography, Faculty of Social Science and Arts, Simon Diedong Dombo University of Business and Integrated Development Studies, (SDD-UBIDS), P.O. Box WA64, Wa, West Africa, Ghana.

is often practiced by individuals or households within urban areas on a subsistence basis utilizing limited spaces such as those at home, community, school, institutional, or rooftops [5]. Again, urban agriculture is often focused on food crops and livestock production [6]. Hence, urban agriculture refers to the practice of cultivating crops and raising animals within urban areas, providing fresh produce to local communities [7]. Urban agriculture refers to the practice of cultivating crops and rearing animals within cities or urban areas [8]. Furthermore, urban agriculture has gained significant attention as a sustainable practice in addressing food security, and economic development within cities in Africa with different characteristics. In countries like Nigeria and Kenya, urban farming is commonly found in peri-urban areas due to the availability of open spaces, while in densely populated cities like Cairo, rooftop gardening and vertical farming are prevalent [9]. Again, staple crops like maize, sorghum, and millet dominate in sub-Saharan countries, while Mediterranean climates in North Africa favor the cultivation of fruits and vegetables [10]. Livestock integration in urban agriculture is a common practice in many African countries, contributing to sustainable waste management and diversified food production. Chickens, goats, and rabbits are frequently integrated into urban farming systems [11].

Urban agriculture in Ghana faces several challenges that hinder its development and potential to contribute to food security, poverty reduction, and sustainable urban development [12]. These challenges can be categorized into various aspects including land availability, environmental factors as in climate change effects, policy and regulatory frameworks, and social and cultural factors [10, 11]. One of the primary challenges in urban agriculture in Ghana is the limited availability of land for cultivation. Rapid urbanization has led to the conversion of agricultural lands into residential and commercial areas, reducing the space for farming activities [13]. Another key challenge faced by urban agriculture in Ghana due to climate change is water scarcity through changing rainfall patterns and farmers use water harvesting and irrigation to address it [14]. Also, rising temperatures and changing rainfall patterns can lead to reduced yields and increased vulnerability to pests and diseases [15]. This study defined climate change as the long-term shifts in temperature and weather patterns that have dire effects on agricultural production [16]. One of the primary effects of climate change on urban agriculture in Ghana is the increase in temperatures which affects crops and animal growth [17]. High temperatures result in to increase in pests such as aphids, mites, and whiteflies that tend to reproduce more rapidly under higher temperatures, posing a threat to urban crops [18]. Extreme weather events such as heat stress caused by high temperatures can lead to various health issues in animals, including respiratory problems, dehydration, and reduced immune function including the spread of anthrax [19].

Notwithstanding, the nature of urban agriculture in Ghana has implications for urban farmers' climate change adaptation measures. Climate change adaptations here refer to the actions and strategies used to withstand the negative impacts of climate change on urban agricultural production [15]. To adapt to these climatic stressors, farmers grow a variety of crops with different climate tolerances, farmers can reduce the risk of crop failure and ensure a more stable food supply [14]. Extent literature laid emphases on urban agricultural production [6, 20]. For instance, Taguchi and Santini [6] worked on the global prospects of urban agriculture, and Abdulai [19] studied ruminant rearing within urban space. Also, the issues of farmers' climate change adaptation have been researched but from the rural perspective [21, 22]. Exemplary, Abazinab et al.[20] focused on livestock farmers' climate change adaptation measures and Wulandari et al. [23] underscored how roots and tuber farmers are climate change adaptation strategies. However, the nexus between urban agriculture's characteristic nature and urban farmers' climate change adaptation has received little attention from the scientific community. The seeks to achieve the following objectives:

1. To explore the nature and characteristics of urban agriculture
2. To explain how the nature and characteristics of urban agriculture constitute urban farmers' climate change adaptations.

Therefore, this study aims to explore the characteristics of urban agricultural production and how that necessitates climate change adaptation for urban Ghana.

## 2 Literature review

### 2.1 Characteristics of urban agriculture

An urban area is meant differently according to country-specific however, its definition differs from villages and hamlets [22]. For instance, Ritchie and Roser [22] said a locality that qualifies as an urban area in Argentina is an

area that has not less than 2000 inhabitants; in Sweden, it is a locality that has more than 200 people with houses spaced 200 m apart. This study borrowed the Ghana census definition of urban areas which is said to be taken as a geographical area with a population of 5000 people or more [24]. The term urban agriculture (UA) means different things to different people. For example, UA is the cultivation of crops and raising of farm animals in small urban spaces for own consumption or sale for income [8]. Also, UA is the growing of crops or rearing of livestock, or both within cities either on large or small scales [6]. Urban agricultural production is characterized by many components. These range from the site and ownership of the farms (private/public) land, to residential yards, and uncompleted building structures as just a few city authorities incorporate urban farming into planning [25]. Urban gardening may also be practiced in the open space [26]. Farmers could, for instance, plant a small orchard in a park, replace street trees with fruit trees, grow herbs and vegetables in pots, or make a hedge of fruiting plants [27]. Urban market gardens, which are tiny farms that grow high-value produce, are perfectly positioned to support the specialty markets in the area and lessen the need to export goods over great distances [28]. Al-Kofahi et al. [27] argued that around 50% of the city gardens are utilitarian, while 21% are aesthetically designed, and 53% are categorized as side yards.

Urban gardening practices are evolving through emergent approaches and the use of diverse materials and components in garden construction [29]. It is crucial to consider the physical characteristics of urban agriculture gardens, such as the size of the plot or constructed area [4], the topography, and how they connect to the surrounding public space, such as the presence of fences [30]. The scale and nature of urban agriculture can vary in the city, such as in intra-urban spaces, and depending on whether the garden is located on marketable land with other possible applications or non-marketable agricultural land with very little public content [31]. Urban gardening also takes place in residents' yards and built-up structures within cities [32]. In most cities, backyard vegetable gardens, which may have long been a common sight in city yards, are regaining popularity as people become more aware of the need for fresh, healthful food [32]. To integrate intensive farming with other urban settings, such as houses and workplaces [33]. There are various opportunities to retrofit existing structures with the necessary technologies to enable food production, even though the futuristic conceptions serve as architectural inspiration for new development. Many cities have flat rooftops that are ideal for urban gardening [34].

### 2.2 Urban agricultural practices and climate change adaptions strategies

Urban agriculture can take many forms, such as raising fruit trees, vegetables, medicinal plants, and spices, and raising poultry or animals to produce eggs, milk, meat, and wool [35]. The common crop types that are grown in urban spaces are fruits such as watermelon, cereals like maize and rice, roots and tubers (yam and cassava), and vegetables in the form of okra, and pepper [35]. Similarly, their findings showed that home gardening is dominant in Ghanaian cities; farmers mostly cultivate staple food crops like maize but not perishable and or cash crops [36]. However, farmers lack the resources necessary to encourage the production of urban food [6]. Many urban dwellers are at food security risk as crops and animal production in their neighbourhoods are affected by climate change conditions in the form of drought and floods. The solution to this is the adoption of production practices to adapt to climate stressors. Urban agriculture is affected by climate change and farmers are at risk [37]. For instance, rising temperatures frequency, and intensity of extreme weather events can lead to heat stress in crops and livestock, affecting their growth and productivity [38]. Adapting agricultural practices is crucial to ensure food production remains resilient in the face of these changes and farmers use strategies such as crop diversification, improved water management, and improved livestock management [21].

