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Extreme weather events and their impact on urban crop production: A case of Kinondoni District, Tanzania

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Abstract

Extreme weather events are anticipated to increase the existing challenges and generate new combination of vulnerabilities, especially in developing countries. Agricultural sector is the most vulnerable due to overreliance on unpredictable rainfall. This study examined the impact of extreme weather events on urban crop production and its adaptation strategies applied by the farmers. Secondary data were collected through literature survey and primary data were collected using structured interviews, observations and focus group discussions. A total of 108 crop farmers were interviewed in two wards of Kinondoni District. The Statistical Package for Social Sciences (SPSS) version 20 was used to analyze the data and Pearson Chi-square was used to test the statistical significance between variables. The study observed that, farmers perceived extreme weather events including floods (39%), extreme temperatures (36%), and drought (25%). These extreme weather events affected negatively crop production leading damaging of crops and low yields (38%), outbreak of crop pests and disease (38%), drying of water sources (20%), and loss of soil fertility (4%). Crop farmers used various adaptation strategies such as crop diversification (28%), the use of pesticides (23%), changing of cropping patterns and planting calendar (16%), irrigation practices (18%) and replanting (10%). The study recommends for adoption of new farming systems such as vertical farming systems for better output with the use of limited water and land resources.

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Introduction

Extreme weather events are having considerable impact on urban crop production which is the major basis of food and income to a large section of the urban population. The growing occurrence and severity of droughts, floods, increased temperatures and other extreme weather events rigorously affect the crop producers in various areas. Diverse types of weather extremes are anticipated to increase and become further recurrent in a number of regions worldwide due to climate change (IPCC, 2012). There is a correlation between extreme weather events (EWE) and climate change as since 1950's, there has been increased temperatures. Climate change is affecting the intensity, frequency, and spatial-temporal extent of EWE (IPCC 2012). An increase of extreme and uncertain events is a characteristic of the most recent climate scenarios (Smith 2011; Fischer 2013). The extent of regions affected by droughts has also increased as precipitation over the land has slightly decreased while evaporation has increased due to warmer conditions. Also the numbers of profound daily precipitation events that lead to flooding have augmented. The increasing frequency of extreme weather events (EWE) related to climate change (CC) represents a severe threat to crop production (Motha, 2011; IPCC, 2007). Studies on climate modeling in diverse scenarios at both global and local scales points to a rise in the regularity of extreme weather events (Swaminathan & Rengalakshmi 2016; Solomon *et al.* (2007).

Rapid urbanization in developed and developing regions has led to increased food insecurity. One response to food insecurity is the establishment of urban crop production. In these regions, urban farming plays an important role in diversifying urban diets and providing environmental services by greening the cities and making productive reuse of urban wastes and thus making cities a desirable areas to live (Oyedipe, 2009; Mlozi *et al.*, 2014). Cities occupy a small percentage (4%) of the land globally but now are habitats for over half the global population (Potts, 2012; Seto *et al.*, 2011). It has been estimated that by the year 2050, the world's population is expected to grow to 9.7 billion people, while, about 6.4 billion people (64%) will be living in cities and thus, feeding it will be a huge challenge (UN, 2019). The increasing demand for food and the high rate of unemployment has further worsened the city situation. Traders, civil servants and artisans are finding it increasingly difficult to cope with the high cost of living due to the stagnant income in the urban areas; all these have promoted crop production within the vicinity of the city (Olayioye, 2012).

Extreme weather events associated with climate change create significant challenges for crop production in urban areas (Mlozi *et al.*, 2014). Tanzania Meteorological Agency (TMA) data shows for decrease in rainfall and increase in temperature in Dar es Salaam region over the past 30 years. It has been reported that, the total annual rainfall in 1986 was 1430.9mm, this had decreased to 782.9mm in 2016, while the minimum and maximum temperatures have increased steadily from an average monthly minimum temperature of 20.7°C in 1986 to 23.2°C in 2016 (TMA, 2017). These variations in temperature and rainfall affect crop production negatively.

