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Review article

Climate change and its impact on urban agriculture in Sub-Saharan Africa: A literature review

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ABSTRACT

Recent surveys have shown that the global urban population is increasing at an accelerated rate. As a result, the associated increased demand for food items has pushed up the overall cost of living for urban dwellers. To mitigate this increased cost of living urban dwellers increasingly find solace in agricultural activities. This surge in urban agricultural activities comes at a time characterized by long term shifts in temperatures, rainfall patterns and general weather conditions. While many researchers have presented evidence of increased urban agricultural activities, there remains a paucity of integrated literature that summarizes climate change issues on urban agriculture. This research reviewed literature on the influence of climate change on urban agricultural operations in sub-Saharan African cities. A narrative review approach was employed to summarize and synthesize findings and make recommendations for future research. The review employed the key terms 'urban farming', 'urban agriculture', 'climate change', 'peri-urban agriculture', and 'urban agricultural production' to search relevant literature indexed in databases: Scopus, Directory of Open Access Journals, Web of Science, Google Scholar and Academic Search (EBSCO). The choice of these keywords was informed by the authors' specialist understanding of urban agriculture and climate change. There is consensus among the reviewed literature that climate change affects urban agriculture from production to processing, storage, and distribution. This study also established that the extent and magnitude of climate change impacts differ from one region to another. Therefore, adaptation and mitigation strategies ought to be context specific and not universally applicable. This is important because Africa is a climatologically diverse continent so that the impact of climate change faced by one sub-Saharan African city may be different from that for other cities in other regions. A framework that simplifies the effects of climate change on urban agriculture-dependent households in sub-Saharan Africa was produced. More specifically, this framework is recommended to those urban farmers and policymakers that are involved in mitigating the consequences of climate change as well as achieving food and nutritional security. The authors also recommend this framework for unpacking the knowledge of the influence of climate change on urban agriculture as well as exposing directions for future research. This work adds to the growing body of knowledge in the domain of climate change on urban agriculture-dependent households.

KEY WORDS: crop production, livestock production, post-harvest losses, distribution, urban agriculture

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1. Background

Recently, the World Economic Forum (WEF) has been actively involved in reporting on urban population trends. The WEF (2020) estimated that 56.2% of the world population live in urban areas and it projects that by 2050 68% of the world population will be urban dwelllers. In Africa, the urban population increased from 20% in 1950 to 43% in 2020 (WEF, 2020). The urban population of sub-Saharan Africa is estimated to grow by 4% annually, more than the predicted world average of 1.9% (WORLD BANK, 2018). Due to harsh global economic environments and the high cost of living for most urban households, the majority of urban dwellers have resorted to seeking alternative coping

strategies and amongst this urban agriculture is dominant (MAWONEKE & KING, 1998; MASVAURE, 2016). Resultantly, there has been a rise in urban agricultural activities, for both poor and rich urban dwellers, resulting in food and nutritional security and hunger alleviation. About 40% of Africa's urban populations are engaged in urban agriculture (MHACHE & LYAMUYA, 2019). Urban agriculture, in the form of crop cultivation, or the raising of livestock in backyards, or on undeveloped plots of land, to supplement food sources, provides fresh food and offers many urban poor families a viable income. Regardless of the nutritional and economic significance of urban agriculture to households, climate change has been posing a threat. The most affected cities, are in developing countries, are arid and water-stressed, and are in coastal and low-lying cities (DUBBELING ET AL., 2019). This study is a literature review on the impact of climate change on urban agricultural activities in the cities of sub-Saharan Africa.

Climate change has also posed a number of risks in the Southern African Development Community (SADC) region with an increased frequency of disasters such as floods, cyclones, and droughts. In Southern Africa temperatures have significantly increased by 0.4°C every decade between 1961 and 2014 across the region (DAVIS & VINCENT, 2017). In the SADC region, the effects of climate change resulted in the displacement of over 500,000 individuals in 2021, the majority of whom moved from rural to urban regions in search of better economic opportunities (RAMIREZ-VILLEGAS ET AL., 2021). In recent years, the city of Durban (South Africa) has been wrecked by catastrophic floods due to amounts of rainfall ranging from 4% to 8% more intense than before (PINTO ET AL., 2022) and these changes in rainfall patterns have been attributed to climate change. On the other hand, countries such as Madagascar, Zimbabwe and Angola have experienced prolonged droughts. Climate changes have also created favourable conditions for desert red and brown locusts to reproduce and spread. Locusts reproduce faster on warm, sandy, and moist soils that are left behind by the heavy rains of tropical cyclones. The winds which accompany cyclones make it easier for the locusts to migrate (SALIH ET AL., 2020). Eastern countries, (Somalia, Ethiopia, and Kenya) and southern Africa countries (Botswana, Namibia, Zambia and Zimbabwe) witnessed the worst locust plague in the 2019/2020 rainy season, following high temperatures, rainfall and cyclone activity in late 2019 (MCCABE ET AL., 2021; GOSLING ET AL., 2020).