Urban agriculture, as a complex and dynamic practice, is deeply influenced by institutional roles and structures. This literature review examines the existing knowledge on how institutions contribute to shaping the characteristics of urban agricultural production. The analysis encompasses diverse aspects such as policy frameworks, governance structures, and institutional support, providing a comprehensive understanding of the institutional dynamics within urban agriculture. Institutional policies play a pivotal role in fostering sustainable urban agriculture [39]. They added that Policies that secure land tenure, incentivize small-scale farming, and integrate urban agriculture into urban planning contribute significantly to the growth and resilience of urban farming practices. Institutions that provide research funding, technical assistance, and knowledge-sharing platforms play a crucial role in shaping the technological landscape of urban agriculture [40]. According to the work of Fanfani, et al. [41], institutions that facilitate community-led initiatives and establish platforms for knowledge exchange contribute to the creation

of social networks within urban agriculture. This, in turn, influences the characteristics of urban farming practices, emphasizing collaboration and shared resources [42].

### 2.3 Conceptual framework

The interrelationship between urban agriculture characteristics and urban farmers' adaptation to climate change strategies has been schematized. Therefore, Fig. 1 shows the connections between urban agriculture characteristics and farmers' climate change adaptation strategies. The characteristics of urban agriculture are affected by climatic stressors. Stakeholders in urban agriculture through policy frameworks have a role to play in urban agriculture within cities through decision-making on urban agricultural land acquisition and locations. Again, the stakeholders in urban agriculture influence the kind of climate change adaptations urban farmers have to put in place based on the characteristics of their activities. These adaptations are remedies to the climatic stressors that are affecting urban agriculture. The effectiveness and efficiency of these climate change adaptation strategies determine the outcome of urban agricultural production. Effective and efficient climate change measures mean increased urban agricultural production and ineffective and inefficient climate change adaptations mean, decreased urban agricultural production.

## 3 Materials and methods

### 3.1 Study area context

This study was conducted in the Wa Municipal, Ghana which lies between latitudes 1°40′N to 2°45′N and longitudes 9°32′ to 10°20′W of the equator with s landmass of about 234.74 km square [24]. Generally, the topography of the Wa Municipality is undulating with an average height between 160 and 300 m above sea level [37]. The temperature ranges between 40 and 45 ℃. The period between November and April does not support crop cultivation but animal

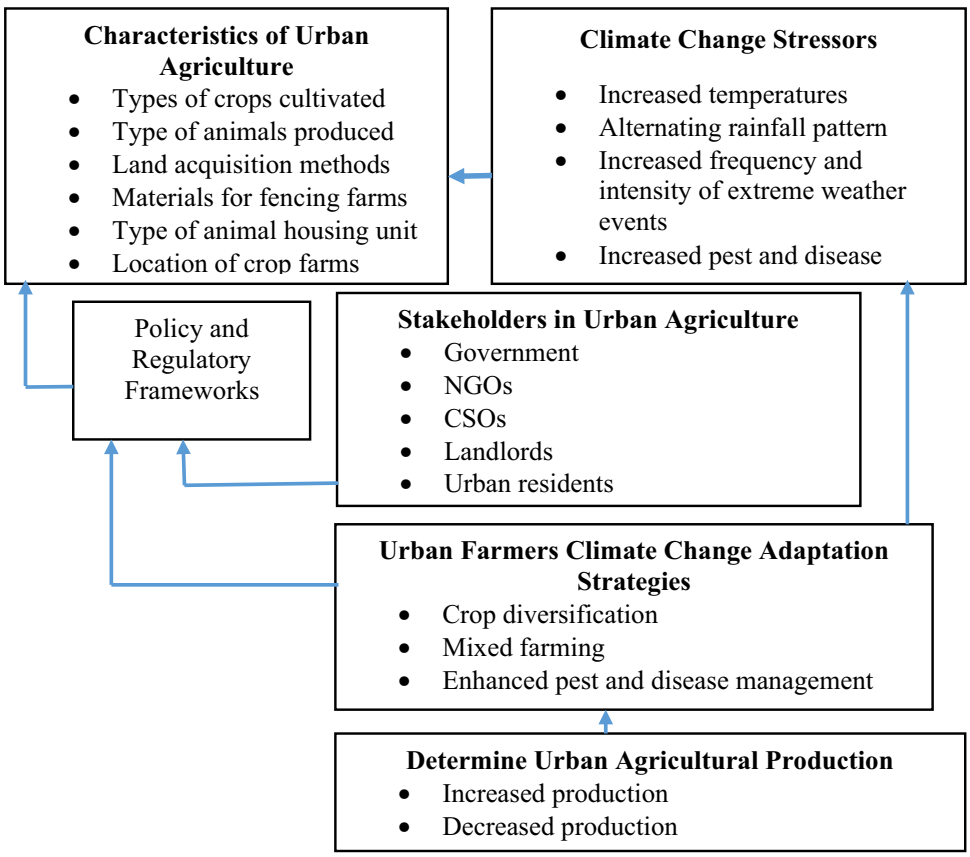


**Fig. 1** Urban Agricultural Characteristics and Climate Change Adaptation Nexus. Source: Authors Construct, 2023

rearing is common. Conversely, the harmattan season increases animal mortality [24]. The Wa Municipality has about 200,672 residents with 143,358 urban dwellers [24]. Also, out of about 70% who engage in agricultural activities, only 30.2% are direct food crops and animal producers [43].

The staple food crops in the municipality are cereals like maize (*Zea mays*), and millets (*Panicum miliaceum*) as well as legumes beans (*Phaseolus vulgari L.*), and groundnuts/cowpea (*Vigna unguiculata*). Other crops are tubers- yams (*Dioscorea alata*), cassava (*Manihot esculenta*) sweet potatoes (*Ipomoea batatas*), and vegetables Cabbage *(Brassica oleracea),* okra (*Abelmoschus esculentus*), tomatoes (*Solanu lycopersicum*), pepper (*Capsicum annuum*), pumpkin (*Cucurbita)* and garden eggs *(Solanum melongena).* Animals reared include sheep (*Ovis aries*), goats (*Capra aegagrus hircus*), cattle (*Bos taurus*), and pigs (*Sus scrofa domesticus*). Other animals also include poultry such as chicken (*Gallus gallus domesticus*), turkey (*Meleagris*), ducks (*Anatidae*), and guinea fowls (*Numididae*). Most of these animals are reared on a subsistence basis [23]. The study was conducted in the Upper West Region of Ghana, particularly Wa Township. The choice of the study area is informed by the fact that many people within the Upper West Region especially, the Wa township mainly derive their livelihood from crop and animal production [44]. Using Osumanu et al. [38] zonation of the Wa township, the study area was divided into three (3) residential zones; lower (Kanbale, Kpaguri, and Mango), middle (Sombo, Konbiehi, and Social Security and national insurance trust (SSNIT) residential area), and high classes (Naporgbakole, Nakoripaani and Bilbao residential areas) (See Fig. 2).

### 3.2 Research approach and design

This study employed mixed methods of data collection and analysis from a pragmatic philosophical point of view to understand the characteristics of urban agriculture and farmers and their relations to climate change adaptation strategies. This is meant to give a philosophical line of direction and the research debate [45]. Primary data were collected directly from the respondents (urban households and urban agriculture stakeholders). The target population of the study consists of all urban households within the Wa township, individuals, and institutions that have a role to play in urban morphology and farming activities. The study zoned the limit of the Wa township, and the households were listed.