The general effects of the extreme weather events on crop production are complex predicaments that require an urgent effort to ascertain efficient and sustainable managing systems (Cogato *et al.,* 2019). In the current decades, the attention of the scientific community on climate change and its impacts on various sectors has considerably augmented. The IPCC (2014) has reported for the increase in number of publications dealing with the impact of climate change on agriculture, its vulnerability and the best adaptation strategies has more than doubled between 2005 and 2010 and this increasing trend has sustained in succeeding years.

The rising interest on the impact of climate change on agriculture is due to its importance in the global economy, especially in developing countries, provided that the majority of the population depends on agriculture for their livelihood. However, the global climate change impact requires a continuous perfection to forecast and adapt to extreme weather events.

Urban farming despite of its contribution to food security; the sector has been given less attention as some scholars discourage urban farming by referring to as a ruralization of urban settings. Most studies on extreme weather events and climate change impacts on agriculture have focused on rural farming. Herefore this study tintended investigate the impact of extreme weather events on urban crop production and its adaptation strategies.

Methods and materials

The study area

The study was conducted in Kinondoni district in Dar es Salaam region. This area was selected because it is one of the districts in Dar es Salaam which is highly involved in crop production. Two wards out of the total of nineteen wards, which constituted 10 percent were selected for the study. The selected wards included; Mabwepande (Mabwe and Bunju sub-wards) and Mbweni (Mpiji and Mbweni Teta sub wards) as shown in Fig. 1.

Data collection methods

This study used both primary and secondary data so as to answer the research questions. Primary data were collected using questionnaires and focus group discussions with the crop producers in the study area. In addition, direct observations were conducted in the study area to identify different crops produced. Secondary data were collected through a literature review. The study unit consisted of 108 respondents who engaged in crop production. Also, 2 focus group discussions (FGDs) were conducted.

Crop production in urban areas contribute positively to food security, a cross tabulation was done so as to explore the association between education level and reasons for participation in crop production. The results showed that 67.6% engage in crop production for purposes of home consumption and generating income despite of their education level (Table 2). Pearson Chi-square test at 9 degree of freedom (df) was used to test if the results were statistically significant. The results showed a significant positive relationship between reasons for crop production and education level of the farmers at X^2=27.67; P Value =0.001.

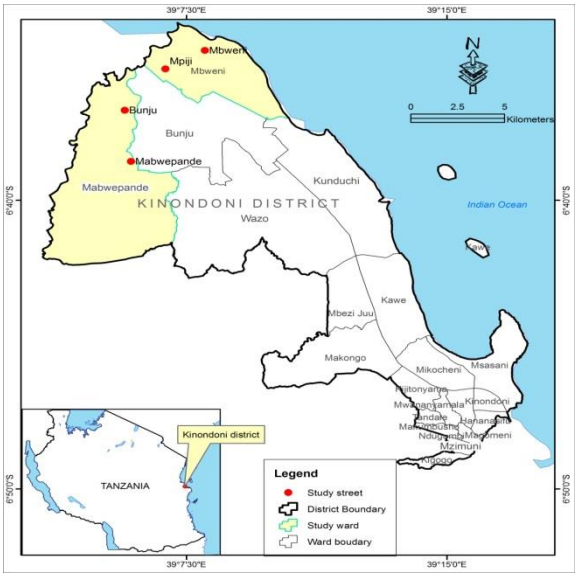

Fig. 1. Location of the study area.

Results and discussion

Profile of the respondents

The ages of the urban crop producers in the study area ranged from 15 to 65+ years averaging between 36 to 64 years as seen in Table 1.

Table 1. Distribution of the respondents by age.

Age (Years)	Responses	
	Frequency	Percentage
15-35	26	24.1
36-64	77	71.3
65 and above	5	4.6
Total	108	100

Table 2. Cross-tabulation between education status and reasons for crop production**.**

Education level	Reasons for Crop Production (%)				Total
	To get food	To get food and income	Lack of other job	To get income	
No formal education	1.9	1.9	0.0	.9	4.6
Primary education	6.5	57.4	6.5	5.6	75.9
Secondary education	2.8	4.6	1.9	1.9	11.1
Tertiary education	0.0	3.7	0.0	4.6	8.3
Total	11.1	67.6	8.3	13.0	100.0

X^2=27.67; P Value=0.001

Extreme weather events in the study area

Extreme weather events have been reported as one of the environmental threat facing the globe today. In the study area, it was observed that the majority (94%) of the crop producers admitted to have observed extreme changes in weather while 6% claimed to have not perceived any change. However, the scope of disparity among farmers on the perception and awareness of weather events in the study area was essentially due to the variations in households' socio-economic distinctiveness.

