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ORIGINAL ARTICLE

Urbanization effects on urban vegetable farmers adaptation: Evidence from Ghana

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Abstract

This study argues that urban change and urban agriculture are linked and this relationship affects urban farmers. This causes urban farmers to adapt to the urban change and, in this study, within the Greater Accra Metropolitan Area (GAMA). This is because urban agriculture serves as a source of livelihood for urban dwellers and a source of vital food ingredients which helps address food security concerns in the city. This study employs an exploratory sequential mixed method to investigate this phenomenon, which first uses a qualitative methodology and then quantitative methodology to investigate the changes that have occurred within the GAMA and how the farmers are adapting to these changes. A heterogeneous sampling aproach was used to select a total of 29 farmers from 10 farm sites for the qualitative data, while a multistage sampling approach was used to select 251 farmers from 16 farm sites for the quantitative data. The changes within the urban space realized by farmers include climate, land scarcity, increased population, and lifestyle dynamics. The population increase and lifestyle change, for instance, increased demand for vegetables and land scarcity caused farmers to move to secured lands, which led to farmers enjoying security on those lands. However, increased population, for instance, led to more unplanned settlements, which negatively resulted in polluted streams for farming. It also led to land scarcity that has resulted in the eviction of farmers from their farmlands. In adapting to some of the effects of these changes, farmers used several water sources to reduce their dependence on the polluted streams and embarked on intensification and relocated to cheap and cost-free lands to be able to manage the land scarcity challenge. All these adaptation strategies prove farmers' resilience to the intense urban changes, which affect their farming activities. This calls for a specialized and focused support for urban agriculture by stakeholders responsible for the promotion of urban agriculture.

Abbreviations: GAMA, Greater Accra Metropolitan Area; OLS, Ordinary Least quares; PCA, Principal Component Analysis; UA, Urban Agriculture.

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1 | INTRODUCTION

The space urban agriculture (UA) operates in is largely dynamic and goes through rapid changes (Hassan & Nazem, 2016; Masters et al., 2013; Satterthwaite et al., 2010; Smit et al., 2001). Among the drivers of urban change are population growth (Deshmukh, 2015; Hassan & Nazem, 2016; Satterthwaite et al., 2010; United Nations, 2009; van Ginkel, 2008), other socioeconomic, political, administrative, and cultural factors (Apostolopoulou & Adams, 2019; Early et al., 2015; Satterthwaite et al., 2010; van Ginkel, 2008). Urban change is characterized by an increase in industrial and residential buildings, road networks (Cobbinah et al., 2015), change in urban lifestyle, and exhibition of neoliberal and globalization ideals (Cockx et al., 2018; Food and Agriculture Organization [FAO], 2012; Hubacek et al., 2009; Sassen, 2012; Satterthwaite et al., 2010; Surya, 2016; van Ginkel, 2008). Urban change depicts climate change, increased competition in land use, change in labor market dynamics, improved production technologies, and change in resource use in general (Arfanuzzaman & Atiq Rahman, 2017; Early et al., 2015; Revi et al., 2014; UN-Habitat, 2014; Zhang & Xu, 2017).

These changes directly and indirectly affect UA since they partly determine the resource use in UA production (Arku et al., 2012; Satterthwaite et al., 2010; van Veenhuizen, 2006). The Greater Accra Metropolitan Area (GAMA), which is the largest metropolitan area in Ghana, gives a clear example of the socioeconomic transformation that has characterized Ghana's urban change. Over the past 30 years, population growth, which has increased the coverage of land use, in Ghana has been a clear feature of GAMA's urban transformation (European Space Agency, 2020; Ampim et al., 2021; UN-Habitat, 2012).

Studies on Ghana's UA have been extensive. These include urban farm land use, challenges and contestations within the urban space and how it has affected urban farmers land security (Allen et al., 2014), the urban vegetable farm sites, the farming systems employed and the prevailing land tenure systems (Danso, Drechsel et al., 2014), the marketing channels of lettuce produced in the urban centers of Kumasi and Accra, from the farm to the table (Henseler & Amoah, 2014), the financial and economic aspects of urban vegetable production in Ghana (Danso, Hope et al., 2014), emerging and existing roles of institutions that are associated with UA (Tuffour, 2022), the use of different compost for UA production (Hofny-Collins, 2006), reducing risk in waste water use in UA (Drechsel, Keraita, Seidu et al., 2014), gender dynamics in UA (Obuobie & Hope, 2014), and the effect of the use of fertilizer on urban farmers health (Nyantakyi-Frimpong et al., 2016). Other studies also include the expansion of cities into peri-urban and village farmlands and their effect on farm systems (Kuusaana & Eledi, 2015), the effect of reduction on urban farmland on farmers livelihoods (Bonye et al., 2021), pressure on urban land and its effect on staple crop production (Abdulai, 2022), and how urban land scarcity is affecting farmers mobility within the urban space (Tuffour, 2023). Although research on UA in Ghana is extensive, a lacuna remains when it comes to connecting urban change, UA, and its effects on urban farmers adaptation with respect to production.