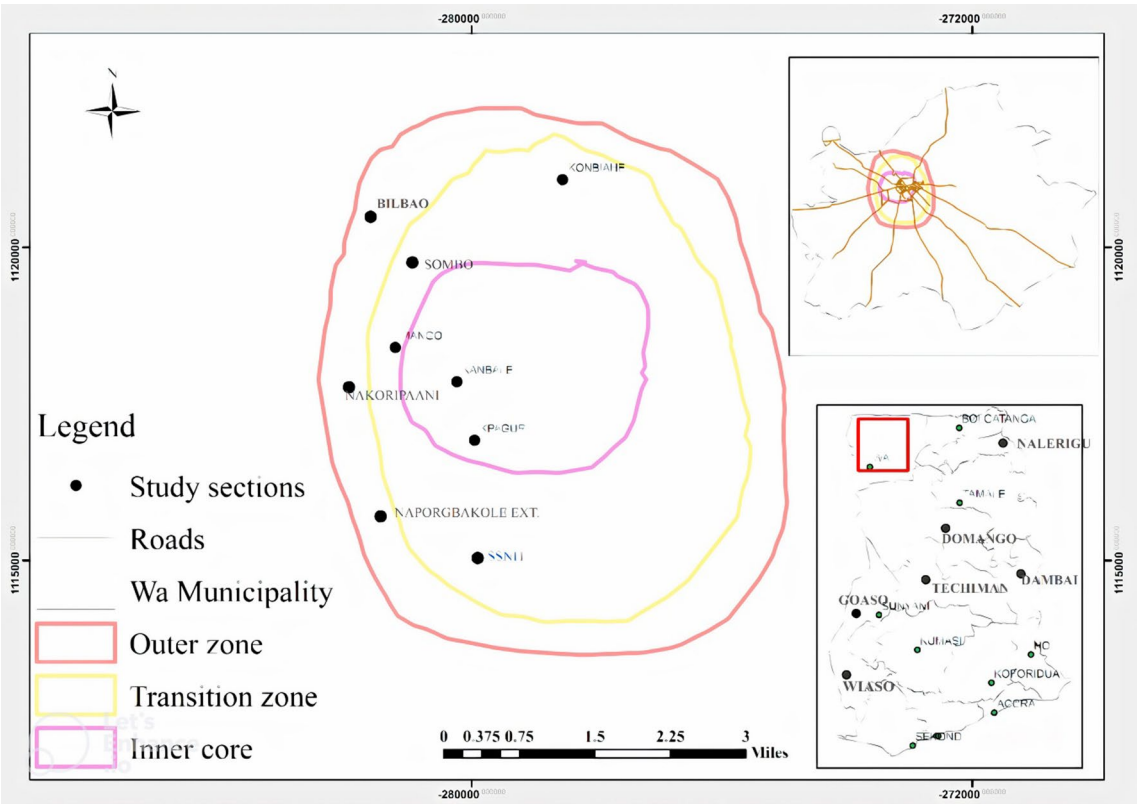


**Fig. 2** Study Area Map. Source: Author's Construct, 2022

In the listing, 1450 were obtained and a sample size of 362 was arrived at using Yamane [43:886] sample size formula which is given as;

$$n = \frac{N}{1 + N(e)2}$$

where:

n = the sample size for the study.
N = the sample population of the study.
1 = constant.
*e* = margin of error for the sample mean.
Therefore, in this study:
N = 1,450.
*e* = 95% or an error margin of 0.05 confidence level.

$$n = \frac{1,450}{1 + 1,450(0.05)2}$$

$$n = \frac{1,450}{1 + 1,450(0.00025)}$$

$$= \frac{1,450}{4} = 362.5 = 362$$

The quantitative phase collected data from urban households using a survey with a semi-structured questionnaire built on mobile phones for easy, safe, and faster enumeration of households. The quantitative data was collected between July and August 2022. In the qualitative phase, there were twelve (12) key informants interviewed at two levels; community and institutional levels. At the community level, eight (8) key informants were interviewed. They included four (4) Chiefs and four (4) '*Tindaabas'.* At the institutional level, the focus was on the Department of Town and Country Planning (2) and Officers from the Municipal Environmental Health and Sanitation Department (2). These are key individuals and institutional representatives with insight into the distribution of urban agriculture practices. The interview guide was used in the qualitative data collection. The development of the tool was informed by earlier document reviews where these key informants and their roles in urban agricultural production were ascertained. Even though the questions were formed in English Language but the actual interview was done in *"Dagaare"/"Waalee",* the common native language, and to some extent, English Language provided the respondent could understand. Non-participant observation was also employed to gain the visual evidence necessary for the study findings [47]. The qualitative data was also collected between November and December 2022. Table 1 shows the sample population and sample size. This sample size distribution was also included.

#### 3.2.1 Data analysis and ethical considerations

The quantitative data were exported to Microsoft Excel format which was exported to Statistical Package for Social Sciences (SPSS) version 20.0 for further analysis. The interviews were recorded transcribed and analyzed. The data analysis made use of descriptive statistics; frequencies, percentages, chi-square-test, and content analysis. The results are presented in the form of tables, graphs, and narratives. In terms of ethical considerations, the study data collection process went through an ethical clearance process before the fieldwork started. There was a community entry process, informed consent was sought from the respondents through the sectional leaders such as the Chiefs, '*Tindaabas*', and Assembly Members by way of an introductory letter signed by the Head of the Department of Environment and Resource Management of the SDD-UBIDS. All participants were assured of the confidentiality of the information.

**Table 1** Sample Frame and Sample Size Distribution

| Cluster | Community | Number of households | Number of households sampled |
|---|---|---|---|
| Lower class | Kanbale | 102 | 25 |
| | Kpaguri | 125 | 31 |
| | Mangu | 140 | 35 |
| | Total | 367 | 91 |
| Middle class | Sombo/Chorkor | 164 | 41 |
| | Konbiehi | 149 | 37 |
| | SSNIT | 175 | 44 |
| | Total | 488 | 122 |
| Upper class | Naporgbakole Ext | 198 | 49 |
| | Nakoripaani | 196 | 48 |
| | Bilbao/airstrip | 201 | 52 |
| | Total | 595 | 149 |
| Overall total | | 1,450 | 362 |

Source: Field Work, 2021

#### 3.2.2 Research ethics

In the study, ethical issues were handled in the following ways; First, introductory letters from the Department of Environment and Resource Management of the Simon Diedong Dombo University of Business and Integrated Development Studies (SDD-UBIDS) were distributed to the community leader and the institutions of the study. Secondly, community entry was done through the community leaders (Assembly Members, Unit Committee Chairpersons, Chiefs, and Landlords). Informed consent was taken from all participants before they took part in data collection. Participation was voluntary and all participants in the study were assured of the secrecy and confidentiality of the information.

## 4 Results

### 4.1 Type of urban agriculture and mode of land acquisition

The study underscores urban households' participation and non-participation in urban agriculture in the era of climatic stressors. Results on urban dwellers' participation in UA production in the Wa Municipality showed that of the 362 households that participated in the survey, the findings show that the majority (52.8%) of the respondents are engaged in UA. Also, many of the urban farmers are into crop production only, representing about 73.5% of the respondents while about 10.9% are into animal production alone and only 15.2% are growing crops, at the same time rearing animals (See Table 2).

Participation in urban agriculture is affected by state regulations and policies. The qualitative findings indicate that farming in the urban areas is accepted but there are several issues affecting its success. These are associated with the nature of urban design and land use planning. Urban planning in Ghana is tailored towards physical development such

**Table 2** Participation and Types of Urban Agriculture (N = 362)

| Participation | Frequency | Percent |
|---|---|---|
| Yes | 191 | 52.8 |
| No | 171 | 47.2 |
| Type of urban farming | | |
| Crop production | 141 | 73.8 |
| Animal production | 21 | 10.9 |
| Both crops and animal production | 29 | 15.2 |

Source: Field Work, 2022

as building purposes, educational and healthcare facilities, entertainment, and recreational centres, and meeting administrative purposes. Even though landowners lease lands to people irrespective of the purpose, the type of development on the land is controlled by the government machinery through the Town and Country Planning Department and the Lands Commission. This is seen in their work in terms of demarcation and leasing of lands for developmental purposes. Interestingly, landlords are of the view that they never had in mind reserving lands for farming because they consider the urban areas prohibited from farming. A landlord said:

> *…" I know that people use their uncultivated land for farming purposes in the urban areas but they later use it for the intended purpose like building. I have been assisting in the sale of lands till I became a family head. What I know is the surveyors reserving lands for parks, schools, hospitals, and roads but I never heard anything like reserving land as a farm"* … (Landlord, June 2022).

