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# Effects of climate change and adaptation strategies on urban crop production in Kinondoni City, Tanzania

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**Abstract.** *Kifunda CF. 2023. Effects of climate change and adaptation strategies on urban crop production in Kinondoni City, Tanzania. Asian J Agric 7: 98-107.* Many countries worldwide, including Tanzania, have felt the effects of climate change on the productivity of major economic sectors, such as agriculture. This study assessed climate change's effects on urban agriculture's sustainability in Kinondoni City, Tanzania. Specifically, the study aimed to determine: i) the effects of climate change on crop production in Kinondoni City over the last 30 years, ii) other challenges of urban agriculture in Kinondoni City, and iii) adaptation strategies employed by smallholder farmers in sustainable urban agriculture in Kinondoni City. Data collection involves accessing temperature and rainfall data from Tanzania Meteorological Agency (TMA) headquarters and administering household questionnaires to 386 respondents who engaged in urban agriculture in Kinondoni City. Five wards of Bunju (118), Kunduchi (42), Mabwepande (102), Mzimuni (28) and Wazo (96) were involved. Focused group discussion, key informant interviews, and direct observation were also employed. Data were analyzed for temperature and rainfall variations over the last 30 years and people's knowledge of climate change indicators. The adaptation strategies employed in sustaining crop production in the study area were also quantified. The study reveals that most smallholder farmers (>70%) are aware of the indicators of climate change, which correlate with the data obtained from TMA. Among the indicators include an increase in temperature (76%) and a decrease in rainfall (73%). Pest and diseases were ranked higher (88%) among the significant effects of climate change on urban agriculture. Land scarcity was also a significant challenge in urban agriculture. The use of pesticides and fertilizers was ranked higher (65%) among the adaptation strategies employed by smallholder farmers. It is recommended that building capacity for smallholder farmers through getting access to micro-credits at low-interest rates and government support may contribute significantly to sustainable urban agriculture in Kinondoni City. Also, farmers in Kinondoni City can adopt sustainable agriculture practices such as Soil and Water Conservation practices and the use of Drought-Resistant Crop varieties to improve their resilience to future climate risks caused by climate change.

**Keywords:** Agriculture, crop productivity, smallholder farmers, sustainability, urban agriculture

## INTRODUCTION

Climate change is the greatest environmental problem of the 21st century affecting many people's lives worldwide (Intergovernmental Panel on Climate Change (IPCC) 2021; Mazhin 2020). All nations worldwide are already experiencing temperature changes, shifts in the rainy seasons, and an increasing frequency of extreme weather events and other climate change impacts (IPCC 2014; Omowunmi and Michael 2016). Cities are exposed to global climate change, and the impacts range from sea level rise, floods, droughts, and damage to infrastructure (Rosenzweig et al. 2014; IPCC 2023). Climate change severely threatens sustainable economic growth for Africa and may lead to extended poverty, particularly in Sub-Saharan Africa (IPCC 2014). The areas that are highly vulnerable to the impact of climate change are food production, the health sector, biodiversity, rangelands, and water resources (Kimani et al. 2014). Crop production is one of the specific areas that are greatly affected by climate change, where the variation in temperature and rainfall patterns and associated extreme weather events can profoundly affect the livelihoods of urban farmers and the availability of fresh produce for urban populations. To avoid the costs that could result from delaying, adaption measures must be made faster as the climate changes.

Urban dwellers areas is food produced in rural areas to meet their dietary needs. Growing and producing food within urban areas is gaining increasing recognition for its numerous benefits and contributions to sustainable development. Urban agriculture is considered to be one of the ways to improve food security and household income of urban dwellers under conditions of persistent economic uncertainty and threats of climate change (Poulsen et al. 2015; Duží et al. 2017; Siegner et al. 2018; Bennedetti 2023). Farming in urban areas could offer a promising opportunity for low-income residents to improve their financial situation, as urban farming often requires a much lower initial investment than other business ventures. By utilizing small plots of land in the city, individuals or groups can grow fresh produce and generate income through sales or local partnerships. Urban agriculture can reduce urban poverty across Sub-Sahara Africa (Akinnagbe and Irohibe 2014; Mudzengerere 2014). However, in many cities, it is more difficult for the urban poor to access the land needed for urban agriculture than for rich people (Mhache and Lyamuya 2019). Urban agriculture enhances food security and household income and contributes to