These observations supports the general view that; climate change is highly felt by the poor people than those who are economically well off due to over reliance on the natural resource base for their livelihoods (Crimmins *et al.*, 2016). Many other studies have recognized parallel annotations in different parts of Tanzania including Kangalawe *et al.* (2009); Mlozi *et al.* (2014); Mwamfupe (2014) in Kasulu, Dar es Salaam and Rufiji districts respectively. In the current study, people perceived extreme weather events in various ways including increased temperatures, drought, and floods (Fig. 2).

Floods

Floods are extreme weather events that have major effects on various sectors. In the study area, respondents (39%) admitted to have observed floods in different scales as seen in Fig. 2. The occurrence of floods is a result of heavy rainfall experienced in the study sites for some seasons. With climate change, floods have been reported in various parts of the world and thus affecting human settlements, infrastructures, crops, livestock's. Also, Human death cases from different parts of the world have been reported. In this study, respondents reported that, 30 years back, their areas did not experience intensive floods, but in the recent year's floods have augmented. In many other parts of the world, floods have been reported as one of the extreme weather event affecting their wellbeing. Studies done in India, floods were reported to be more frequent due to adverse changes in temperature and precipitation (Swaminathan and Rengalakshmi, 2016).

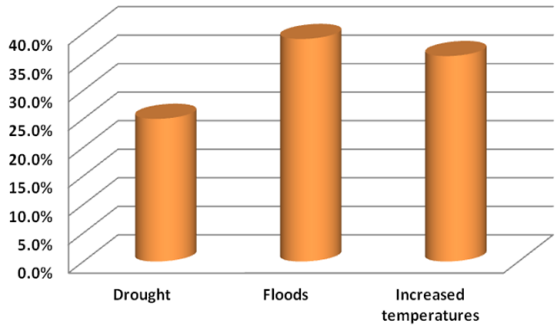

Fig. 2. Extreme weather events reported in the study area. Source: Survey data 2020

Increased Temperatures

Temperature is a fundamental ecological factor that influences the escalation and progress of plants and animals. In this study 36% of the respondents mentioned increased temperatures as one of the extreme weather event experienced in their areas (Fig. 2). The data obtained from Tanzania Meteorological Agency (TMA) for the year 1986-2016 indicated for the variations in average minimum and maximum temperature over the past 30 years. In 1986 the average annual minimum temperature was 20.7°C, this rose to 23.2°C by the year 2016. Also, the average annual maximum temperature had changed from 31°C in 1986 to 31.3°C in 2016 as shown in (Fig. 3 and Fig. 4).

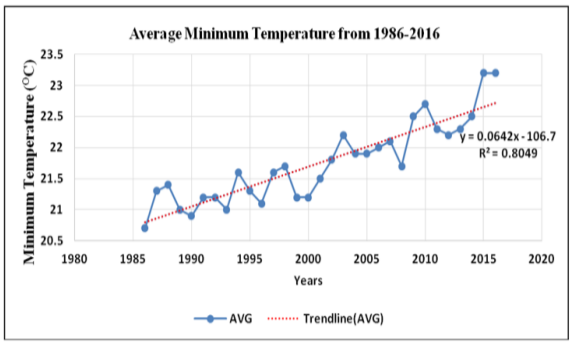

Fig. 3. Average annual minimum temperature (°C) from 1986-2016 in the study area.

Drought

Drought is an environmental anxiety which is characterized by periods of inadequate soil moisture through the growing period. During the study, respondents (25%) reported for increased incidences of drought resulting from increased temperatures, decrease in rainfall as well as increased water use.

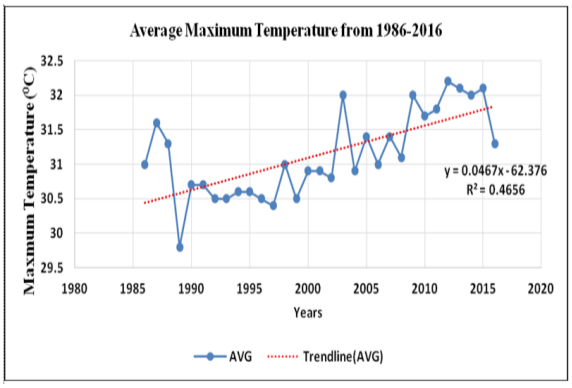

Fig. 4. Average Maximum temperature (°C) from 1986-2016 in the study area.