Many landlords were surprised to learn that farming around their houses in the city is possible. Another landlord had this to say:

> *"Really!!!, I have sold all my farmlands because I never knew I could farm in the city. If I were aware of this, I should have left some portions closer to my house to farm on … even though, one day my children will sell or develop on it"* (Landlord, June 2022).

Furthermore, it was clear that there have been Municipal level by-laws for managing urban farming but not yet gazetted. Urban agriculture is criminalized under the Criminal Code Act of 1960 in Ghana. That is the Criminal Procedure Code (Act 80), Sect. 300. In, the law on animal rearing talks about stray cattle including swine, sheep, and goats where animals are confiscated if the owners do not appear before 10 days. Vegetable and legume production is legal while other crops such as cereal, roots, and tubers are not legal because of security reasons. In an interview section, a respondent said:

> *The law states that rearing of animals and cropping are not supposed to be done in the urban centres but there was reconsideration with the advent of Operation Feed Yourself' in the 1970s. Another law is that stray animals on the street and in town without their owners controlling them should be rounded up by the environmental health department and the owners prosecuted* (Municipal Environmental Health and Sanitation Department, June 2022).

## 4.2 Types of animals and crops urban farmers produce

The study revealed that many types of animals are reared within the urban space. These are grouped into ruminants such as sheep, goats, and cattle, and non-ruminants like pigs. Interestingly, the majority of the urban residents raise ruminants; sheep, goats, and cattle. The majority (73.3%) of the urban households produce sheep. Again about 25.7% of the urban households rear goats and 24.3% rear cattle. However, the majority (75.7%) of urban households do not raise cattle, 74.3% do not rear goats, and 70.0% do not rear non-ruminants like pigs. Similarly, the findings hold that urban dwellers keep poultry in and around their neighbourhoods despite the recent climate change effects. A

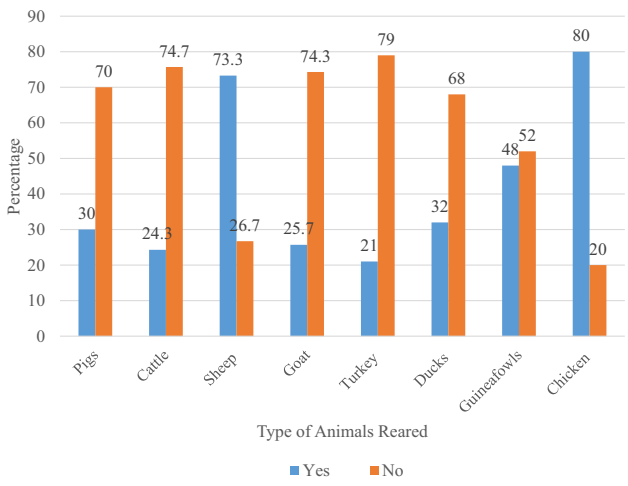


**Fig. 3** Common Types of Animals Urban Farmers Raise. Source: Field Work, 2022

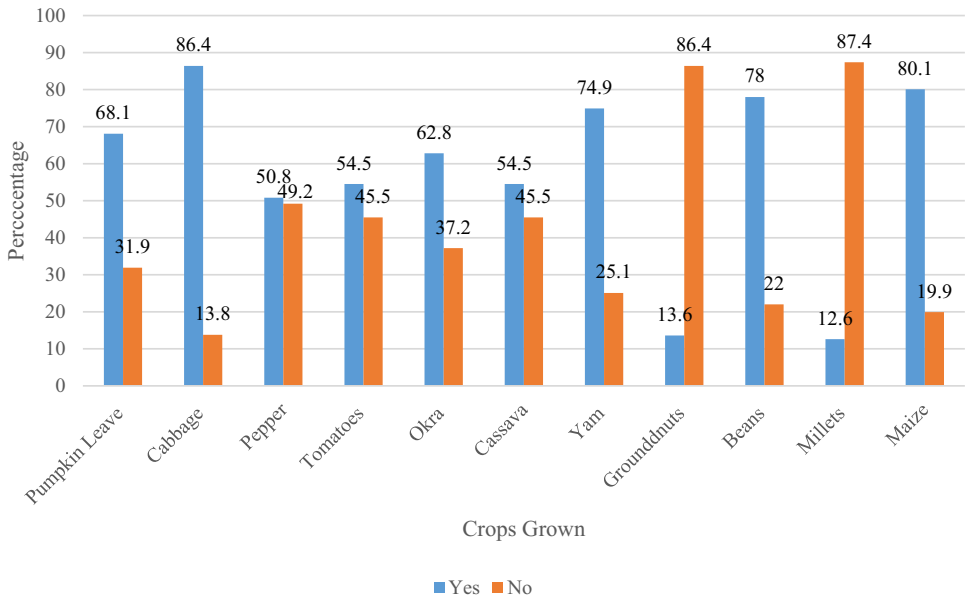


**Fig. 4** Common Types of Crops Urban Farmers Grow. Source: Field Work, 2022


**Fig. 5** An Urban Backyard Maize Farm. Source: Field Observation, 2022

total of 80.0% of Urban residents raise poultry such as chicken, 79.0% raise turkey 68.0% raise ducks and 52.0% raise guinea fowls 52% (See Fig. 3).

In examining urban households' urban farming patterns under climatic difficulties, the study further unravelled the type of crops that are commonly grown in urban neighbourhoods. The results in Fig. 4 indicate that there are different categories of crops that urban farmers cultivate namely; vegetables, roots and tubers, legumes, and cereals. Urban farmers also cultivate vegetables like cabbage which the majority of the farmers representing 86.4% grow. This is followed by the growing of pumpkin leaves byabout 68.1% of the respondents. Of the urban farmer population, those who engage in the cultivation of okra and tomatoes are about 62.8% each, and pepper 50.8%. The study findings suggest that aside from the cultivation of vegetables, urban farmers are interested in growing cereal crops such as maize representing about 80.1% of the responses. Furthermore, the results indicate that urban farmers cultivate legumes such as beans and groundnuts/cowpeas. However, the majority, representing about 78% of the responses, favoured the cultivation of beans.

The cultivation of maize is also common because millet such as the traditional varieties takes a longer time to mature and with obstructions such as climate change stressors, farmers cultivate crops that are early maturing to reduce climatic effects such as maize varieties. During field observation, many maize farms were found within the urban space (See Fig. 5).

### 4.3 Land ownership and physical characteristics of urban farms

To deepen the understanding of crops and animal production within urban settings, the study assessed land ownership and urban farm dynamics. Interestingly, the ownership regime of the urban farm plots leasing where lands are purchased represents about 53.4% of the responses (See Table 3). Of the total number of urban farmers, the majority of their crops farms are located in a fenced environment representing about 94.7% of the total responses. Wire mesh is 42.0%, the use of sticks is 32.6%, and the use of bricks or bricks is 14.0%.

The majority of urban farmers, representing about 94.7%, revealed that they house their animals with different types of structures. These animals are housed in wooden structures representing about 49.1% while that of bricks or blocks structures represents about 41.9% of the responses. Just 9.0% of urban farmers practice open space or free-range housing of animals within urban settings. During the observation, crop farmers fenced their plots with different materials such as sticks, old zinc, wooden boards, and blocks (See Fig. 6).

During field observations, it was clear that wire mesh is crucial in the fencing of urban farms. Some farmers mount sticks as poles while others use metal poles. This means that the sticks are subjected to change when they get rotten. However, the metal poles last longer because they can be used repeatedly in each farming season (See Fig. 7).