biodiversity conservation in urban areas by providing habitats for pollinators and reducing urban heat island effects, which are caused by the absorption and retention of heat by urban surfaces like buildings and roads. Urban agriculture can increase vegetation cover in urban areas, which helps to absorb and shade the sun's energy. This leads to a reduction in the amount of heat absorbed by urban surfaces and can mitigate the urban heat island effect (Abdul-Rahman et al. 2021; Hanson et al. 2021). It also helps preserve traditional crop varieties and local food cultures, promoting the conservation of agricultural biodiversity (Siegner et al. 2018). By promoting sustainable and equitable urban agriculture practices, cities can protect biodiversity, build resilient and sustainable food systems, and address climate change. However, it is important to consider potential impacts on local ecosystems, manage resources efficiently, and ensure equitable access to land and financial resource for sustainable urban agriculture.

Whereas many efforts and measures like the promotion of urban agriculture by the government and introduction of new technologies such as hydroponics and vertical agriculture are taken towards the intensification of the contribution of urban agriculture to food security, little attention has been put on assessing the negative impact of climate change on urban agriculture and quantifying the adaptation strategies employed by smallholder farmers in sustainable urban agriculture. This study therefore aimed to assess the effects of climate change on the sustainability of urban agriculture in Kinondoni City, Tanzania. The Kinondoni City was chosen for this study due to its large population size and because a significant portion of the population relies on agriculture as their primary source of income (URT 2013). Specifically, the study aimed to assess: i) the effects of changes in rainfall and temperature on crop production in Kinondoni City over the last 30 years, ii) challenges of urban agriculture, and iii) adaptation strategies employed by smallholder farmers in sustaining urban agriculture in Kinondoni City. The study provides valuable insights into the support needed to develop effective adaptation strategies to overcome the effects of climate change and enhance food security and resilience to climate change in urban areas.

## MATERIALS AND METHODS

### Study area

Kinondoni City is one of the four municipalities in Dar es Salaam City, Tanzania. The municipality is bordered by the Indian Ocean to the North East, Ilala District to the South, and Ubungo District to the North (Figure 1). Climatically, Kinondoni City experiences a modified type of equatorial climate. It is generally hot and humid throughout the year, with an average temperature of 29°C. The hottest season is from October to March, while it is relatively cool between May and August, with temperatures around 25°C. There are two rain seasons: a short rainy season from October to December and a long rainy season between March and May. The average annual rainfall is 1,300 mm. The climate is also influenced by the Southwest monsoon winds from April to October and Northeast monsoon winds between November and March (URT 2017).