These findings are in line with those of Jacob *et al.* (2000) who also revealed for scarcity of water during the dry season, as the public water-supply system can hardly keep up with the requirements of the increasing population which is said to be 5.6% per year (URT, 2012). When there is scarcity of water for irrigation, farmers depend on rainfall which is not predictable.

The impact of extreme weather events on crop production in the study area

Despite of its contribution to food security, urban crop production is affected adversely by the extreme weather events such as droughts, extreme temperatures and floods. Over reliance on rain fed agriculture makes the activity vulnerable to weather events. Increased rainfall inconsistency has affected agricultural schedule and decisions over significant farming actions. The increasing frequency of EWE related to climate change (CC) represents a severe threat to crop production.

Drying of water sources

An increase in temperature adversely affects crops as excessive heat and decrease in rainfall amount leads to drought. In the current study 20% of the farmers reported for the drying of water sources thus leading to decrease in production as farmers depended mostly on rainfall. Basing on these results it is evident that extreme weather events affect the production of crops. These results tallies well with what was found by Kasimba (2012) in Zimbabwe who revealed for an increase in temperature as a threat to crop growth.

Crop pests and diseases

In the study area, 38% of the farmers reported for increased pests and crop diseases as a result of extreme weather events (Fig. 5 and Fig. 7). Several major crop pests and diseases including parasitoids and soup were identified during questionnaire survey. Many other studies have reported for prevalence of crop pests and diseases as a result of extreme weather events, all of which affects crop production systems. Vegetables are affected by bacterial leaf spot, club root, downy mildew, late blight, mosaic virus, and powdery mildew which are often spread through an insect vector. Similar results were also observed by Malekela and Nyomora (2019) who reported for various pests and diseases affecting urban crop production as a result of the changing climate.

Fig. 5. Fruits attacked by parasitoids and soup in Mbweni ward.
Source: Researcher, 2020

Damaging crops and low yields

Crop production is extremely vulnerable to the changing climate. Extreme weather events and changing patterns of precipitation have adversely impact on crop development, growth and yield of crops. In the study area 38% of the farmers reported for damaging of crops and low crop yields due to increased temperatures, drought and floods (Fig. 6 and Fig.7). Rainfall has become impulsive in the study area and therefore affecting farmers to plan for their activities. Also, lack of capacity for farmers to make proper plans on what to produce, when and how to produce has led to crop failure and thus decrease in crop yields. Various studies including (Malekela and Nyomora, 2019; Kikoyo, 2013) have reported for decline in crop yields as a result of increased temperatures, decrease in rainfall totals and floods.

Fig. 6. Tomatoes and maize affected by floods in Mbweni and Mabwepande wards.
Source: Researcher, 2020

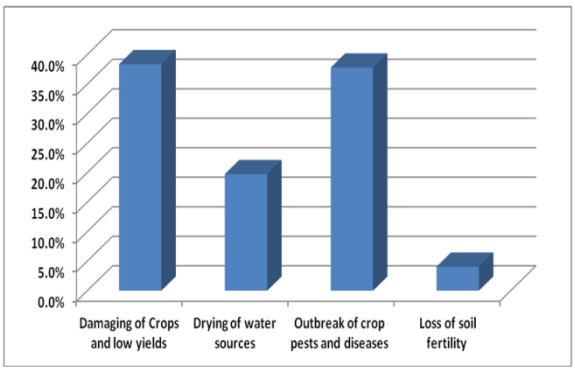

Fig. 7. The impact of extreme weather events on crop production (%).

Adaptation strategies to extreme weather events in the study area

Adaptation strategies refer to measures that communities take to alter to the impact of extreme weather events occurred. Adaptation has main three viable objectives including: to reduce exposure to the risk of damage; to develop the ability to cope with inevitable damages; and to take advantage of new opportunities. The IPCC (2007) define adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. In the study area, various adaptation strategies were reported by the farmers in response to the impact of extreme weather events.