Core Ideas

- Urban change affects urban vegetable production.
- The effects of the changes are both negative and positive to urban farmers.
- Urban vegetable farmers adapt to these changes to sustain production and as a livelihood survival strategy.

With respect to the existing literature at the global level, a linkage between UA and urbanization has been studied (Amato-Lourenço et al., 2021; Amerasinghe et al., 2011; Ernwein, 2014; Heimlich & Barnard, 1992; Lima et al., 2000; Mougeot, 2000; Petts, 2001; Satterthwaite et al., 2010; Smit et al., 2001; van Veenhuizen, 2006; Yi-Zhong & Zhang, 2000), as well as an extensive review and conceptualization of city expansion and how it affects urban and peri-UA and food security (Follmann et al., 2021). Gaps, however, remain. The clear link between urbanization, its effect on UA, and how urban farmers adapt to this change with respect to production is lacking. In addition, studies have partially examined the effect of urbanization on farmers' production from a negative perspective and have not considered the positive effects (Allen et al., 2014; Drechsel, Adam-Bradford, & Raschid-Sally, 2014; Obosu-Mensah, 2002). Many of these studies have analyzed urbanization and UA with the use of qualitative data, largely neglecting a mixed-method approach (Danso, Dreschel, et al., 2014; Henseler & Amoah, 2014; Obosu-Mensah, 2002; Obuobie et al., 2003, 2004) Therefore, this study examines the changes in the urban space which have resulted in opportunities and challenges for urban vegetable farmers and how these farmers have adapted to the effects of these changes. It also uses a mixed-method approach to acheive its set objectives.

The study employs the resilience theory (Holling, 1973) to explain urban change and how farmers adapt to the change with respect to production. The resilient theory argues that change is unavoidable in social and ecological processes (Darnhofer et al., 2016; Scott, 2013; Weis, 2010). As the system (urban space) goes through a period of change, it finds ways of retaining its mode of operation. When disturbed, it tries to return to its original state of function though not in the same way as before because it has gone through a process (Holling, 1973). As the urban space changes, it affects UA.

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As the agricultural system changes, new patterns in farming emerge (Palekiene et al., 2015). This implies urban farmers must adjust their production patterns in planting and managing their farms with new strategies (Lin, 2011). In short, farming will continue even though the approach, or method, may change (Holling & Walker, 2003; Klein et al., 2003). In this study, aspects of urban changes were examined and linked to how they affect urban farmers' adaptation as suggested in other studies (Carpenter et al., 2014; Darnhofer et al., 2016; Langemeyer et al., 2021; Sabatino, 2016; Sundstrom et al., 2023; van der Lee et al., 2022).

2 | METHODS

2.1 | Site description

The GAMA, which houses Ghana's capital city, and is sometimes referred to as the Accra Metropolitan Area or Accra, was the study site. During the period of data collection, GAMA had 13 metropolitan and municipal assemblies combined. The largest cities within GAMA are Tema and Accra, even though separating the two has become almost impossible (Ministry of Local Government & Rural Development, 2017; Songsore, 2009; Stoler et al., 2012; World Bank, 2015). Relating the change in the study area to the resilience theory, GAMA has gone through an immense change which has affected UA production and even marketing. Farmers activities have gone through immense changes because of urbanization on UA. Farmers must adapt to survive and make a living out of it because UA has become important in GAMA mainly because of the changing lifestyle of residents who have become more concerned about their health and have increased their demand for vegetables (Food and Agriculture Organization (FAO), 2012). They must be resilient because the situation presents an opportunity for farmers to produce more vegetables and make more profit. Figure 1 shows a map of GAMA with its respective municipal assemblies, the vegetable farm sites, and type of land ownership.

2.2 | Study design

An exploratory sequential mixed-method design was used to collect and analyze data. The qualitative methodology was the dominant and first, and quantitative was complementary and second. The study's ontology was based on multiple realities of respondents who were farmers. Based on the study's axiology, there was extremely limited value placed on the views of farmers. Even though the qualitative methodology dominated the study, we limited our value placed on the responses, and this helped bring out the real views of these farmers who have witnessed the urban space go through change over a long period, how it has affected their farming activities, and how they have proven their resilience over the period. In addition, the study design guaranteed a flexible, diverse, accurate, and hands-on strategy in collecting, and analyzing the primary data, including the nuances (Creswell, 2013; Creswell & Creswell, 2017; Najmaei, 2016; Saunders et al., 2009; Yin, 2009).