From the interviews, institutional-level data portrayed that there are Laws regarding spatial planning and zoning. For instance, the Land Use and Spatial Planning Act, of 2016 (Act 925). Furthermore, the aim of the Land Use and Spatial Planning Act, 2016 (Act 925) is to promote the sustainable development of lands and the expansion of human settlements through decentralization of the planning system. There is also the Land Act 2020 (ACT 1036) which spells out two categories of land ownership in Ghana: public and private. While the public lands are owned by the government, the

**Table 3** Ownership and Fencing of Urban Farms

| Attributes | Frequency | Percent |
|---|---|---|
| Urban farmers' land ownership | | |
| Family/relative | 61 | 32.0 |
| Purchased | 102 | 53.4 |
| Gift | 10 | 5.2 |
| Rented | 16 | 8.3 |
| Others | 2 | 1.1 |
| Total | 191 | 100.0 |
| Fencing | | |
| Yes | 184 | 96.3 |
| No | 7 | 3.7 |
| Total | 191 | 100.0 |
| Materials in fencing urban farms for crop production | | |
| Block/bricks | 26 | 14.0 |
| Wire mesh | 77 | 42.0 |
| Sticks | 60 | 32.6 |
| Guinea corn stocks | 10 | 5.4 |
| Others | 11 | 6.0 |
| Total | 184 | 100.0 |
| The housing of animals in urban farming | | |
| Yes | 181 | 94.7 |
| No | 10 | 5.3 |
| Total | 191 | 100.0 |
| Housing unit for animals | | |
| Bricks/blocks | 76 | 41.9 |
| Wooden structure | 89 | 49.1 |
| Open space | 16 | 9 |
| Total | 181 | 100.0 |

Source: Field Work, 2022

**Fig. 6** An Urban Crop Farm Fenced with Different Types of Materials. Source: Field Observation, 2022

**Fig. 7** An Urban Crop Farm Fenced with Wire Mesh. Source: Field Observation, 2022

private are owned by individuals or groups. These laws are decentralized to the Metropolitan, Municipal, and District Assemblies (MMDAs) to implement by giving permits to developmental establishments. A respondent for the Town and Country Planning Department explained the land use planning and urban agriculture this way;

> *Even though there are central laws regarding land use planning in Ghana there is no portion with clarity on urban agricultural production. For urban agriculture to be part of our national laws, then it should be within the area of land use planning for special purposes. Mostly the implementation of these spatial planning laws is decentralized to the Metropolitan, Municipal, and District Assemblies (MMDAs) to implement (Town and Country Planning Department, June 2022).*

The study further analyzed the significant level of the type of urban farming that takes place among the different residential classes (high, medium, and lower) within the urban neighbourhood. Crop cultivation is done across both residential classes with differences in the number of farmers per class but very common among the medium class (31.9%), high-class residential class (29.3%), and low class (12.6%) (See Table 4). These results are not statistically significant at alpha 0.05 (p-value = 0.348 > 0.05). Therefore, the results showed a weak relationship between the type of urban farming and the residential class within cities (Cramer's V = 0.108 > 0.05).

Land acquisition is critical in urban farming. Therefore, the study again measured the statistical association between the residential classes and the mode of land acquisition. Although urban farming takes place in all the residential classes, the mode of land acquisition is through purchase. This is represented by about 25.1% in the

**Table 4** The Significant Level of Urban Farming Type and Land Acquisition by Residential Class

| Residential class | Type of urban farming | | | Total |
|---|---|---|---|---|
| | Crop | Animal | Both crop and animal | |
| High class | 56 (29.3%) | 13 (6.8%) | 12 (6.3%) | 81 (42.4%) |
| Medium class | 61 (31.9%) | 7 (3.7%) | 13 (6.8%) | 81 (42.4%) |
| Lower class | 24 (12.6%) | 1 (0.5%) | 4 (2.1%) | 29 (15.2%) |
| Total | 141 (73.8%) | 21 (11.0%) | 29 (15.2%) | 191 (100.) |

$N = 191, x^2 = 4.455, df = 4, p = 0.348 and \text{Cramer}^{'}\text{sV} = 0.108$

| Residential class | Land tenure arrangement | | | | | Total |
|---|---|---|---|---|---|---|
| | Family/Relatives | Purchased | Gift | Rented | Others | |
| High class | 30 (15.7%) | 45 (23.6%) | 4 (2.1%) | 2 (1.0%) | 0 (0.0%) | 81 (42.4%) |
| Medium class | 22 (11.5%) | 48 (25.1%) | 5 (2.6%) | 6 (3.1%) | 0 (0.0%) | 81 (42.4%) |
| Lower class | 9 (4.7%) | 9 (4.7%) | 1 (0.5%) | 8 (4.2%) | 2 (1.0%) | 29 (15.2%) |
| Total | 102 (53.4%) | 61 (31.9%) | 10 (5.2%) | 16 (8.4%) | 2 (1.0%) | 191 (100.0%) |

$N = 191, x^2 = 32.292, df = 8, p = 0.001 and \text{Cramer}^{'}\text{sV} = 0.291$

Cramer's V > 0.25, very strong relationship; Cramer's V > 0.15, strong relationship; Cramer's V > 0.10, moderate relationship; Cramer's V > 0.05, weak relationship and Cramer's V > 0, no or very weak relationship

p-value < 0.05, statistically significant; p-value > 0.05, statistically insignificant

Source: Field Work, 2022

medium class and about 23.6% in the high-class areas. However, in the low-class areas, the mode of acquisition is either through the family or relatives. This represents about 4.7% (See Table 5). The mode of land acquisition defines the types of crops and animals farmers produce.

The cultivation of different types of crops is associated with the residential class a farmer resides in. It was ascertained that about 38.9% cultivate beans in high-class areas, and 39% and 37% do not cultivate maize in medium and high-class areas. Again, in terms of vegetable production like cabbage, about 29.9 and 28.2% of urban farmers cultivate this crop in medium and high-class residential areas (*See* Table 5). The results were explicit on crop types such as legumes (beans), cereals (maize), and vegetables (cabbage) to be statistically significant at alpha 0.05 (p-values = 0.001, 0.001, and 0.001 < 0.05) respectively. Hence, there is a relationship between the type of crop an urban farmer cultivates and the residential class the farmer lives in. The study shows that beans, maize, and cabbage have a strong relationship with the type of residential class (Cramer's V = 0.161, 0.166, and 0.175 < 0.10) respectively. Interestingly, the results showed that about 35.3 and 33.3% of urban farmers produce chicken in the high and medium classes. Sheep production is said to be within some high-class areas, representing about 33.2% of the urban farmers who are into chicken production. This result indicates a statistically significant (p-value = 0.004 and 0.008 < 0.05) in that order.

## 5 Discussions

This study focuses on the nature and characterization of urban agricultural production and how these enforce urban farmers' climate change adaptation strategies. Urban agriculture is characterised by both crop and animal production where different crops and animals are produced as climate change adaptation strategies. The land acquisition is purchasing. Predominantly urban farms are located near farmers' compounds and are fenced with materials to cater for pest destructions.