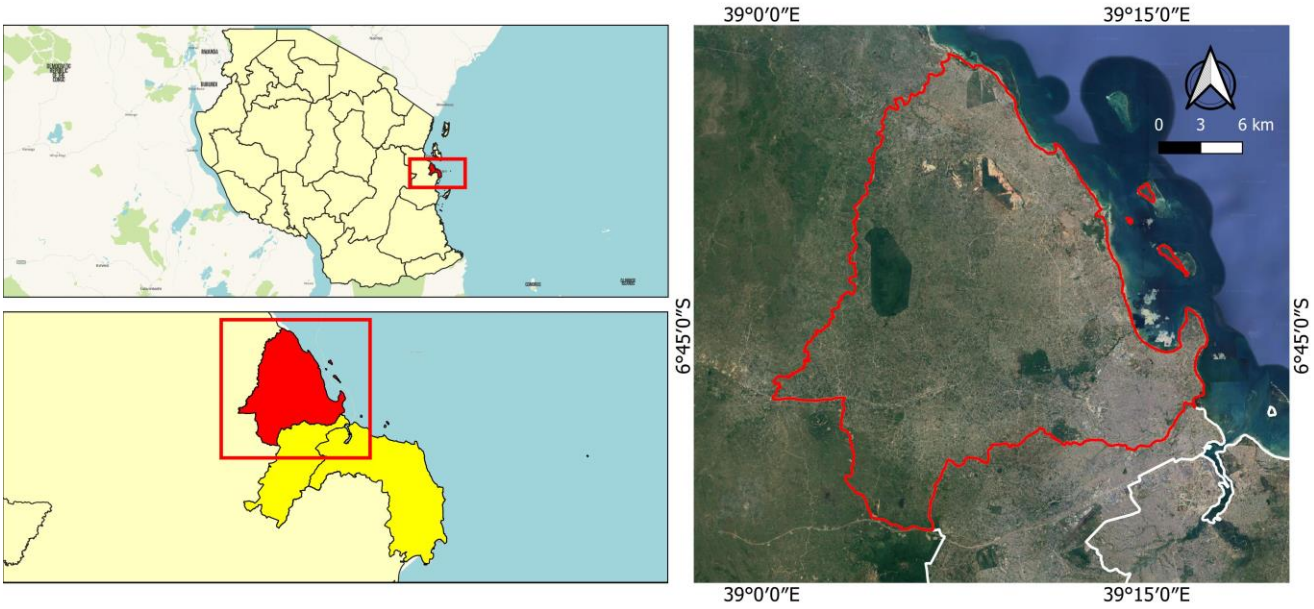


**Figure 1.** Map of Tanzania showing the location of Kinondoni City, Dar es Salaam Region, Tanzania

Kinondoni City was selected because it had the highest population, with some of the population engaged in agriculture (about 10%) as their main economic activity (URT 2013; Mlozi et al. 2017). Five wards were selected for the study: Bunju, Kunduchi, Mabwepande, Mzimuni, and Wazo. These wards had the majority of people practicing urban agriculture compared to the rest of the 20 wards found in Kinondoni City.

**Data collection**

The field survey was conducted from October 2018 to January 2019 and, among other activities, involved accessing temperature and rainfall data from Tanzania Meteorological Agency (TMA) headquarters in Dar es Salaam. Semi-structured questionnaires were administered to a total of 386 respondents from the five wards of Bunju (118), Kunduchi (42), Mabwepande (102), Mzimuni (28), and Wazo (96) who engaged in urban agriculture. The questionnaires provided the respondents' socio-economic characteristics, knowledge of climate change indicators, perceptions of climate change's impact on crop production, and the adaptation strategies employed by the farmers. A separate set of questions was addressed to key informants such as agricultural extension officers, leaders of the local markets, leaders of agricultural groups, and a few selected farmers from the five wards. Furthermore, focus group discussions were conducted using 5-10 group people. In addition, Direct observation was also conducted to cross-check the reliability of the information gathered from the techniques mentioned above.

**Data analysis**

Quantitative data from household interviews were compiled, summarized, and analyzed by using Statistical Package for Social Sciences (SPSS) software version 20 and Excel spreadsheets. Qualitative data from key informants and focus group discussions were captured through content analysis with the assistance of the Maxqda program. Both descriptive and inferential statistics were used. Data were presented using tables and figures.

## RESULTS AND DISCUSSION

**General characteristics of the respondents**

The general characteristics of the respondents are presented in Table 1. Concerning gender, 44.8% of respondents were males, and 55.2% were females. People of middle age between 41-60 accounted for the largest portion of the studied population (44.6%). The majority of the households (53.4%) showed to have an average of 4 to 6 members per household. Migrants from different regions of Tanzania and respondents with primary education accounted for the majority of the respondents, 85.5% and 73.1%, respectively.

The dominance of females found in this study is a phenomenon that was expected. In many studies, females have been found to engage more in urban agriculture than males (Sebata et al. 2014; Mwangi 2015; Malekela and Nyomora 2019). In these studies, it has been shown that females participated in urban agriculture to supplement their household income and ensure food security for their families. Other studies noted that the participation of females in urban agriculture could also be due to gender roles and responsibilities in a particular society, as women traditionally have responsibilities related to food production and household management (Cele and Mudhara 2022; FAO 2023; Mwale 2023).