2.3 | Data collection

The qualitative data that were first collected covered 10 farm sites by using a heterogeneous sampling method, which is non-probabilistic. The heterogeneous sampling method was applied because farmers had differences in terms of age, years of experience in farming, the circumstances characterizing their farm business in terms of their witness of change, how it has affected their resources, and how they are adapting to prove their resilience within the urban space. Besides, the study was interested in seeking common themes and issues that covered farmers concerning their adaptation to the immense urban change in GAMA (Patton, 2002). The qualitative data collection seized at the 10th farm site when the point of saturation in data collection was reached. This signifies a period where further interviews did not add new data to the ones already provided by the farmers (Creswell, 2013; Guest et al., 2006; Saunders et al., 2009). The qualitative interviews totaled 29 farmers in all. The qualitative data were collected using electronic recorders augmented with field notes books (Phillippi & Lauderdale, 2018). This was followed by the quantitative data collection which added an extra six farm sites to the already 10 sites the qualitative data collection had covered making a total of 16 farm sites for the quantitative. This is because a relatively larger number was needed for a fair representation which would help in the generalization of the findings. In collecting quantitative data, a total of 251 farmers, which represented 72.13% of the sample frame, was selected (Table 1). This satisfies the standard minimum number required in selecting from a population as indicated in some studies (Bartlett et al., 2001; De Vaus, 2002; Glenn, 1992).

2.4 | Method of data analysis

In analyzing the qualitative data, thematic analysis was used with the aid of Atlas.ti, a computer-assisted qualitative data analysis software (Cope, 2009). The analyses centered on urban changes, their effect on UA, and urban farmers' production adaptation strategies. Primary codes were initially formed and later upscaled to secondary codes. The secondary codes and some of the primary codes formed the themes which were in line with the objectives of the study (Saldaña,

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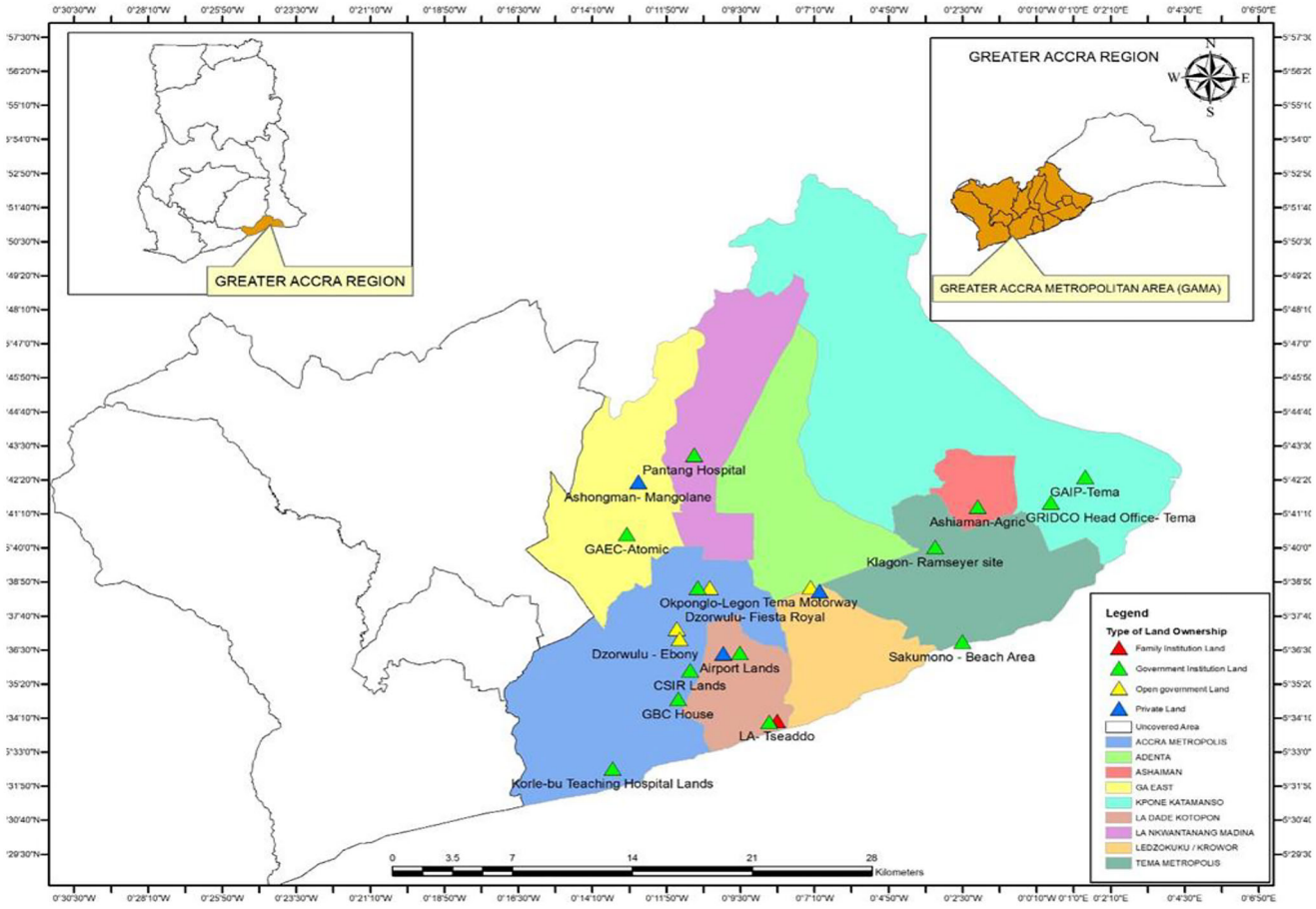

FIGURE 1 Map of Greater Accra Metropolitan Are (GAMA), location farm sites visited and respective Municipal Assemblies. *Source*: Department of Geography and Resource Development, University of Ghana, Legon.