**Table 5** The Significant Level of Urban Crop and Animals Types Class

| Type of crop cultivated | | Residential class | | | |
|---|---|---|---|---|---|
| | | High | Medium | Lower | Total |
| Beans | Yes | 58 (38.9%) | 64 (17.7%) | 27 (7.5%) | 149 (87.6%) |
| | No | 10 (47.6) | 10 (2.8%) | 1 (0.3%) | 21 (12.4%) |
| | Total | 68 (20.1%) | 74 (20.5%) | 28 (7.8%) | 170 (100.0%) |
| $N = 170, x^2 = 20.034, df = 4, p = 0.001 and \text{Cramer}'\text{sV} = 0.166$ | | | | | |
| Maize | Yes | 5 (3.0%) | 6 (3.6%) | 6 (3.6%) | 17 (10.2%) |
| | No | 63 (37.0%) | 68 (39.9%) | 22 (12.8%) | 153 (89.7%) |
| | Total | 68(40.0%) | 74 (43.5%) | 28 (16.4%) | 170 (100.0%) |
| $N = 170, x^2 = 22.216, df = 4, p = 0.001 and \text{Cramer}'\text{sV} = 0.175$ | | | | | |
| Cabbage | Yes | 67 (28.2%) | 71 (29.9%) | 27 (11.3%) | 165 (69.4%) |
| | No | 1 (6.12%) | 3 (18.3) | 1 (6.12%) | 5 (30.6%) |
| | Total | 68 (34.3%) | 186 (48.2%) | 70 (17.5%) | 170 (100.0%) |
| $N = 170, x^2 = 18.792, df = 4, p = 0.001 and \text{Cramer}'\text{sV} = 0.161$ | | | | | |
| Type of animals | | | | | |
| Chicken | Yes | 18 (35.3%) | 17 (33.3%) | 5 (9.9%) | 14 (27.4%) |
| | No | 6 (11.7%) | 3 (5.8%) | 2 (3.9%) | 37 (72.6%) |
| | Total | 24(49.0%) | 20 (39.1%) | 7 (13.8%) | 51 (100.0%) |
| $N = 51, x^2 = 15.213, df = 4, p = 0.004 and \text{Cramer}'\text{sV} = 0.145$ | | | | | |
| Sheep | Yes | 17 (33.2%) | 8 (15.6%) | 4 (7.8%) | 29 (56.8%) |
| | No | 7 (13.9%) | 12 (23.5%) | 3 (0.8%) | 22 (43.2%) |
| | Total | 24 (47.1%) | 20 (39.1%) | 7 (8.6%) | 51 (100.0%) |
| $N = 51, x^2 = 13.922, df = 4, p = 0.008 and \text{Cramer}'\text{sV} = 0.139$ | | | | | |

Cramer's V > 0.25, very strong relationship; Cramer's V > 0.15, strong relationship; Cramer's V > 0.10, moderate relationship; Cramer's V > 0.05, weak relationship and Cramer's V > 0, no or very weak relationship

p-value < 0.05, statistically significant; p-value > 0.05, statistically insignificant

Source: Field Work, 2022

### 5.1 Type of urban agriculture and mode of land acquisition

There are urban production activities taking place in the urban area which are in three categories; crop producers, animal producers, and those who are into both crops and animal production. This trend revealed that it is easier to produce crops within the urban space than animals in the era of climate change. Animal rearing is quite difficult since they destroy other people's property. In some situations, categories of animals are religiously unacceptable aside from the cost of production. In northern Ghana, farmers' choices and preferences in livestock farming are influenced by factors such as species, lifespan, housing system, stocking density, and production system [48]. This means that despite the increasing climate change effects on agriculture, urban residents are interested in producing within any available space. This can be attributed to the limited space to be used for both crops and animal production within cities, unlike the rural settings with vast land. This finding confirms the claim of Pham and Turner [42] and FAO [8] who asserted that urban farming is aligned with the production of either crops, animals, or both in an urban neighbourhood. This does not support the findings of Alimba et al. [7] and Wilson [43] that in improving urban food systems, the focus should be higher on the processing and supply value chain than the direct production. This is associated with the fact that the prevailing climatic conditions do not favour animal production within the urban space because they are vulnerable to bad weather. For instance, poultry production is not effective under excessive heat and rain, however, most crops are vulnerable under excessive heat and rain [44, 46]. Even though the possibility of urban farm sizes being small is higher, however, intensification of agricultural practices gives urban farmers opportunities in production [43].

Even though animal rearing in the city meets socio-economic significance the act causes sanitation issues as it makes the surroundings untidy [50] apart from challenges emanating from thefts. Farmers in the urban area who are

into the production of both crops and animals are better off adapting to climate change than those who are not. This corroborates the findings that agricultural diversification is a way of tackling the negative consequences of weather [18]. Climatic stressors such as the outbreak of tropical animal diseases, flooding, and drought affect agricultural production and cannot be precluded in climate change and agriculture discourse [47]. This supports the idea that farmers produce animals that are easy to handle under the current weather pattern of the area pointing to the fact that understanding farmers' perspectives is crucial for the successful implementation of improved urban livestock production under the prevailing climatic situations [55]. In terms of crop production characteristics, vegetable cultivation is predominant in the urban environment because farmers do not need large plots for it. The cultivation of many types of crops points to the diversification of crop production to survive even under the negative effects of climate change as crop resiliency increases [56]. To buttress the above point, the subsistence nature of urban vegetable production means that urban households could rely on minor irrigation from households' water in the absence of rainfall due to climate change. This confirms the argument that most urban dwellers' choice of crop is more on the cultivation of vegetables to meet the nutritional needs of the population [36]. However, Mackay's [35] findings do not corroborate the emphasis that urban vegetable producers are targeting the urban market.

Urban farming remains illegal according to the study and agriculture producers within the urban space are liable to punishment under the Criminal Procedure Code (Act 80). This punishment is in the form of fines. This confirms the claim that animals found in selected urban centres in Ghana shall be confiscated and a fine of GHS 2,00.00 per head shall be paid to the Accountant-General [49]. The owners either pay a fine or forfeit the animals when they come after ten (10) days of confiscation [49]. Again, some bylaws are formulated and implemented by the Municipal Assembly. This confirms that city authorities in Africa formulate and implement bye-laws that ban urban farming Meenar et al. [50] particularly animal rearing which has moved from extensive grazing to semi-intensive zero grazing [57]. Drawing from the above findings, it is clear that urban crop and animal production are not strengthening stakeholders to increase farmers' capacity and willingness to participate in producing any type of crops and animals of their choice. This suggests that urban farming is not on the developmental agenda of city authorities [25]. Farmers are restricted by the type of crops and animals to produce because it is illegal. The fear of appearing before authorities to answer questions serves as a disincentive for urban crop and animal production. Crops such as vegetables and legumes and animals like sheep, goats, poultry, and pigs are allowed to be produced within urban neighbourhood because these crops complement the food needs of the urban population. However, animal production under the intensive system is encouraged because sanitation-related challenges resulting from farm animals will be reduced.

### 5.2 Locations, land ownership, and physical characteristics of urban farms

The location of urban farms and land acquisition mode is done by stakeholders. Land ownership is largely at the individual and family levels. Land tenure security plays a crucial role in attracting investments to urban agriculture within African cities as insecure land tenure hinders the development of urban agriculture and limits the potential for investment and growth [58]. Animals are housed in urban farming. This means that urban farmers use intensive farming systems in raising animals within urban settings. This has some climate change implications because animals are not exposed to disease-infested environments due to the changing climatic effects [50]. This means that the associated high temperatures resulting from climate change affect animal production when only an intensive system is practiced by urban farmers [44]. However, this does not support the findings of the work of Ferreira et al. [51] that an intensive farming system is ideal for animal production. The reasons for fencing a farm include managing stock breeding, preventing stock from straying, improving property appearance, promoting successful vegetation growth, and controlling disease outbreaks among livestock [52, 53]. The study does not support the finding of Osman et al. [54] that the rearing of small ruminants such as goats and sheep is not regulated by urban farmers. There are laws on urban zoning and planning in Ghana, but these laws do not integrate urban agriculture into land use planning and zoning [56]. This affects accessing space for urban agricultural production. The implication is that although urban farming has no place in zoning in Ghana, there is the opportunity to place urban planning under the special development component of the zoning regulations [35, 56]. This will pave the way for land allocations to urban agriculture be it private or government land. This can be initiated by using undeveloped government lands that could support urban food production within the urban neighbourhoods.