Climate change has been contributing to harsh environmental conditions, health crises, and disasters, posing fundamental challenges to local economies and livelihoods across the globe. Developing countries are more at risk to the adverse impacts of climate change due to their heavy reliance on agriculture (RAVINDRANATH & SATHAYE, 2002). Cities in sub-Saharan Africa have not been spared from climate change effects, as many cities have experienced floods, droughts and cyclones for example (DUBE ET AL., 2021a). Figure 1 shows sub-Saharan Africa and the World: frequency of natural disasters in the years 2000-2020 relative to the 1980s.

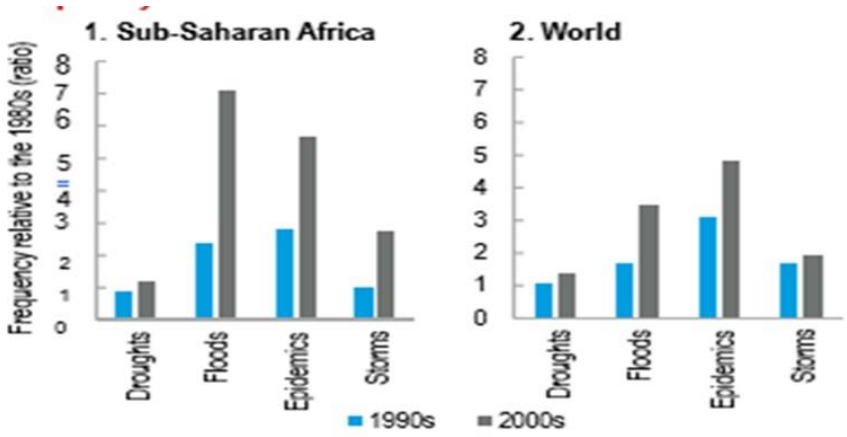

Fig. 1. Sub-Saharan Africa (1) and the World (2): Frequency of Natural Disasters Relative to the 1980s

Livelihoods of urban households cannot be improved without significantly reversing the effects of climate change and managing urban agricultural activities. This development calls for the effective articulation of climate change impacts and vulnerabilities to ensure resilience to climatic extremes by urban and peri-urban farmers in Africa. Climate change has different effects in different areas of the world. For instance, farmers in some places will suffer widespread droughts while others will receive more rainfall and experience heavy flooding (NICHOLLS ET AL., 2007). Madagascar's cities of

Antananarivo and Tuléar experience cyclones, heavy rains, and winds resulting in severe flooding while Tsihombe, a city in the same country, experiences recurring droughts (United States Agency for International Development (USAID, 2018). It is, therefore, paramount to establish the specific impacts of climate change on (peri-) urban agriculture in different urban centres. It is to the best of the knowledge of these authors that no similar study has conducted a literature review on the influence of climate change on urban farming households in sub-Saharan Africa. Therefore, the primary aim of this study was to establish and describe the impacts of climate change in (peri-) urban sub-Saharan Africa. Prior to that, this study defines the concepts of climate change and peri-urban agriculture. Focusing on agriculture in peri-urban areas of sub-Saharan Africa, the researchers ask the research question: How has (peri-) urban agriculture in sub-Saharan Africa been affected by climate change?

The rest of the article is organized as follows: Section 2 describes and justifies the search strategy used to review the literature, and section 3 describes of the study area. Section 4 is the body of the review article containing the discussion of sources and is organized thematically. Finally, section 5 is the conclusion and offers recommendations on how researchers can conduct further research as a result of this review.

2. Methods and strategy

This section describes the research strategy used to conduct a comprehensive peer-reviewed literature search. This literature review article identified peer reviewed journal articles that featured the impact of climate change on urban/peri-urban agriculture in sub-Saharan Africa. A semi-systematic, or narrative, review approach was used in the study to map this field of research, synthesize the state of knowledge, and create an agenda for further research. The researchers started the review process by searching the key words ('urban farming', 'urban agriculture, 'climate change, 'peri-urban agriculture', and 'urban agriculture production') on the multi-database, cross-disciplinary online citation services of Google Scholar. The keywords were selected based on the authors' collective knowledge of the field of urban agriculture and climate change. The authors also conducted literature reviews relying on citation tracking (snowballing) by considering literature cited by others and citation analysis obtainable from Scopus, or Google Scholar (BOELL & CECEZ-KECMANOVIC, 2014). This study includes only studies that were in peer reviewed journals in the domain of agriculture and climate change, published in English language from the year 2002 up to 2022. A total of 24 articles was identified. After the search these scholars analyzed, assessed and synthesized the identified literature, qualitatively using thematic analysis (BOELL & CECEZ-KECMANOVIC, 2014). A topic-centric approach of presenting earlier research was used as opposed to listing results from previous studies. A qualitative research software, NVivo version 12, was used to identify, analyse, and report patterns in the form of themes within the text. The reviewed articles were tabulated with column headings that included authors, the study fields, and countries of study.