2021; Venkatesh et al., 2016). In conducting the thematic analysis, the resilience theory which underlined the study was considered in almost every aspect.

The quantitative data were first used to estimate the adaptation index of farmers before the index was used in a regression model. Following previous studies conducted which have created adaptation indexes (Below et al., 2012; Khanal & Wilson, 2019; Thathsarani & Gunaratne, 2018), we created the intensity of farmers' adaptation strategies with respect to production. Following Thathsarani and Gunaratne (2018), we first used the principal component analysis (PCA) to create the adaptation index. The PCA values were used as weights for the variables of interest. The weighted components of adaptation were first used to form the dependent variable called the adaptation intensity index which was later used for the ordinary least squares (OLS) regression (Gujarati, 2009). Equations (1) and (2) represent the weighted production adaptation of a single and total strategy used by a farmer, respectively, while Equation (3) represents the linear regression model. For Equations (1) and (2), ProAdap_i is the score obtained for using the production-related adaptation strategy i. The W_p represents the PCA weight obtained for production-related adaptation strategy. The weighted value for a farmer who uses production adaptation i is estimated as $W_p \times ProAdap_i$. The total index for the production-related adaptation strategy for the ith farmer can also be represented as $\sum_{1}^{n} W_p \times \text{ProAdap}_i$. Following Khanal and Wilson (2019), the total adaptation index represented the dependent variable in the multiple regression model which is in Equation (3). From Equation (3), the independent variable is represented as y, which is the same as the total adaptation index of Equation (2), α_0 is the intercept of the model and x_i is the ith independent variable which could be the farmer's personal or farm characteristic. The coefficients of the farm and farmer's characteristic are β_i and δ_i, respectively. Relating Equation (3) to regression Table 5, x_1, x_2, x_3, x_4, and x_5 are the set of farm characteristics which represent vegetable production intensity, total land size, government land, total labor size, and technology, respectively, while x_6, x_7, $x_8, x_9\, x_{10}$, x_{11}, and x_{12} are the set of farmer's characteristics which represent age, age squared, education, male, household size, stayed in GAMA all my life, and places farmed in GAMA, respectively. The relationship analyzed indicates the significance of the factors that are asso-

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TABLE 1 Sites visited for quantitative data collection.

Metropolitan Municipal and District Assemblies	Site	Number reached	Total number of farmers	Percentage reached
La-Dadekotopon Municipal Assembly	Airport	6	8	75
	La-Tseaddo	9	20	45
Accra Metropolitan Assembly	Dzorwulu—Fiesta Royal	5	6	83
	Dzorwulu Ebony	18	25	72
	CSIR	8	12	67
	Okponglo	9	15	60
	Korle-bu	28	42	67
Ga East Municipal Assemply	Ashongman	15	21	71
	GAEC	26	35	74
La Madina Nkwantanang Municiplal Assembly	Pantang	18	24	75
Ashiaman Municipal Assmebly	Ashaiman	23	32	72
Adenta Municipal Assembly	Tema Motorway	52	61	85
Tema Metropolitan Area	Klagon	7	11	64
	Sakumono Beach Road	3	5	60
Kpone Katamanso Municipla Assembly	GHAIP	12	16	75
	GRIDCo	12	15	80
	Total	251	348	100

Source: Field data.

ciated with urban farmers resilience to the urban change based on their personal abilities and farm characteristics.

$$i\text{th Weighted adaptation strategy of the } i\text{th farmer} = W_p \times \text{ProAdap}_i \quad (1)$$

$$\text{Total weighted adaptation strategy of } i\text{th farmer} = \sum_{1}^{n} W_p \times \text{ProAdap}_i \quad (2)$$

$$y = \alpha_0 + \beta_1 x_1 + \beta_2 x_2 + \ \ldots\ \beta_3 x_5 + \delta_1 x_6 + \delta_1 x_7 \ldots + \delta_2 x_{12} + \varepsilon \quad (3)$$

2.5 | Ethical considerations

All the necessary ethical issues were factored into the collection and analysis of data as well as the presentation of the research findings (Saunders et al., 2009). The study was first subjected to review and approval by Ethics Committee for Humanities of the University of Ghana, a leading university in Ghana.