**Table 1.** Socio-economic characteristics of the respondents in Kinondoni City, Dar es Salaam Region, Tanzania

| Respondents Characteristics | Name of the Ward | | | | | |
|---|---|---|---|---|---|---|
| | **Bunju** | **Kunduchi** | **Mabwepande** | **Mzimuni** | **Wazo** | **Total (%)** |
| *Gender* | | | | | | |
| Males | 13.0 | 6.1 | 10.1 | 3.9 | 11.7 | 44.8 |
| Females | 17.6 | 4.7 | 16.3 | 3.4 | 13.2 | 55.2 |
| *Age* | | | | | | |
| 17-30 | 1.8 | 3.6 | 7.8 | 4.2 | 1.0 | 18.4 |
| 31-40 | 3.4 | 6.5 | 9.8 | 7.0 | 1.8 | 28.5 |
| 41-60 | 4.9 | 12.4 | 10.6 | 13.5 | 3.2 | 44.6 |
| 61+ | 0.8 | 2.3 | 2.3 | 1.8 | 1.3 | 8.5 |
| *Origin* | | | | | | |
| Natives | 4.9 | 1.0 | 3.9 | 1.0 | 3.7 | 14.5 |
| Migrants | 25.7 | 9.8 | 22.5 | 6.3 | 21.2 | 85.5 |
| *Education* | | | | | | |
| Informal | 1.3 | 1.6 | 2.8 | 0.8 | 3.1 | 9.6 |
| Primary | 21.5 | 7.5 | 20.5 | 6.2 | 17.3 | 73.0 |
| Secondary | 5.2 | 1.3 | 2.3 | 0.3 | 3.4 | 12.4 |
| Tertiary | 2.6 | 0.5 | 0.8 | 0.0 | 1.0 | 4.9 |
| *Household size* | | | | | | |
| 1-3 | 10.1 | 1.8 | 5.4 | 1.6 | 6.5 | 25.4 |
| 4-6 | 15.5 | 5.7 | 16.8 | 3.7 | 11.7 | 53.4 |
| 7-9 | 4.1 | 2.3 | 3.4 | 1.6 | 5.7 | 17.1 |
| 10+ | 0.8 | 1.0 | 0.8 | 0.5 | 1.0 | 4.1 |

Urban agriculture, which often involves small-scale gardening and animal husbandry, aligns with these roles and can be seen as an extension of women's domestic responsibilities. The predominance of females in urban agriculture highlights their crucial role in ensuring food production, promoting local food security, and contributing to the socio-economic development of urban areas. Empowering and supporting women in urban agriculture can enhance livelihoods, gender equality, and sustainable urban food systems.

Most respondents under the middle age group of 41-60 years old indicate a potential working force useful for urban agriculture activities in the study area. The age group is in line with the age structure of the Tanzanian working population, which ranges between 15 to 64 years of age (URT 2014). According to Malekela and Nyomora (2019), most people who participate in urban agriculture are of middle age because they play an important role in various aspects of the production system. This group may also have valuable skills and experience that contribute to the development and implementation of sustainable production practices and the ability to manage and operate production facilities. Moreover, the middle age group may be more likely to establish networks and connections within the communities or industries, which help facilitate cooperation and knowledge sharing between different stakeholders. The dominant age of the respondents in this study, between 41 and 60, is consistent with other studies in different countries (Sebata et al. 2014; Fry 2018; OECD 2023). The participation of the middle age group in agriculture is vital as their skills, experience, and connections contribute significantly to the development, implementation, and sustainability of agricultural practices while fostering cooperation and knowledge sharing among stakeholders. Their presence in the agricultural sector ensures a strong workforce and promotes agriculture's continued growth and success.

Most of the respondents (73%) in the study area attained a primary level of education. Education is a key element in the recovery strategies to counter the various crises (Omoniyi 2013). Aduke (2011) asserts that in many developing countries, education is the primary means of breaking the cycle of poverty. Education is crucial in advocating for sustainable agricultural practices that minimize environmental damage and bolster long-term food security. It can raise awareness about climate change, biodiversity conservation, soil health, water management, and agroecology, enabling farmers to make deliberate and thoughtful choices of using sustainable farming methods (Belay and Araya 2015; Pauw et al. 2015; Maini et al. 2021). Education is a transformative force that cultivates innovation, fosters sustainable practices, and paves the way for a prosperous future in agriculture. It serves as the cornerstone of agricultural development, enabling farmers to acquire the knowledge, skills, and awareness necessary for sustainable practices to increase the productivity of urban agriculture.

**Changes in rainfall and temperature in the study area**

Indicators of changes in climate in the study area are presented in Table 2. Based on multiple responses from the household survey, most respondents (76%) had experienced an increase in temperature followed by a decrease in rainfall (73%) in the study area. These claims were supported by the data obtained from the Tanzania Meteorological Agency (TMA). The data shows that there has been a decrease in rainfall in the last 30 years, from 1,430.9 mm in 1986 to 782.9 mm in 2016 (Figure 2). An abnormal increase in rainfall has also occurred, i.e., up to 1,500 mm/year, resulting in flooding. In April 2010, Dar es Salaam received unprecedented rainfall above 400 mm, resulting in widespread flooding (TMA 2017). In addition, there has been increasing in both minimum and maximum temperatures in the study area in the last 30 years, i.e., from 20.7°C in 1986 to 23.2°C in 2016 (Figure 3) and from 30.9 in 1990 to 32.1°C in 2015 (Figure 4) respectively.