3. Description of study area

Sub-Saharan Africa is a term used to describe the area of the continent of Africa that lies south of the Sahara Desert. Sub-Saharan Africa consists of all African countries with the exception of Arab Africa (GABER, 2011). Sub-Saharan Africa is shown in orange on the map in Figure 2. Sub-Saharan Africa was chosen because it is one of the geographical areas most at risk from the effects of climate change (IPCC, 2014).

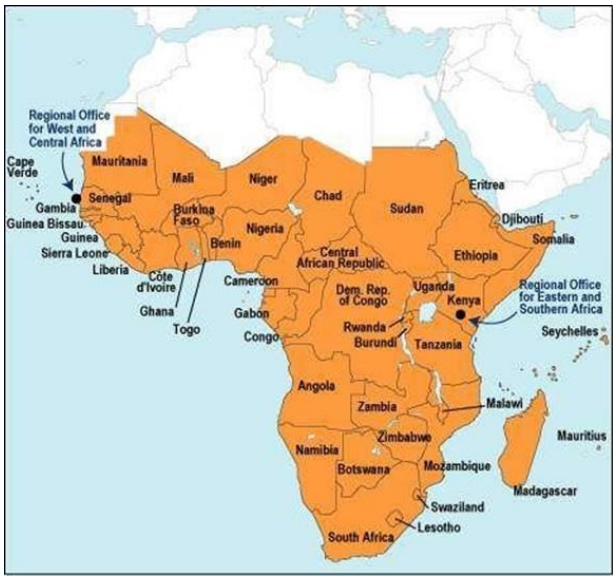

Fig. 2. Sub-Saharan Africa map

4. Results and discussion

4.1. Definition of climate change

It is of paramount importance in this study that the concept of climate change is first understood. The Intergovernmental Panel on Climate Change (IPCC, 2007) defined climate change as a "change in the state of the climate that can be identified by changes in the mean and/or the variability of its

properties that persists for an extended period, typically decades or longer". On the other hand, SHABANGU (2017) viewed climate change as a phenomenon caused by human activities through burning of fossil fuels, causing shifts in the normal climatic conditions such as rainfall and temperature. There is consensus among researchers that climate change is unavoidable and is likely to increase the incidence of natural hazards, such as droughts, cyclones, floods, and heat waves (IPCC, 2012). Climate change has been blamed for wind and temperature extremes, floods and resulting landslides, water shortages, drought and dry periods, reduced water tables, seasonal unpredictability extreme weathers, storms, cyclones, and storm surges (SIMATELE ET AL., 2012). Cities, and city inhabitants are directly, and indirectly, affected by climate change. Climate change aggravates the urban heat island effect, which results from increased residential and industrial activity and the construction of urban infrastructure (LADAN ET AL., 2022). Consequently, urban agriculture is the sector most affected by climate change especially in cities that heavily rely on agricultural food production. This study reviews a wide range of literature on this subject.

4.2. Urban/peri-urban agriculture in Africa

"Urban agriculture is an industry located in the intra-urban or peri-urban area of a town, or city, which grows crops and raises animals, processes and distributes agricultural products, using human, land and water resources, products and services found in and around that urban area" (LADAN ET AL, 2022:2). Urban agriculture is not defined by the location but by the fact that it is thrust in, and interacts with, the urban environment and its needs. It ranges from small and large areas within the city, or its outskirts, such as on plots, community gardens and balconies, rooftops of buildings or terraces. The use of urban farming differs depending on the location and environment of the city.

Urban agriculture encompasses the whole value chain running from field to fork, so in addition to crop farming and livestock production, it includes agro-processing, supply of inputs, marketing and distribution. Different cities in sub-Saharan Africa such as Bobo-Dioulasso (Burkina Faso), Lilongwe (Malawi), Cape Town (South Africa), Lagos (Nigeria), Bulawayo (Zimbabwe), Lusaka (Zambia) and Kinshasa (Democratic Republic of Congo) have adopted different forms of urban and peri-urban agriculture. The agricultural activities of city inhabitants include: animal breading, crop and flower cultivation, fish farming among other activities (LADAN ET AL., 2022). The farmers in sub-Saharan Africa are more involved in the production of short-duration crops. The most popular crops are vegetables followed by maize and cassava. However, fruit trees like oranges, grapes and bananas are not grown by many of the farmers (OLUMBA ET AL., 2021).