In terms of conceptual reflection, urban agricultural production is a multifaceted phenomenon influenced by a myriad of factors ranging from spatial dynamics to socio-cultural contexts. Reflecting on the characteristics of urban agricultural production provides insights into the complexities and opportunities that arise within this dynamic field. A conceptual reflection on the characteristics of urban agricultural production reveals a dynamic and interconnected system. It

highlights the need for a holistic approach that considers spatial, ecological, technological, and socio-cultural dimensions. The diversity of crops cultivated in urban areas highlights the adaptability of urban farmers to local climates and consumer demands. Urban agriculture goes beyond traditional crops, incorporating a rich variety of fruits, vegetables, and herbs. This diversity not only contributes to food security but also promotes a more balanced and nutritious urban diet. Integrating livestock into urban farming systems underscores the holistic approach to sustainable agriculture. Chickens, goats, and other small animals play a crucial role in waste management, pest control, and providing additional sources of nutrition. This characteristic reflects a shift towards more integrated and circular urban farming systems. Understanding and appreciating these characteristics can inform policy-making, foster sustainable practices, and contribute to the resilience and vibrancy of urban agricultural systems.

## 6 Conclusions and policy recommendations

The study explored the characteristics of urban crop and livestock production and how it contributes to climate change adaptation strategies among urban farmers. To a large extent, agricultural production drives the climate change adaptation strategies of urban farmers. This is reflected in the adoption of mixed farming, which is predominated by crop diversification to buffer against total production failure. Farmers cultivate legumes, vegetables, cereals, and livestock. However, urban farmers' crop and livestock production is done around undeveloped lands at their homes in the form of gardens fenced with different materials. To improve urban agricultural production under climate uncertainty, we advocate for the integration of urban agriculture into national-level agricultural and urban planning policies to harness the full potential embedded in them at the municipal level. This study is limited on the grounds of stakeholders' analysis and collaboration in the promotion of urban agriculture. This could give insight into understanding the current nature and classification of urban agricultural production.

**Acknowledgements** The study acknowledges Endogenous Development Services (EDS) Ghana for providing office space for this work and all the Associates of EDS Ghana, particularly Dr. Issah Baddianaah. Also, we acknowledge the contributions of the following individuals and Institutions during the field work, Mr. Abu Inusah, Mr. Crispin Kanaata Dankana, Mr. Richard B. Bapuurintiere, Mrs. Janet B. Yelfaare, Mr. Alex Tieronwie and Mr. Edward Kandolnyuo. Again, appreciation goes to the Crop and Animals Departments of the Ministry of Food and Agriculture (MoFA), Upper West Region especially Mr. Saeed, the Upper West Regional Town and Country Planning Department. The editorial services from ALHAJI Ibrahim Kwabena ANTWI, Former University Liberian, University for Development Studies, Tamale are acknowledged.

**Author contributions** All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Godwin K. Naazie, Isaac Agyemang, and Anthony M. Tampah-Naah. The first draft of the manuscript was written by Godwin K. Naazie and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

**Funding** No funding was received for conducting this study.

**Data availability** The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

**Code availability** The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

## Declarations

**Ethics approval** No approval of research ethics committees was required to accomplish the goals of this study because no experimental work was conducted with invertebrate species.

**Informed consent** Informed consent was obtained from all individual participants for whom identifying information is included in this article.

**Consent to publish** The participant has consented to the submission of the case report to the journal.

**Competing interests** There is no competing interest among the Authors of this paper.

## References


1. Acharya G, Cassou E, Jaffee S, Ludher EK. RICH food, smart city. RICH Food Smart City. 2021. https://doi.org/10.1596/35137.
2. NM Aliman, L Kester. Epistemic defenses against scientific and empirical adversarial AI attacks. CEUR Workshop Proc. 2021;2916
3. Korbéogo G. Ordering urban agriculture: farmers, experts, the state and the collective management of resources in Ouagadougou, Burkina Faso. Environ Urban. 2018;30(1):283–300. https://doi.org/10.1177/0956247817738201.
4. Khan R, Aziz Z, Ahmed V. Building integrated agriculture information modeling (BIAIM): an integrated approach towards urban agriculture. Sustain Cities Soc. 2018;37:594–607. https://doi.org/10.1016/j.scs.2017.10.027.
5. Ayerakwa HM, Dzanku FM, Sarpong DB. The geography of agriculture participation and food security in a small and a medium-sized city in Ghana. Agric Food Econ. 2020. https://doi.org/10.1186/s40100-020-00155-3.
6. M. Taguchi, G. Santini. Agriculture in the Global Perspective. 2019.
7. JO Alimba, CC Olumba, CN Onunka. Assessing How Food Production in Urban Areas Contribute To Household Food Security in Southeast Nigeria Assessing How Food Production in Urban Areas Contribute To Household Food Security in Southeast Nigeria. no. February, 2020.
8. FAO. Cities and Local Government at the Forefront in Building Inclusive and Resilient Food Systems. Rome. 2020.
9. Davies J, et al. Barriers to urban agriculture in Sub-Saharan Africa. Food Policy. 2020;2050:101999. https://doi.org/10.1016/j.foodpol.2020.101999.
10. Mutambisi T, Chirisa I. Environmental resilience food and the city—Zimbabwe. Singapore: Springer; 2022.
11. Giordano A. Sub-Saharan agriculture and migrations. J Agric Environ Int Dev (JAEID). 2018;112(1):185–237. https://doi.org/10.1289/jaeid.20181.781.
12. Azunre GA, Amponsah O, Peprah C, Takyi SA. A review of the role of urban agriculture in the sustainable city discourse. Cities. 2019;93(April):104–19. https://doi.org/10.1016/j.cities.2019.04.006.
13. Ziem Bonye S, Yiridomoh GY, Derbile KE. Urban expansion and agricultural land use change in Ghana: implications for peri-urban farmer household food security in Wa municipality. Int J Urban Sustain Dev. 2021;13(2):383–99. https://doi.org/10.1080/19463138.2021.1915790.
14. Akoto-Danso EK, et al. Agronomic effects of biochar and wastewater irrigation in urban crop production of Tamale, northern Ghana. Nutr Cycl Agroecosyst. 2019;115(2):231–47. https://doi.org/10.1007/s10705-018-9926-6.
15. IPCC. Global warming of 1.5°C an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change. Companion Appl Ethics. 2018. https://doi.org/10.1002/9780470996621.ch50.
16. Hallegatte S, Rentschler J, Rentschler J. The adaptation principles a guide for designing strategies for climate change adaptation and resilience. Washington DC: World Bank; 2020.
17. Serrano JO, et al. Euclidean distance: integrated criteria to study sheep behaviour under heat stress. Not Sci Biol. 2021;13(1):1–8. https://doi.org/10.15835/nsb13110859.
18. Shah A, et al. PGPR in agriculture: a sustainable approach to increasing climate change resilience. Front Sustain Food Syst. 2021;5(July):1–22. https://doi.org/10.3389/fsufs.2021.667546.
19. Mwinkom FXK, Damnyag L, Abugre S, Alhassan SI. Factors influencing climate change adaptation strategies in North-Western Ghana: evidence of farmers in the Black Volta Basin in Upper West region. SN Appl Sci. 2021;3(5):1–20. https://doi.org/10.1007/s42452-021-04503-w.
20. Ali DA, Deininger K, Mahofa G, Nyakulama R. Land use policy sustaining land registration benefits by addressing the challenges of reversion to informality in Rwanda. Land Use Policy. 2019. https://doi.org/10.1016/j.landusepol.2019.104317.
21. Abdulai IA. Rearing livestock on the edge of secondary cities: examining small ruminant production on the fringes of Wa, Ghana. Heliyon. 2022;8(4):e09347. https://doi.org/10.1016/j.heliyon.2022.e09347.
22. Fang C, Yu D. Urban agglomeration: an evolving concept of an emerging phenomenon. Landsc Urban Plan. 2017;162:126–36. https://doi.org/10.1016/j.landurbplan.2017.02.014.
23. H. Ritchie and M. Roser. Urbanization. 2019;
24. Ghana Statistical Service. Ghana 2021 Population and Housing Census General Report. 2021.
25. Poulsen MN, Neff RA, Winch PJ. The multifunctionality of urban farming: perceived benefits for neighbourhood improvement. Local Environ. 2017;22(11):1411–27. https://doi.org/10.1080/13549839.2017.1357686.
26. Mack EA, Tong D, Credit K. Gardening in the desert: a spatial optimization approach to locating gardens in rapidly expanding urban environments. Int J Health Geogr. 2017;16(1):1–16. https://doi.org/10.1186/s12942-017-0110-z.
27. Al-Kofahi SD, Gharaibeh AA, Bsoul EY, Othman YA, St Hilaire R. Investigating domestic gardens' densities, spatial distribution and types among city districts. Urban Ecosyst. 2019;22(3):567–81. https://doi.org/10.1007/s11252-019-0833-7.
28. Kirsch KR, Newman GD, Zhu R, McDonald TJ, Xu X, Horney JA. Applying and integrating urban contamination factors into community garden siting. J Geovisualization Spat Anal. 2022;6(2):2022. https://doi.org/10.1007/s41651-022-00129-7.
29. Lal R. Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. Food Secur. 2020;12(4):871–6. https://doi.org/10.1007/s12571-020-01058-3.
30. Tapia C, Randall L, Wang S, Aguiar Borges L. Monitoring the contribution of urban agriculture to urban sustainability: an indicator-based framework. Sustain Cities Soc. 2021;74:103130. https://doi.org/10.1016/j.scs.2021.103130.
31. Sroka W, et al. Understanding residents' acceptance of professional urban and peri-urban farming: a socio-economic study in polish metropolitan areas. Land Use Policy. 2021. https://doi.org/10.1016/j.landusepol.2021.105599.
32. Prayitno G, Dinanti D, Hidayana II, Nugraha AT. Place attachment and agricultural land conversion for sustainable agriculture in Indonesia. Heliyon. 2021;7(7):e07546. https://doi.org/10.1016/j.heliyon.2021.e07546.
33. Shackleton CM, Cilliers SS, Davoren E, Du MJ. Urban ecology in the global south. Cham: Springer International Publishing; 2021.
34. Contesse M, van Vliet BJM, Lenhart J. Is urban agriculture urban green space? A comparison of policy arrangements for urban green space and urban agriculture in Santiago de Chile. Land Use Policy. 2018;71(October):566–77. https://doi.org/10.1016/j.landusepol.2017.11.006.