According to farmers ' point of view and the data from TMA, this study shows climate change is a reality in Kinondoni City. The study has revealed the presence of unreliable rainfall patterns and an increase in maximum temperatures in the study area. Many other studies have documented similar observations in parts of Tanzania, like Dodoma, Dar es Salaam, and Singida (Mlozi et al. 2014; Mwamfupe 2014; Myeya 2021). The reliance on rainfall makes rain-fed agriculture vulnerable to climate change. In addition, increased rainfall variability has affected the agricultural calendar and decisions over important farming activities (Mwamfupe 2014). The changes in crop production-related climatic variables will possibly have major influences on regional and global food production.

Moreover, the study by Malekela and Nyomora (2019) investigated the local indicators of climate change in Dar es Salaam City, Tanzania. Among the indicators mentioned were increased temperatures, changes in rainfall patterns, and a decline in rainfall. These findings are worrying as they indicate that climate change could affect the study area and progressively hinder agricultural activities.

**Table 2.** People's perceptions of the changes in rainfall and temperature in the study area

| Indicators of climatic changes | Number of respondents (N=386) | Percent |
|---|---|---|
| Increase in temperature | 293 | 76 |
| Decrease in rainfall | 283 | 73 |
| Occurrence of floods | 178 | 46 |
| Shifting of the rain season | 152 | 39 |
| Occurrence of drought | 126 | 33 |

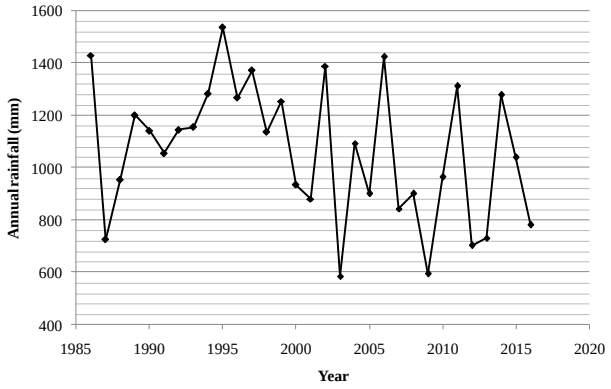


**Figure 2.** The general trend of rainfall pattern from 1986 to 2016 in Kinondoni City, Dar es Salaam Region, Tanzania

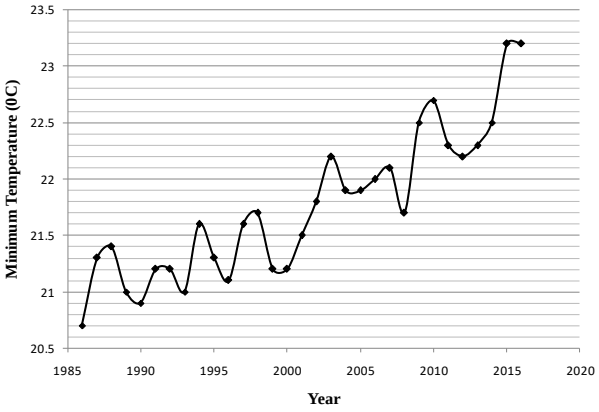


**Figure 3.** The general trend of Minimum Temperature from 1986 to 2016 in Kinondoni City, Dar es Salaam Region, Tanzania

**Effects of climate change on urban agriculture**

Indicators of the effects of change in climate in urban agriculture in the study area are presented in Table 3. Based on multiple responses from the household survey, smallholder farmers revealed to know the effects of climate change on crop production. Most respondents (88%) reported increased pests and diseases due to climate change in recent years. Temperature change and unreliable rainfall were said to cause water shortage in the study area (67%). The occurrence of floods was reported by very few respondents (27%). These farmers claimed to have floods due to unpredictable, heavy rainfall, which brought large crop losses. Especially for those farms located in lowland areas, such as river valleys, are frequently affected by floods. Farmers witnessed the effects of this erratic occurrence of rainfall in April 2018. The running water destroyed many farms along the Msimbazi and Mpiji river valleys and others covered by mud (Figure 5). This leads to a reduction in the size of the farms.