3 | RESULTS

3.1 | Farmer and their farm characteristics

Tables 1 and 2 present the summary of farmer and farm characteristics from the 251 farms visited within GAMA. With respect to the means of the farmer characteristics, age was 41.40 years, household size was 5.21 persons, and places farmed in GAMA was 1.47. Male respondents were 94.02% and female respondents were 5.98%. Those with no education were 33.47%, primary level education 16.33%, junior high or middle school 25.90%, secondary, technical, or vocation 17.13%, tertiary 3.19%, and nonformal education 3.98%, while those who had spent their entire life in GAMA were 28.29% and otherwise 71.71%. With respect to the farm characteristics, farm size had a mean of 3.29 acres, technology intensity was 4.56, and labor size was 11.67. With respect to the type of farm employment, 72.51% of respondents worked as full time and 27.49% worked as part-time farmers. Only 0.8% of farmers owned the lands they farmed on. Lands owned by private people were 12.35%, those owned by state-owned organizations were 56.97%, those owned by family or communal were 4.78%, and the open government lands were 25.10%.

3.2 | Urban change and its effects on urban agriculture

3.2.1 | Change in climatic patterns

From the narration of the farmers, there have been changes in the weather pattern within GAMA over the past 10 years and beyond. They specifically indicated that the rainfall pattern has become highly unpredictable over the years. Besides, there have been extended and continuously increasing heat

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TABLE 2 Demographic of farmers surveyed.

Variable	Mean	Frequency	%
Age	41.40 (15.01)[a]		
Household size	5.21(3.30)		
Places farmed in GAMA	1.47(0.73)		
Sex			
Male		236	94.02
Female		15	5.98
Level of education			
None[b]		84	33.47
Primary		41	16.33
Junior high school/middle school		65	25.90
Secondary/technical/vocation		43	17.13
Tertiary[c]		8	3.19
Nonformal education[d]		10	3.98
Entire life in GAMA			
Yes		71	28.29
No		180	71.71

Abbreviation: GAMA, Greater Accra Metropolitan Area.
[a]Values in parenthesis are standard errors.
[b]Means no education at all whether formal or informal.
[c]Those who have schooled above secondary level. Thus, with higher diplomas, degrees etc.
[d]Means some education but not in a formal way.

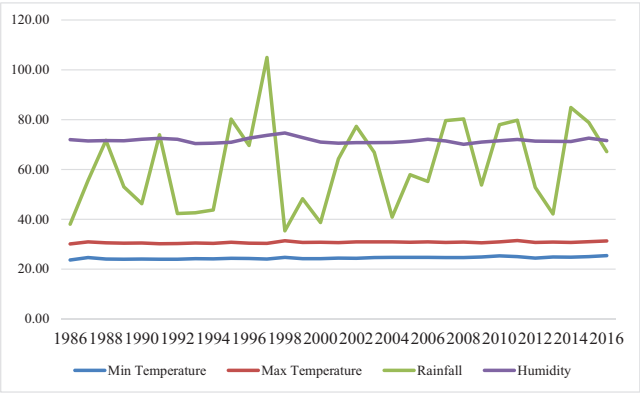

FIGURE 2 Average rainfall, temperature and humidity in Accra from 1986 to 2016. *Source*: Ghana Meteorological Agency.

and dry periods. Figure 2 shows that average rainfall pattern is unstable, and average temperature has steadily increased in the past 30 years (1986–2016) (Ghana Meteorological Agency, 2017). The observations made by the farmers agree with the evidence provided by the secondary data.

3.2.2 | Change in built environment

Farmers confirmed they have witnessed GAMA transform in terms of massive spread of new residential and business buildings specifically springing up from manufacturing and industrial centers. Over the years, they have seen an increase in the number of roads and other infrastructural networks. Many places which served as farmlands have been taken over by these buildings and infrastructure. This change has been influenced by an enormous increase in the commercial and economic activities in GAMA.

3.2.3 | Change in lifestyle dynamics

The farmers noted that GAMA has a population whose lifestyle has become more westernized. This has made urban dwellers increase their demand for vegetables. For example, vegetables, such as carrot, lettuce, green pepper, and cabbage, that were not a part of the diet of many urban dwellers have now become regular part of it.

3.2.4 | Change in farm land ownership

Farmers indicated land ownership has shifted from natives of GAMA to private and business owners who are not natives. Urban farmers are in low-income brackets and unable to afford expensive lands in the city to farm on. Majority of farmers have moved from their former lands owned by the individuals and private firms and are now farming on govern-

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TABLE 3 Farm characteristics of vegetable growers ($n = 251$).

Variable	Mean	Frequency	%
Vegetable production intensity	13.79 (12.30)[a]		
Farm size	3.29 (3.55)		
Technology	4.56 (1.05)		
Total labor size	11.67 (13.12)		
Type of farming			
Only full time		182	72.51
Only part time		69	27.49
Land ownership			
Farmer		2	0.8
Private but not farmer[b]		31	12.35
State owned organization		143	56.97
Family/communal		12	4.78
Open government land[c]		63	25.10

[a]Values in parentheses are standard deviations.
[b]Farmers on private lands neither own or rent lands. The owners mainly give it to them as means of protecting the lands.
[c]Land owned by government in open spaces and not dedicated to a specific organization.

ment lands because the new owners of the lands use them for other purposes. Of the 251 farmlands visited, only 0.80% were owned by the farmers themselves, 4.78% were communal or family owned, 12.35% were for individuals and not the farmers, and 82.07% were for either the Government of Ghana or government institutions (see Table 3).