35. A Allen, A Apsan Frediani, M Wood Hill. Land and planning for urban agriculture in Accra: Sustained urban agriculture or sustainable urbanisation?. Irrig urban Veg Prod Ghana Charact Benefits Risk Mitig. 2014;pp. 161–179. http://www.iwmi.cgiar.org/Publications/Books/PDF/irrigated_urban_vegetable_production_in_ghana-chapter-13.pdf
36. Mackay H. Mapping and characterising the urban agricultural landscape of two intermediate-sized Ghanaian cities. Land Use Policy. 2018;70:182–97. https://doi.org/10.1016/j.landusepol.2017.10.031.
37. Wulandari E, Karyani Ernah T, Alamsyah RTP. What makes farmers record farm financial transactions? Empirical evidence from potato farmers in Indonesia. Int J Financ Stud. 2023. https://doi.org/10.3390/ijfs11010019.
38. Nkrumah A. Immigrants' transnational entrepreneurial activities: the case of Ghanaian immigrants in Canada. J Int Migr Integr. 2018;19(1):195–211. https://doi.org/10.1007/s12134-017-0535-z.
39. Langemeyer J, Madrid-Lopez C, Mendoza Beltran A, Villalba Mendez G. Urban agriculture—a necessary pathway towards urban resilience and global sustainability? Landsc Urban Plan. 2021;210:104055. https://doi.org/10.1016/j.landurbplan.2021.104055.
40. Hanna C, Wallace P. Planning the urban foodscape: policy and regulation of urban agriculture in Aotearoa New Zealand. Kotuitui. 2022;17(3):313–35. https://doi.org/10.1080/1177083X.2021.1996403.
41. Fanfani D, Du B, Mancino M, Rovai M. Multiple evaluation of urban and peri-urban agriculture and its relation to spatial planning: the case of Prato territory (Italy). Sustain Cities Soc. 2022. https://doi.org/10.1016/j.scs.2021.103636.
42. Wa Municipal Assembly. Municipal composite budget for 2021–2024. Wa, 2021.
43. B. Adolph et al. through Serious Gaming. 2023.
44. Osumanu IK, Akongbangre JN, Tuu GNY, Owusu-Sekyere E. From patches of villages to a municipality: time, space, and expansion of Wa, Ghana. Urban Forum. 2019;30(1):57–74. https://doi.org/10.1007/s12132-018-9341-8.
45. Fijn LB, van der Josef Staay F, Goerlich-Jansson VC, Arndt SS. Importance of basic research on the causes of feather pecking in relation to welfare. Animals. 2020;10(2):1–14. https://doi.org/10.3390/ani10020213.
46. T. Yamane, Statistics, An Introductory Analysis, 2nd Editio. New York: Harper and Row, New York, Evanston and London and John Weatherhill, Inc., Tokyo, 1967.
47. Anton IA. An overview of qualitative research methodology for public health researchers. Int J Med Public Heal. 2014;4(4):318. https://doi.org/10.4103/2230-8598.144055.
48. Alhassan SI, Shaibu MT, Kuwornu JKM, Damba OT. Factors influencing farmers' awareness and choice of indigenous practices in adapting to climate change and variability in Northern Ghana. West African J Appl Ecol. 2018;26:1–13.
49. Kumar M, Ratwan P, Dahiya SP, Nehra AK. Climate change and heat stress: impact on production, reproduction and growth performance of poultry and its mitigation using genetic strategies. J Therm Biol. 2021;97:102867. https://doi.org/10.1016/j.jtherbio.2021.102867.
50. IA Abdulai, A Dongzagla, A Ahmed. Urban livestock rearing and the paradox of sustainable cities and urban governance in West Africa: Empirical evidence from Wa, Ghana. no. xxxx, pp. 1–11, 2020.
51. IPCC. Synthesis Report of the IPCC Sixth Assessment Report (AR6). 2018. https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:32016R0679&from=PT%0Ahttp://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012PC0011:pt:NOT
52. Kumar G, Engle C, Tucker C. Factors driving aquaculture technology adoption. J World Aquac Soc. 2018;49(3):447–76. https://doi.org/10.1111/jwas.12514.
53. Kibona CA, Yuejie Z. Factors that influence market participation among traditional beef cattle farmers in the Meatu district of Simiyu Region, Tanzania. PLoS ONE. 2021;16(4):1–14. https://doi.org/10.1371/journal.pone.0248576.
54. Alemneh T, Getabalem M. Beef cattle production systems, marketing and constraints in Ethiopia. J Mark Consum Res. 2017;32(1):1–7. https://doi.org/10.19080/JOJPH.2019.05.555651.
55. Balzani A, Hanlon A. Factors that influence farmers' views on farm animal welfare: a semi-systematic review and thematic analysis. Animals. 2020;10(9):1–25. https://doi.org/10.3390/ani10091524.
56. Rukhsana L, Kumar S. Crop diversification: an adaptive option for climate change resilience in West Bengal. Clim Chang Agric Soc. 2017. https://doi.org/10.1007/978-3-031-28251-5_10.
57. Ahmed S, Dávila JD, Allen A, Haklay M, Tacoli C, Fèvre EM. Does urbanization make emergence of zoonosis more likely? Evidence, myths and gaps. Environ Urban. 2019;31(2):443–60. https://doi.org/10.1177/0956247819866124.
58. Duvernoy I, Zambon I, Sateriano A, Salvati L. Pictures from the other side of the fringe: urban growth and peri-urban agriculture in a post-industrial city (Toulouse, France). J Rural Stud. 2017;57:25–35. https://doi.org/10.1016/j.jrurstud.2017.10.007.