The results of this study concurred with studies done elsewhere which showed that an increase in temperature and unreliable rainfall lead to crop diseases, which in turn leads to low harvests hence extreme poverty to the smallholder farmers (Baker 2013; Kifunda 2014; Smith 2015). The rising temperatures are adversely affecting farmers, causing heat-related illnesses, exacerbation of pre-existing health conditions, psychological impacts, and significant financial losses due to crop damage and reduced yields, as well as the inability to work during extreme heat events (El Khayat 2022; IPCC 2023). Hatfield and Prueger (2015) showed that an increase in temperature adversely affects crops as excessive heat is a limiting factor of production. Kasimba (2012) from Zimbabwe reaffirmed that an increase in temperature threatens crop growth as they would dry. The increased prevalence of pests and diseases poses a significant challenge to crop production in urban areas. Addressing this challenge through adaptive strategies for sustainable urban agriculture is imperative.

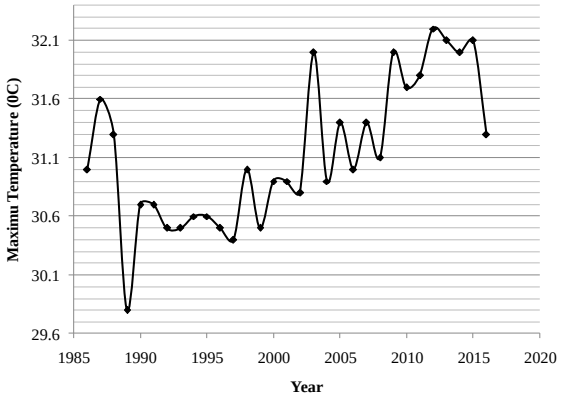


**Figure 4.** The general trend of Maximum Temperature from 1986 to 2016 in Kinondoni City, Dar es Salaam Region, Tanzania

**Table 3.** The effects of climate change on urban agriculture in Kinondoni City, Dar es Salaam Region, Tanzania

| Indicators | Ward | | | | | Total (%) |
|---|---|---|---|---|---|---|
| | Bunju | Kunduchi | Mabwepande | Mzimuni | Wazo | N=386 |
| Increase in pests and diseases | 29.0 | 10.4 | 22.5 | 5.7 | 20.7 | 88 |
| Shortage of water | 20.5 | 9.1 | 18.8 | 3.4 | 15.0 | 67 |
| Decline in crops quality | 22.3 | 9.3 | 15.3 | 3.6 | 14.2 | 65 |
| Low harvests | 17.9 | 9.8 | 19.2 | 3.6 | 12.7 | 63 |
| Seeds failing to germinate | 8.3 | 3.6 | 10.1 | 1.8 | 6.5 | 30 |
| Drying of crops | 11.1 | 2.9 | 6.2 | 4.1 | 8.3 | 33 |
| Occurrence of floods | 8.0 | 2.6 | 5.2 | 7.3 | 4.1 | 27 |


**Figure 5.** Farms destroyed by running water along Msimbazi River Valley as witnessed by farmers in April 2018: A. A farm destroyed by running water in Mzimuni ward, B. A farm covered with mud in Mzimuni ward

Climate change leads to drought and declining crop yields, negatively impacting crop quality. Various studies have documented the impacts of climate change on water availability, crop yields, and quality. The increased frequency of droughts and water scarcity leads to reduced crop production. Similarly, research in different parts of the world has also demonstrated the negative effects of climate change on crop yields and quality (Challinor et al. 2014; FAO 2015; Pareek et al. 2020). Global efforts to mitigate climate change and reduce greenhouse gas emissions are crucial to safeguarding agricultural systems and ensuring future food security.

**Other challenges of urban agriculture**

Other challenges besides climate change affecting urban agriculture are presented in Table 4. According to the survey, the majority of respondents reported inadequate farm inputs as a major challenge (81.3%), while market problems were faced by only 47.4% of respondents (Table 4). Land scarcity was also a significant challenge, with 74% of all respondents indicating this as an issue. Urban agriculture was conducted in various locations, including backyards, open spaces such as river valleys and road reserves, building plots, and some respondents' farms. One extension officer noted, "Farming in her ward primarily occurs in open spaces and people's plots that the owners do not yet develop. This is because much of the land in the city is occupied by other things, such as houses and industries. For instance, some farmers in Kilongawima Street cultivate on road reserve areas, while others in Ununio Street farm in government open spaces, including a plot owned by the Daily News magazine".