3.2.5 | Rapid rising cost of living in the urban economy

Farmers complained of a general rising cost of living in GAMA. They specifically indicated that prices of goods and services for both consumption and production have risen exponentially, making cost of living and production in GAMA very high. This has led to a situation where the price levels of goods and services have increased. The situation has equally increased the prices of production inputs, even though they are readily available. Examples include pumping machines, fertilizers, weedicides, pesticides, and labor.

3.3 | Positive outcomes of urban change on farmers' production

Low rainfall and its unpredictability have not been present only in Accra or GAMA, but in the whole Greater Accra Region. This led to a relatively low level of production of vegetables in the peri-urban centers which are partly their competitors. Since vegetable farming in GAMA is not rain dependent, farmers have taken advantage of the unpredictability of water supply for peri-urban farmers and increased production to meet the shortage in supply from other parts of Ghana, especially in the dry season. From the observation of the vegetable farmers in GAMA, it is a benefit even though they face the challenge of using polluted streams when they experience long periods of drought.

The increase in demand for vegetables has improved the market conditions for farmers since it has increased their market base. Most of the farmers revealed that there is always a reliable market for vegetables. Majority of the farmers indicated their financial earnings have improved from production of vegetables and provided them with a reliable source of livelihood. Table 4 shows 97.21% of the farmers indicated there is always a reliable market for the vegetables they produce. Also, 88.45% of farmers indicated it has improved their financial earnings from the production of the vegetables and provided them with a reliable source of livelihood and improved their living standards as well. The massive infrastructural development over the years has resulted in improvements in the transportation network and easy access to transport within GAMA. This has made the movement of farm produce to the market easier and cheaper. It has also made it easier for farmers to visit their farms and to market their produce.

Since most lands remaining for farming in GAMA are largely owned by government, farmers find it beneficial accessing these lands at least for the period they are using them. Farmers on government lands hardly face problems from people encroaching on them. Almost all were happy on their present lands and enjoyed low cost of production since they did not pay rent for the lands they were using. From

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TABLE 4 Responses on urbanization effect farmers' production and adaptation.

Urbanization effect	%
Effects of urban change on farmers' production	
Reliable market for vegetables	97.21
Improved financial earnings	88.45
Enjoy government protection	42.23
Happy on present lands	81.67
Low cost of production	82.87
Negative effects of urban change on farmers' production	
Eviction from farm lands	21.12
Contestation on farmlands	10.36
Low soil fertility	14.34
Uncertainty of fate on present lands	62.95
High cost of labor	64.14
Unreliable supply of labor	25.90
Adaptation strategies	
Farm all year round	92.83
Practice multiple or mixed cropping	61.35
Relocated farms to lands under high tension poles	21.91
Using government owned lands	82.07
Multiple locations of farmland within the city	25.09
Use of migrant labor	28.68
Use of family labor	33.80
Use of female labor	47.41

Source: Field data.

Table 4, 42.23% noted they enjoyed the protection of government on their present lands, 81.67% said they were happy on their present lands, and 82.87% said they enjoyed low cost of production since they did not pay anything for the lands they were using.

3.4 | Negative outcomes of urban change on urban farmers' production

Notwithstanding the high market demand for vegetables within the urban space, farmers complained they sometimes experience the risk of losing money from the unpredictability associated with the sale of vegetables produced. Farmers complained that it results in financial losses. Also, the overpopulation and increased residential and commercial buildings coupled with poor city planning have resulted in the presence of poor drainage systems, which channel waste water into previously clean streams for UA. This has resulted in the use of dirty streams for irrigation by urban farmers.

The land scarcity challenge and the competing use of farmlands have resulted in other challenges. Table 4 confirms 21.12% had witnessed eviction on their previous lands, 10.36% had experienced contestation on their farmlands, 14.34% were facing low soil fertility challenges, and 62.95% were uncertain on their future on the lands they were using.

Farmers complained of high cost of living in GAMA, a situation which makes it more difficult for workers within the low-income groups such as farm laborers to survive in the city. Since farm labor work does not pay much, farmers find it difficult to employ reliable labor for their farms especially the young ones. This creates difficulties for farmer owners in the form of farm labor shortages. Table 4 indicates 64.14% and 25.90% encountered high cost of labor and unreliable supply of labor, respectively, due to the unattractiveness of labor to UA.

3.5 | Farmers' production adaptation strategies to effects of urban change

3.5.1 | Use of different water sources

In adapting to the challenge of water shortages and weather unpredictability, farmers use multiple sources of water. These are hand-dug wells, waste water that flows into streams, clean streams, and treated water from the Ghana Water Company Limited (GWCL) to irrigate their farms.