Some urban farmers are involved in livestock production, although it is not as common as crop production. For example, a study in Nigeria indicated that multiple farmers are engaged in poultry production (OLUMBA ET AL., 2021). Urban farmers are also involved in agro-processing of farm produce. More so, these urban farmers contribute a significant proportion of raw materials to manufacturing and distribution organization (MHACHE & LYAMUYA, 2019, 2021).

4.3. Impact of climate change on urban agriculture

This review revealed that some scholars (DUBE ET AL., 2021b; LACETERA, 2019, MALEKELA & NYOMORA, 2019; OLUMBA ET AL., 2021) have made great strides in establishing the impact of climate change on urban and peri-urban agriculture. This literature review on climate change impact on urban agriculture in sub-Saharan African cities has revealed that studies were conducted in Tanzania (MALEKELA & NYOMORA, 2019, RAPHAEL, 2015; NAMWATA ET AL., 2015), Zambia (SIMATELE ET AL., 2012), Nigeria (OLUMBA ET AL., 2021), Malawi (MATTHEW ET AL., 2021), Kenya (MCCABE ET AL., 2020), Ghana (ANAAFO & AKOLGO, 2018), Uganda (ISUNJU ET AL., 2015; KATONGOLE ET AL., 2012), Zimbabwe (DUBE ET AL., 2021b; CHEBANGA ET AL., 2018), Swaziland (SAM ET AL., 2021) and South Africa (SHEZI & NGCOYA, 2016; DUBE ET AL., 2021a). Presented in Table 1 is a summary of reviewed articles tabulated with column headings that include authors, the study fields and countries of study.

The reviewed literature has indicated that climate change either supports or destabilizes agricultural activities in sub-Saharan urban centres. An increase in climate change has adversely, or favourably, impacted urban agriculture at different stages of the agricultural supply chain, from production, processing, storage, distribution and marketing. Figure 3 shows a schematic presentation of these results which are discussed in the subsections that follow.

Table 1. Impact of climate change on urban agriculture in sub-Saharan Africa

Author	Year	Article title	Source	Country
Anaafo & Akolgo	2018	The role of urban agriculture in climate change mitigation and adaptation in Ghanaian cities	Journal of Energy and Natural Resource Management	Ghana
Bakyusa Katongole, Nambi-Kasozi, Lumu et al.	2012	Strategies for coping with feed scarcity among urban and peri-urban livestock farmers in Kampala, Uganda	Journal of Agriculture and Rural Development in the Tropics and Subtropics	Uganda
Chebanga Mukumbi, Mutetwa & Mtaita	2018	Postharvest losses to agricultural product traders in Mutare, Zimbabwe	Journal of Scientific Agriculture	Zimbabwe
Davies et al.	2021	Barriers to urban agriculture in sub-Saharan Africa	Food Policy	Sub-Saharan Africa
de Vries, Yigrem & Vellinga	2016	Greening of Ethiopian Dairy Value Chains: Evaluation of environmental impacts and identification of interventions for sustainable intensification of dairy value chains	Wageningen University & Research centre	Ethiopia
Drechsel & Dongus	2009	Dynamics and sustainability of urban agriculture: Examples from sub-Saharan Africa	Sustainability Science	Sub-Saharan Africa
Dube, Nhamo & Chikodzi	2021	Flooding trends and their impacts on coastal communities of Western Cape Province, South Africa	Geo Journal	South Africa
Dubbeling, van Veenhuizen & Halliday	2019	Urban agriculture as a climate change and disaster risk reduction strategy	The journal of field action	Global
Dube, Sibanda & Chiwara	2021	Adapting peri-urban agriculture to climate change in Bulawayo, Zimbabwe: A qualitative assessment	Cogent Social Sciences	Zimbabwe
Gillah et al.	2012	Urban and peri urban dairy farming in East Africa: A review on production levels, constraints and opportunities'	Livestock Research for Rural Development	East Africa
Guendel	2002	Peri-urban and urban livestock keeping in East Africa - A coping strategy for the poor?	UK Department for International Development (DFID)	East Africa
Harvey	2022	Climate Change Doubled the Likelihood of Devastating South African Floods Hundreds of people were killed and thousands of homes destroyed in Durban after torrential rains unleashed flooding	Natural disasters	South Africa
Isunju, Orach & Kemp	2015	Hazards and vulnerabilities among informal wetland communities in Kampala', Uganda Environment & Urbanization	International Institute for Environment and Development (IIED)	Uganda
Lacetera	2019	Impact of climate change on animal health and welfare	Animal Frontiers	Global
Ladan et al.	2022	A geographical review of urban farming and urban heat island in developing countries	IOP Conf. Series: Earth and Environmental Science	Global
Malekela & Nyomora	2019	Climate change: Its implications on urban and peri-urban agriculture in Dar es Salaam city, Tanzania	Science and Development	Tanzania
Matthew, Chiotha, Orbinski & Byomkesh	2021	Research note: Climate change, peri-urban space and emerging infectious disease	Landscape and Urban Planning	Malawi
McCabe, Barboza, Basu et al.	2020	A Weather and Bio-climatic Case Study of Desert Locust Conditions in Northern Kenya, Technical Paper: Desert Locust and Climate	International Center for Humanitarian Affairs	Kenya
Namwata, Kikula & Kopoka	2015	Access of urban farmers to land, water and inputs for urban agriculture in Dodoma municipality, Tanzania	Journal of African Studies and Development	Tanzania
Olumba, Olumba & Alimba	2021	Constraints to urban agriculture in southeast Nigeria	Humanit Soc. Sci. Commun	Nigeria
Raphael	2015	Revealing the Impacts of Climate Change on Peri-Urban Agriculture and Vegetation Cover in Dar es Salaam City, Tanzania	University of Dar ES Salam Journals	Tanzania
Sam, Abidoye & Mashaba	2021	Climate change and household welfare in sub-Saharan Africa: Empirical evidence	Food Security	Swaziland