Most urban farmers (38.9% of respondents) cultivate on freehold land given to them by the owners for free with the intention of taking care of the land (Table 5). However, due to the temporary nature of this land ownership, cultivation in the study area tends to shift from one place to another. Moreover, 85% of respondents reported conducting farming activities temporarily because they lack permanent land in the city. Only 15% of all respondents conduct permanent farming, indicating that a small minority has secured more stable land tenure for their agricultural activities (Table 5).

The highlighted challenges in this study are not unique to Kinondoni City but are prevalent in many African cities, where urban agriculture is critical in providing food and income for urban residents. Limited access to appropriate agricultural inputs, including certified seeds for improved crop varieties, pesticides, and fertilizers, is a significant challenge for urban farmers (FAO 2017; FAO 2022). This is particularly concerning as it can lead to low yields, decreased profitability, and even the discontinuation of farming activities. Therefore, sustainable agricultural practices such as seed saving, organic farming, and agroecology should be promoted to address this challenge.

The scarcity of land in urban areas has resulted in many urban farmers relying on temporary land tenure arrangements, leaving them vulnerable to displacement and limiting their capacity to make long-term investments in their farming activities. Findings from this study resemble studies by Kiduanga and Shomari (2017) which show that most of the vegetable growers in Dar es Salaam city use land temporarily, which makes them ready to move out at any time when needed by the land owners. Also, Schmidt (2011) and Malekela and Nyomora (2019) conducted a study in Dar es Salaam revealing various farm location changes due to urban sprawl leading to farmland scarcity. Land competition has become the undermining factor for sustainable urban agriculture in cities; land is scarce and expensive in urban centers (Githugunyi 2014; Tuffour 2023). Land competition with other urban land uses, such as residential, commercial, and industrial, further exacerbates this challenge (Kuang et al. 2022; Tornaghi 2014). Addressing land scarcity requires innovative land management practices to maximize productivity and ensure sustainable crop production in the face of limited available land resources.

**Table 4.** Challenges facing urban agriculture in Kinondoni City, Dar es Salaam Region, Tanzania

| Challenges facing urban agriculture | Ranking | Frequency n = 386 | Percent |
|---|---|---|---|
| Inadequate farm inputs | I | 314 | 81.3 |
| Land scarcity | II | 288 | 74.6 |
| Inadequate capital | III | 274 | 71.0 |
| Insufficient extension services | IV | 270 | 69.9 |
| Limited irrigation technologies | V | 203 | 52.6 |
| Market problem | VI | 183 | 47.4 |

**Table 5.** Nature of land ownership in Kinondoni City, Dar es Salaam Region, Tanzania

| Land ownership | Wards | | | | | Total% |
|---|---|---|---|---|---|---|
| | Bunju | Kunduchi | Mabwepande | Mzimuni | Wazo | |
| Freehold land | 16.1 | 2.3 | 13.2 | 0.8 | 6.5 | 38.9 |
| Leasehold | 9.1 | 4.1 | 7.5 | 1.3 | 4.9 | 26.9 |
| Own land | 5.2 | 1.0 | 4.7 | 2.6 | 5.7 | 19.2 |
| Communal land | 0.3 | 3.4 | 1.0 | 2.5 | 7.8 | 15.0 |

Inadequate capital is a significant constraint that impedes the growth and expansion of urban agriculture, resulting in low production levels and posing a threat to food security and livelihood enhancement in urban areas. Similar findings were observed in various studies by the World Bank (2013) and Mhache and Lyamuya (2015), which also identified lack of capital as a constraint for urban farmers, leading to low production. Insufficient capital hinders the development and expansion of urban agriculture and threatens food security and livelihood improvement in urban areas; the study highlights the need for increased investment in urban agriculture to overcome this challenge. In addition, inadequate irrigation technologies further exacerbate the challenges urban farmers face in Kinondoni City. Using poor facilities, such as buckets and hands, to irrigate crops is time-consuming and inefficient (Figure 6). Therefore, to improve production and efficiency in urban agriculture, there is a need for investment in appropriate irrigation technologies.

Effective extension services are critical for agricultural development and productivity. Inadequate extension services pose a significant challenge to agricultural development and productivity. Studies have shown that inadequate extension services are a significant challenge facing farmers in many regions. For example, Danso et al. (2018) highlight the critical role that extension services play in disseminating knowledge and providing technical support to farmers. However, when these services are limited or unavailable, farmers are disadvantaged. Farmers may lack access to vital information, skills, and resources needed to enhance their agricultural practices when insufficient extension services exist. This can result in lower yields, decreased profitability, and limited new technologies or practices adoption.