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3.5.2 | Intensification of urban vegetable production

Since the farmers have small portions of land to farm on and would hardly have room to expand, they use the most modern technology at their disposal, such as improved seed varieties, modern irrigation methods, and use modern weedicides and pesticides to farm all year round. The main source of soil nutrients the farmers depend on is inorganic fertilizer even though they use minimum proportions of organic fertilizer mainly from poultry manure prepared by the farmers themselves or by firms and research institutions such as the Ghana Atomic Energy Commission. Farmers mostly use the land throughout the year without any break and do their best to obtain the maximum output during the production period. Out of the 251 farmers, 92.83% indicated they farmed all year round and 61.35% practised multiple or mixed cropping (see Table 4).

In order to make sure they continue to farm amid dwindling available farmlands, farmers have moved to free and cheap lands within the city that have not been used by their owners. On these lands, they pay either nothing or a small amount for their use. Since farmers have an available market in the city and enjoy cheaper, or almost zero cost in transporting their goods, they hardly relocate to peri-urban or rural areas. They either relocate to lands under high-tension pylons, use government-owned lands, or farm on lands at multiple locations within the city. Table 4 shows that 21.91% of farmers have relocated their farms to high-tension lands, 82.07% are using government owned lands, and 25.09% have farms at multiple locations within the city.

3.5.3 | Use and train labor from multiple sources

Due to the farm labor supply challenges the farm owners face, they use four main sources of labor: they themselves, migrant labor who are mostly male, family labor, and female labor. Table 4 shows 28.68% of farmers use migrant labor, 33.80% use family labor, and 47.41% use female labor. The migrant laborers working within the study area are in two main categories: those from within Ghana and those outside Ghana, who normally come from neighboring Burkina Faso. In using some of these sources of labor, they sometimes train the new entrants who have no experience on the job but are relatively cheaper to use. With respect to family labor, they use their wives, cousins, nephews, and sometimes their children who are above 18 years and part of their households. For the female laborers, they mostly help in the planting of the vegetables. These laborers may be permanent or temporal depending on their reliability and availability to the farmers.

3.6 | Factors influencing urban farmers production adaptation to urban change

The results of stepwise OLS regression which is presented in marginal effects are indicated in Table 5. From the data, farms which grow a lot of vegetables, use a larger labor size, and employ more improved technology are those that exhibit high production adaptation intensity. Farmers who were born in Accra, had larger households, higher education, and farmed in multiple places within GAMA also embarked on high production adaptation intensity.

4 | DISCUSSION

The results indicate that farmers' activities are affected in several forms by urbanization and they prove their resilience in production through adaptation of several strategies. The resilience theory underscores that change is inevitable and it is responded with adaptation strategies. The study area, GAMA, has witnessed intense urbanization according to the farmers. This change is reflected in the climatic patterns, land ownership, population and lifestyle dynamics, and cost of production which to a large extent affects urban vegetable production. For the changed in climatic patterns, farmers over the years have learned to adapt to it with intense irrigation. Poku-Boansi and Cobbinah (2018) have asserted climate change continues to be a threat in the equation of Ghana's urbanization. Since farmers produce vegetables throughout the year, they try to adapt to prolonged drought and the unpredictability of rainfall by using different water sources, which are rainfall, shallow wells, clean and dirty streams, and water from GWCL. Their ability to farm using multiple water sources keeps them in business and gives them a competitive urge over their counterparts in the peri-urban and rural areas. Almost all the farmers do not own the lands they farm on. Natives who were the original land owners, who used their lands for farming and gave portions to other farmers at a relatively cheaper rate have sold the lands to private individuals and firms. As established in other existing literature within Ghana (Badami & Ramankutty, 2015; Mackay, 2018; Owusu, 2013) and beyond (Peerzado et al., 2019; Vermeiren et al., 2013), this is largely accounted for by globalization, neoliberalism, and modernization which have shot the prices of lands up. These private individuals and firms evict these farmers when they become owners of the lands. These evicted farmers have no option than to relocate to lands owned mainly by government, which are in the open and unused. Since urban vegetable production is mainly through irrigation, farmers must find spare lands which are close to streams, water bodies, or where shallow wells can be dug and used. This creates a situation where they have very limited lands to find and farm on.

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TABLE 5 Ordinary least squares (OLS) estimates of factors associated with urban farmers' adaptation.

Variable	OLS model 1[a]	OLS model 2[b]	OLS model 3[c]
	Coefficients/marginal effects		
Vegetable production intensity	0.0210***		0.0148***
	(0.00467)[d]		(0.00419)
Total land size	0.0217		0.0122
	(0.0190)		(0.0192)
Government land	−0.0578		−0.0576
	(0.117)		(0.117)
Total labor size	0.0725***		0.0499*
	(0.0244)		(0.0288)
Technology[e]	0.0749*		0.0779**
	(0.0390)		(0.0393)
Age		−0.0284	−0.0327
		(0.0216)	(0.0204)
Age squared		0.000222	0.000287
		(0.000236)	(0.000222)
Primary education		0.296**	0.254*
		(0.148)	(0.139)
Male		0.195	0.109
		(0.204)	(0.206)
Household size		0.0648***	0.0442**
		(0.0249)	(0.0211)
Stayed in GAMA all my life		0.340**	0.353**
		(0.143)	(0.144)
Places farmed in GAMA		0.327***	0.248***
		(0.0840)	(0.0813)
Constant	0.474**	0.983**	0.581
	(0.227)	(0.492)	(0.492)
Observations	251	251	251
R-squared	0.148	0.176	0.245

Abbreviation: GAMA, Greater Accra Metropolitan Area.