		from Swaziland		
Shezi & Ngcoya	2016	Adaptation to the Impacts of Climate Change on Agriculture in eThekwini: A literature review	National Research Foundation of South Africa Research Report	South Africa
Simatele, Binns & Simatele	2012	Urban Livelihoods under a Changing Climate: Perspectives on Urban Agriculture and Planning in Lusaka, Zambia	Journal of Human Development and Capabilities: A Multi-Disciplinary Journal for People-Centered Development	Zambia
Zezza, & Tasciotti	2010	Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries	Food Policy	Developing Countries

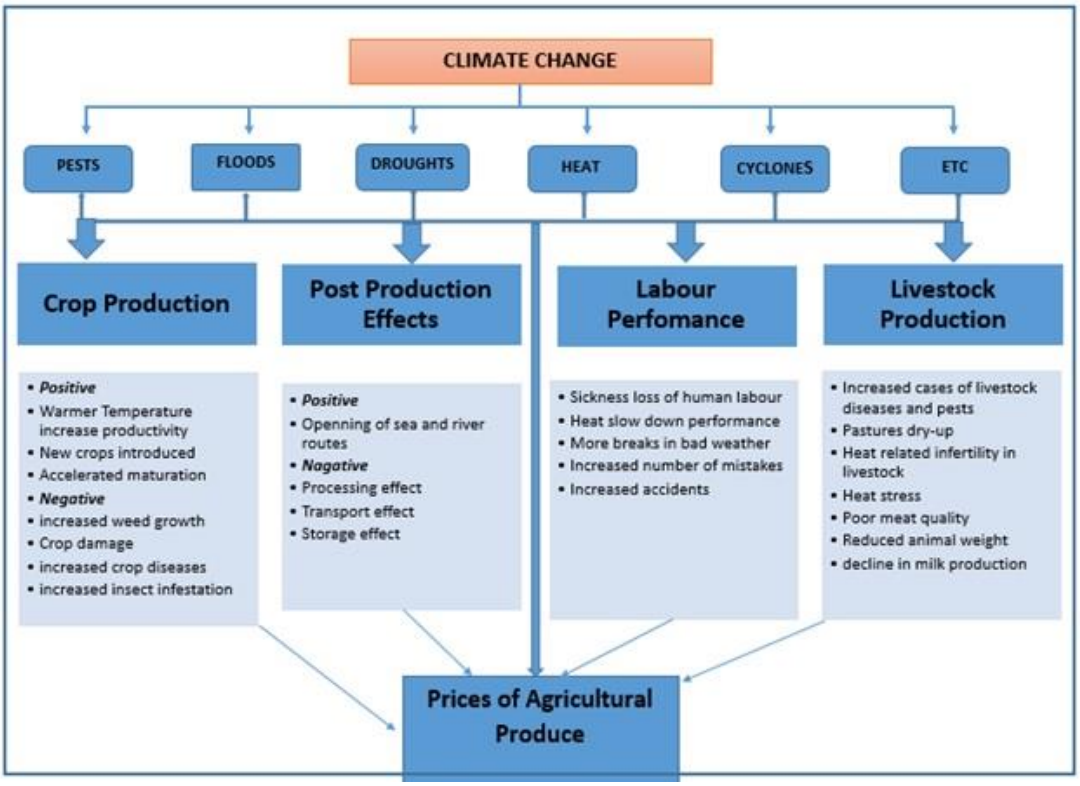

Fig. 3. A schematic presentation of the effects of climate change on (peri-) urban agriculture in sub-Saharan Africa 4.3.1. Effects of climate change on crop production