Crop diversification

Crop diversification is a high priority adaptation measure in both irrigated and non-irrigated areas. The need for new crop varieties is exacerbated by extreme weather events. Farmers need to replace crop varieties with better-adapted ones to match rapidly evolving climate conditions. In the study area, 28% of the respondents reported to diversify the crop types as a means of adapting to EWE (Table 3). As most of the farmers produced vegetables including sweet potato leaves, okras, amaranths and pumpkin leaves, some of these vegetables such as amaranths demand enough water throughout their growth, thus with water scarcity, the farmers could grow sweet potato leaves and okras which do not demand much water for their growth. Studies done by Adger *et al.* (2003) have also documented that crop diversification has been used as one of the adaptation strategies to extreme weather events.

Table 3. Adaptation strategies to the impact of extreme weather events used by crop producers in the study area (%).

Adaptation strategies	Responses (%)
Replanting	10
The use of improved seeds	5
Irrigation practices	18
Changing in cropping patterns and calendar of planting	16
Crop diversification	28
The use of pesticides	23
Total	100.0%

Source: Survey data 2020

The use of pesticides

The Environmental Protection Agency (US EPA) defines pesticide as an active ingredient that prevents,

destroys, repels, or mitigates a pest, or is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. A pesticide may be a chemical substance or biological agent (such as a virus or bacteria) used against pests. The use of pesticides on crop production have been a hub of argument for a long time and are tied with risks to human health and the environment. However, communities accepts these risks within convinced limits due to its significance on crop production in this era of climate change and its associated extreme weather events. In this study 27% of the respondents admitted to use various pesticides such as parasitoids as a means of adapting to the outbreak crop pests and diseases as shown in Fig. 8.

Fig. 8. Local adaptation strategy to crop pests by using parasitoids.
Source: Researcher, 2020

Change in cropping patterns and calendar of planting
Extreme weather events adversely affects crop production due variations in rainfall leading to changes in cropping pattern and calendar of planting. Changing of planting date/calendar is one of the adaptation strategies used by the farmers.

In this study 16% of the respondents reported for changing in planting date so that they can cope with the changes in rainfall. This tails with the observations done by Ahmad *et al.* (2018) in Pakistan who reported for the similar method used by the farmers in adapting to the impact of extreme weather events by changing the planting calendar.

Irrigation practices
Achievement of extreme weather events adaptation depends on accessibility of fresh water in drought-prone areas. In the study area, 18% of the respondents admitted to engage in irrigation as an adaptation option during the dry seasons. Most adaptation strategies provide positive impact on crop production. As water becomes a restrictive factor, irrigation becomes an important adaptation tool, for the reason that, irrigation practices for dry area are water intensive. Many other studies done in Egypt, Kenya, and South Africa, Gambia and Sudan revealed for the similar strategy whereby a considerable number of farmers had used to adapt to rainfall variability by (Osman *et al.*, 2005).

With the increase of temperatures, farmers tend to irrigate more regularly. Irrigation practices is an evidently adaptation approach to warming, when there is an increase in precipitation, they tend to irrigate less Akinnagbe and Irohibe (2014). However, some respondents (10%) admitted to adapt by replanting in the areas which have been affected by weather events especially floods.

In such case, farmers wait until when the flooded plots of land become dry and replant the same or other crops for the second time. This method is not sustainable, as a farmer may replant other crops, then within a short period the same area might undergo flooding resulting from unpredictable rainfall.

Conclusion

Extreme weather events including floods, drought and increased temperature incidences affects negatively crop production in urban areas. All these extreme weather events led to the drying of water sources, outbreak of crop pests and diseases, damaging of crops and low yields.

The communities have developed traditional agricultural adaptation strategies to cope with the impact of extreme weather events.

The familiarity with these strategies needs to be shared among communities. These techniques include; irrigation practices, the use of pesticides, changing of cropping patterns and planting calendar, the use of improved seeds and replanting.

Recommendations

The study has shown that urban food production is affected by the extreme weather events. Thus the study recommends for the adoption of vertical farming systems which use limited water resources while giving large amount of yields instead of depending on rain fed agricultural production.

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