[a]OLS estimates using only farm characteristics.

[b]OLS estimates using only farmers' personal characteristics.

[c]OLS estimates using both farmers' personal and farm characteristics.

[d]Values in parentheses are standard errors.

[e]Count of modern inputs used in the production. For example, pumping machine, weedicides etc.

***, **, and * denote statistical significance at $p < 0.01$, $p < 0.05$, and $p < 0.1$ levels, respectively.

Therefore, when these farmers find these usually small-sized lands, they must make maximum use of them. This explains why vegetable farmers through intensification farm all year round to make the best use of the land for maximum profit. Even though the urban change has negative effects on UA, it has also brought opportunities to farmers. The high level of intensification for instance results in higher profitability for farmers. Besides, the ever-increasing urban population with its changing lifestyle dynamics have resulted in an increase in the demand for vegetables which has also increased the profitability of vegetable production. Farmers, however, overproduce in anticipation of excessive demand and when the demand is not up to expectation, and they make losses. This phenomenon of losses due to the unpredictability of the market is not new in literature. It has been present within and outside Ghana (Herbon & Khmelnitsky, 2017; Obuobie & Hope, 2014; Tuffour & Dokurugu, 2015).

Farmers farm year round to meet the market demand and maximize the use of the small land sizes to increase their profit. They also use different forms of labor; some of which are from Ghana and the neighboring countries. In addition to those from their own households such as wives, brothers, and children over 18 years, those from Ghana are mostly from the northern part who know the trade of vegetable farming in their

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hometowns already before migrating to Accra. Those beyond Ghana are mostly from Burkina Faso and Mali. The phenomenon where farmers hire labor from the northern part of Ghana and these neighboring countries has been established in extant literature (Asomani-Boateng, 2002). Even though some of these laborers are conversant with vegetable farming, farmers would have to train them for a period to be effective on the farms on GAMA.

The assertion that farmers with high production adaptation intensity are those who produce a lot of vegetables, use a larger labor size, and use improved technology is in line with the expectation of the study. For farmers who produce more, they need to be able to show a high level of adaptability. One sure way of indicating their ability to adapt is by increasing their labor size and using the best of technology. The quantitative results blend perfectly with the qualitative which explains how the farmers adapt to the ever-changing urban dynamics which affect their production. Also, there is a high possibility that those born within GAMA will be able to adapt compared to those born outside Accra since they would know the GAMA terrain better and will be able to meander their way through the changing urban space. Farmers who have farmed in multiple places, they are able to adapt compared to those who have farmed in fewer places. Tuffour (2023) concludes that those who have multiple farms within GAMA can produce more vegetables. For the positive relationship between larger household size and high level of adaptability, a clear explanation could not be given. However, Tessema et al. (2018) assert that smallholder farmers with larger households are able to adapt more to climate change. Farmers with higher education will be able to adapt more since they can read and obtain reliable information compared to those with lower levels of education. This assertion has been made in studies in climate change adaptation (Tessema et al., 2018; Uddin et al., 2014).

5 | CONCLUSION

When there is intense urbanization over a relatively longer time period, there are positive and negative effects on UA production on several fronts. These changes include unpredictability of the climate, high land scarcity and cost, population and lifestyle dynamics as well as change in the physical environment. The positive effects of these changes on UA production include increased demand for vegetables, which leads to increase farmers' profitability and temporal farmland security on the lands they are currently using. The negative effects of the urban changes on UA include presence of polluted streams, eviction and contestation on lands, and unpredictability of labor supply. In responding to these effects, farmers use various adaptation strategies. Some involve the use of several water sources, embark on the intensification of vegetable production, and relocate to cheap and cost-free lands. In an emerging economy such as Ghana, UA is not a form of mainstream farming even though it has numerous opportunities among many urban dwellers. However, many farmers are left on their own to survive and prove their own resilience from the effects of rapid urbanization. Farmers will continue to adapt to these changes largely on their own. This calls for support from organizations that promote UA in general. This must include land provision, logistic support, training on production, and support in strategic marketing.

AUTHOR CONTRIBUTIONS

Michael Tuffour: Conceptualization; data curation; formal analysis; methodology; writing—original draft; writing—review and editing. **George Owusu**: Methodology; supervision; writing—review and editing. **Daniel Bruce Sarpong**: Methodology; supervision; writing—original draft; writing—review and editing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The datasets are available upon request.

ETHICS STATEMENT

Ethical approval was given by Ethics Committee for Humanities (ECH) of the University of Ghana, Legon.

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