The impact of climate change varied among countries and crops and livestock. Studies show variation in the extent to which different crop and animal yields have responded to climate change effects. Climate change, through either droughts, cyclones or floods, has affected the availability of ground and surface water, resulting in poor quality crop production. Climate change exacerbates the vulnerability of cities to the disruption of critical food supplies. Changing temperature and precipitation patterns influence what crops can be grown in a given location (LOTSCH, 2007). If the rains do not fall during the critical phase of crop growth, both the crop yield and quality is reduced (NAMWATA ET AL., 2015). Reviewed studies have revealed that climate change may lower agricultural production in non-coastal areas due to a shift in agro-ecological zones in Africa (DUBE ET Al., 2021b). In an assessment of the impact of climate change on urban agriculture in Lusaka, SIMATELE ET AL. (2012) noted that the weather had been oscillating between droughts and episodes of heavy rainfall which resulted in uncertainties that are associated with climate change, making it difficult to reliably predict weather patterns. Subsequently, the shift in rainfall duration has also affected germination of rice seeds. The shorter rainy season experienced in Lusaka, Zambia, significantly affected urban agriculture activities, especially maize production. In another instance, farmers in the city of Dar es Salaam had a decrease in crop yields due to increased temperatures, water scarcity and a shift in rainfall duration (MALEKELA & NYOMORA, 2019).

Climate change in some countries (Dube et al., 2021b; Malekela & Nyomora, 2019) has reduced rainfall amounts contributing to reduction of stream flows leading to changes in growing conditions for crops, and subsequently leading to declined agricultural production. A study by Dube et al. (2021a) found that some of the recent flooding in the city of Cape Town damaged vineyards. A similar trend was observed in Dar es Salam where excessive rains destroyed urban vegetable gardens and vegetation (Raphael, 2015). Malekela & Nyomora (2019) found a decrease in crop yields in Dar es Salaam due to increased temperatures, water scarcity and a shift in rainfall duration. This study is corroborated by Dube et al. (2021b) where Bulawayo farmers faced poor rainfall and extreme high temperatures resulting in poor seed germination and scorching of the crop once it had germinated.

Conversely, an assessment conducted in eThekwini Municipality, South Africa, on the impacts of climate change revealed that heat waves and temperatures over 30°C between October to March improve condition for pumpkins, bananas, mangoes, and paw paws (Shezi & Ngcoya, 2016). Similarly, an increase in temperature due to climate change, in high-altitude areas which previously had low temperatures, allow farmers to have longer growing seasons (Praveen & Sharma, 2019).

4.3.1. Effects of climate change on livestock production

There are increased efforts to review the effects of climate change on livestock in urban areas (Anaafo & Akolgo, 2018; Lacetera, 2019; Malekela & Nyomora, 2019). These effects are suggested to be both direct, and indirect, on livestock production (Lacetera, 2019). Climate change affects the supply of livestock feed through its impacts on water supply and increases the competition for water between livestock, crops and nonagricultural uses. Livestock farmers use water to feed animals, grow feed crops, and in product processing. Anaafo & Akolgo (2018) note that urban agriculture in Ghanaian cities is faced with inadequate access to water resources that is attributed to climate change. Dube et al., (2021b) found increasing temperatures and reduced rainfalls were responsible for reduced animal productivity in Bulawayo (Zimbabwe). This is substantiated by Guendel (2002) who that found that livestock farmers in Nairobi who faced grass shortages due to dry spells consequently relied on contaminated sewerage water for grass production. In other circumstances, floods in coastal cities of the Western Cape often led to the washing away of animals (Dube et al., 2021a). Livestock production is also vulnerable to changes in grain prices due to poor yields or to changes in pasture productivity as a result of climate change as illustrated by Dube et al., (2021b) in their study in Bulawayo where poor yield of the maize crop, meant for fodder for cattle, resulted in farmers paying higher costs to acquire substitute feeds.