**Adaptation strategies employed by smallholder farmers**

In response to rainfall and temperature changes in Kinondoni City, urban farmers have adopted several strategies to cope with climate changes in their area, as shown in Table 6. The majority of the respondents (about 65%) reported using pesticides and fertilizers as one way of adapting to the effects of climate change. However, some respondents (3.6%) admitted using mulching to cope with the situations. About 53.8% of the respondents use irrigation systems to overcome the problem of drying crops during the dry season. Farmers use water from boreholes, and others construct dams in the riverbed to increase the amount of water for irrigation activities (Figure 7). However, some farmers claim to stop farming during the dry season because their farms are far from water sources. Digging up a deep well appears to be challenging to them and not rewarding.

**Table 6.** Adaptation strategies employed by smallholder farmers to cope with the effects of climate change on crop production in Kinondoni City, Tanzania

| Adaptation strategies | Ward | | | | | Total (%) N=386 |
|---|---|---|---|---|---|---|
| | Bunju | Kunduchi | Mabwepande | Mzimuni | Wazo | |
| Use of pesticides and fertilizers | 24.1 | 9.6 | 12.2 | 3.6 | 15.5 | 65.0 |
| Use of irrigation | 13.1 | 13.8 | 11.7 | 4.9 | 10.4 | 53.9 |
| Stop cultivating | 10.9 | 2.3 | 16.8 | 4.1 | 9.3 | 43.4 |
| Application of mulching | 1.3 | 0.5 | 1.5 | 0 | 0.3 | 3.6 |


**Figure 6.** The irrigation facilities used by urban farmers in Kinondoni City, Tanzania: A. Irrigation facilities used at Wazo Ward, B. Irrigation facilities used at Kunduchi Ward

**Figure 7.** A dam used by farmers for irrigation in the Mabwepande ward in Kinondoni City, Tanzania

The adaptation strategies practiced by smallholder farmers in the study area are more or less similar to those reported by several authors which were adopted by people for the sustainable production of various crops in different areas (e.g., Challinor et al. 2014; Kifunda 2014; Lipper et al. 2014; Malhi et al. 2021; Koné and Galiegue 2023). Altering amounts and timing of irrigation and other water management practices like drip irrigation have been suggested to be good adaptation strategies for smallholder farmers (Ndamani and Watanabe 2015; Ogundeji 2022). However, the use of irrigation systems was observed to be practiced by very few smallholder farmers. In contrast, due to a lack of capital, others could not buy irrigation facilities like water pumps and pipes for carrying water from the rivers or dams (Kifunda 2014; Mkuna and Wale 2023; Nzeyimana et al. 2023). The findings also align with Odewumi et al. (2013), who reported using irrigation, fertilizers, mulching, and chemicals to enhance crop yields in the changing climate. Some Kinondoni City farmers stopped farming for sometimes waiting for rainfall as they cannot irrigate during the dry season. The results are supported by the study conducted in Dodoma City by Namwata et al. (2015), who reported that access to quality water is expensive and therefore unaffordable by many farmers. Other studies, such as the research of Koné and Galiegue (2023), have recommended the combination of improved seed varieties, soil and water conservation practices, and the application of Biochar as one of the best innovations to adapt to climate change in agriculture.

In conclusion, the study revealed that changes in rainfall and temperature in the last 30 years have also affected activities related to urban agriculture in Kinondoni City. Farmers have witnessed an increase in pests and diseases which proves to be challenging, leading to a decline in crop quality and total harvest. Farmers who appeared to access agricultural inputs, including irrigation facilities, were seen to be better off than those who didn't. Lack of enough capital was noted to be a big challenge to most of the farmers. Thus, assisting farmers in accessing

micro-credits that are provided at low-interest rates is necessary for the commercialization of their farming activities. It will be helpful to assist them in establishing their own Servings and Credit Cooperation Societies (SACCOS). Financial assurance to farmers will enhance access to farm inputs and use of irrigation systems which are essentials in sustainable urban agriculture, especially in changing climate. The use of other crops, such as drought and salt-resistant crops, and the adoption of innovative farming techniques such as drip irrigation, rainwater harvesting, and smart agriculture practices should be encouraged to ensure the sustainability of urban farming in the changing climate. Next, research may focus on the impact of adaptation strategies on the welfare of urban farmers.

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