Climate change increases the incidence of diseases of livestock and other animals, since most diseases are transmitted by ticks and flies, which thrive in high temperatures. In Dar es Salaam, poultry diseases such as bacteria, mycoplasma, and parasites often contribute to the death of livestock due to climate change (Malekela & Nyomora, 2019). The increased temperatures and decreases in rainfall in Dar es Salaam caused various sources of grasses for feeding livestock to dry up, which lead to reduced livestock outputs (Malekela & Nyomora, 2019).

Alterations in temperatures can cause animals to be more vulnerable to diseases and raise the incidence of certain diseases, leading to an increased potential of death. Heat stress affects poultry reproduction. It is reported that heat stress causes heat-related infertility in male broilers as well as delaying the process of ovulation and a reduction of egg yok quality in chicken layers. Some studies (Malekela & Nyomora, 2019; Olumba et al., 2021) have shown that climate change has negatively impacted the health and welfare of animals. In Nigeria cities with increased temperatures and heat waves, which resulted in heat stress eventually led to diseases and death of livestock (Olumba et al., 2021). The availability and quality of drinking water and feedstuffs have also subsequently affected the health and welfare of animals. As highlighted by Olumba et al., (2021) it is projected that climate change will continue to have negative effects on livestock. Increasing temperatures have been known to affect yield as well as meat quality and shell quality of eggs in poultry production (Lara & Rostagno, 2013).

The higher temperatures have also been blamed for a decline in dairy production, reduced animal weight gain and reproduction. Contrary to that, in cooler regions positive impacts are predicted (Aydinalp & Cresser, 2008; Shezi & Ngcoya, 2016). Global warming is reducing the intensity and length of cold periods which is reducing animal feed requirements, and energy costs for heating of animal quarters (Aydinalp & Cresser, 2008). However, it is worth noting that studies on how climate change is influencing livestock production specifically in (peri-) urban areas in sub-Saharan Africa are still scarce with most of them concentrated in a few countries such as Nigeria, Kenya and Tanzania.

4.3.2. Post-production effects

Post-production losses usually occur during one of the post-production operations i.e., harvesting, handling, transportation, packaging, storage, processing, and marketing. At post-harvest insects and pests jeopardize food security throughout the developing world. Studies from eastern and southern Africa revealed that the highest proportion of food waste is encountered in post-harvest losses. In extreme cases, for example in Nigeria and Senegal, the majority of farmers experience post-harvest losses of up to 40% of their dairy products, fruits, and vegetables before reaching the end consumer (OLUMBA ET AL., 2021).

Transportation. Few studies (DE VRIES ET AL., 2016; DUBE ET AL., 2021a) have researched the impacts of climate change on transportation in urban areas. Variations in temperature and heavy rainfall may adversely affect urban agricultural transportation systems. Transportation of agricultural inputs and agricultural food outputs in urban areas may be disrupted more frequently by storms or floods. For example, Cape Town, and other coastal urban areas of the Western Cape in South Africa are often threatened by floods and road links are damaged (DUBE ET AL., 2021a). In other countries that are prone to floods and cyclones, these adverse weather conditions present a hazard to the networks at the transportation stage of the supply chain, and a lack of adequate refrigerated transport has led to the deterioration of agricultural produce. When handling and transporting raw milk, higher average temperatures, storms, and high precipitation variations have an impact on the growth of both spoilage and pathogenic microorganisms. Farmers in Ethiopian cities reported post-harvest milk losses between production and sales due to an increase in spoiling bacteria in raw milk as a result of changes in average temperatures and sunlight exposure (DE VRIES ET AL., 2016).

On the contrary, there are existing studies (PRAVEEN & SHARMA, 2019) that reveal positive impacts of climate change on the distribution of agricultural produce in urban areas. In colder latitudes, for example, increasing temperatures result in reduced winter maintenance costs and opening of sea and river routes for longer periods of the year.

Storage. Storage infrastructures are affected by extreme weather events (CHEBANGA ET AL., 2018). Noteworthy among these extreme events is increasing temperatures that lead to strains on electricity grids, air conditioning, and refrigeration, subsequently leading to high storage costs (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, 2018). Authors (CHEBANGA ET AL., 2018; ATANDA ET AL., 2011) have also discussed climate change as a contributor to increased biological and insect pest damage to agricultural produce during storage. The rate of biological deterioration depends on several environmental factors, including temperature, relative humidity, wind speed, and sanitation procedures. Higher temperatures affect the perishability and safety of fresh produce and the storage life of agricultural products is shortened (DUBE ET AL., 2021b). In general, the higher the temperature, the shorter the storage life of agricultural products and the greater the amount of loss within a given time (ATANDA ET AL., 2011).

Processing. Environmental conditions, such as humidity, rainfall, and temperature influence both the quantity and quality of a harvest (GROLLEAUD, 2002). In many African countries, the post-harvest losses of food cereals are estimated at 25% of the total crop harvested. Many (peri-) urban farmers lose their produce during harvesting due to pest infestation, while extreme wet weather conditions during harvesting may increase the moisture content of the harvested products causing decay, especially in incessant rains (KAMINSKI & CHRISTIAENSEN, 2014).

4.3.3. Prices of agricultural produce

Climate change translates to an increase in costs and prices along agricultural supply chains. This increase in food prices directly impacts most urban consumers as they mostly rely on purchasing their food. Farmers have to make significant investments to be able to improve the quality and quantity of products for their consumers. For instance, climate change has increased urban farm production costs and, in some cases, farmers have resorted to irrigating their crops resulting in increased electricity bills (DUBE ET AL., 2021b). The impact of climate change on animal product prices could come as a result of increased instability of livestock feed supply (KATONGOLE ET AL., 2012). Extreme climate conditions such as drought, floods, heavy storms, and cyclones, may negatively affect crop production, reduce arable land and restrict animal access to pastures (DUBE ET AL., 2021b). Seasonal availability and sometimes unavailability of stock feeds have resulted in farmers paying increased costs of feeds in Addis Ababa, Ethiopia, and Kampala in Uganda (GILLAH ET AL., 2012). Research on climate change and prices of urban agricultural produce is still scarce. The direct and indirect effects of climate change on prices of both agricultural inputs and produce in many cities in sub-Saharan Africa are still to be fully identified or understood.

4.3.4. Effects of climate change on labour performance

Numerous direct and indirect consequences of climate change have an impact on labour performance. Urban sub-Saharan Africa's dependence on high levels of human labour in agriculture exposes agricultural workers to the harsh weather caused by climate change, which reduces labour productivity. These impacts relate to temperature, floods and storms, ultraviolet radiation, and air quality. Farmers in drought-stricken areas are forced to irrigate their crops in the intense heat, which forces them to hire more labourers and raises labour expenses (DUBE ET AL., 2021b). People who work in the agricultural supply chain are more likely to contract infectious diseases including cholera, salmonellosis, and malaria as a result of the heat stress brought on by climate change. Heat stress is projected to reduce total working hours in Africa by 2.2% by 2030 (ISUNJU ET AL., 2015). For instance, significant rains and high temperatures both enhance the likelihood of disease transmission. More so, diseases and pests have become more common as a result of climate change, and some farmers now use hazardous farm chemicals that are detrimental to the health of farm workers. This is supported by research from Malawi that demonstrates how extreme weather conditions brought on by climate change are a factor in the emergence of infectious illnesses in peri-urban areas (MATTHEW ET AL., 2021). Another study that shows how disease vectors and communicable diseases affected agricultural activity in Kampala (Uganda) as a result of flooding, waterlogging, and dampness lends more credence to this (ISUNJU ET AL., 2015). However, our analysis found that very few studies (ISUNJU ET AL., 2015; DUBE ET AL., 2021b; MATTHEW ET AL., 2021) have specifically examined how climate change has affected the availability and productivity of agricultural labor in (peri-) urban areas of sub-Saharan Africa.

5. Conclusions and suggestions for future research

This article has explored the literature on climate change and urban agriculture in sub-Saharan Africa. Urban agriculture and climate change are two phenomena that have received attention from both academics and practitioners. The impacts of climate change are reported in all sectors; however, they scantily capture the impact of climate change on agriculture in urban areas. While there is consensus that climate change affects urban agriculture from production to processing, storage, transport and marketing, the extent and magnitude of these impacts differ from one region to another. It is evident from this review that climate change has both positive and adverse impacts on urban agriculture in sub-Saharan Africa. Large uncertainties remain as to the nature, extent and magnitude of these impacts. Simultaneously, adaptation and mitigation strategies are context specific and not universally applicable. Africa is a climatologically diverse continent and the impact of climate change faced by one sub-Saharan African city may be different from how it would affect cities in other regions. Based on the findings of this study, it is recommended that localized studies on the impact of climate change be conducted to benefit farmers, governments, companies, development banks, donors, and other organizations. More so, the effects of climate change need to be considered along with other factors that affect agriculture, such as the economics of the country, the crop and animal species, land tenure and technology. This is expected to assist in formulating climate change intervention and adaptation strategies. It is also expected to offer theoretical contributions, with the aim of advancing academic discourses and thinking, policymaking and execution of climate change intervention strategies in urban environments in sub-Saharan Africa. There is a need for greater empirical evidence and quantification of the impact of climate change in cities. Therefore, further research is needed to identify local impacts and to suggest locally appropriate mitigation and adaptation strategies, as well as a change in policy approach to encourage and implement mitigation strategies.

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