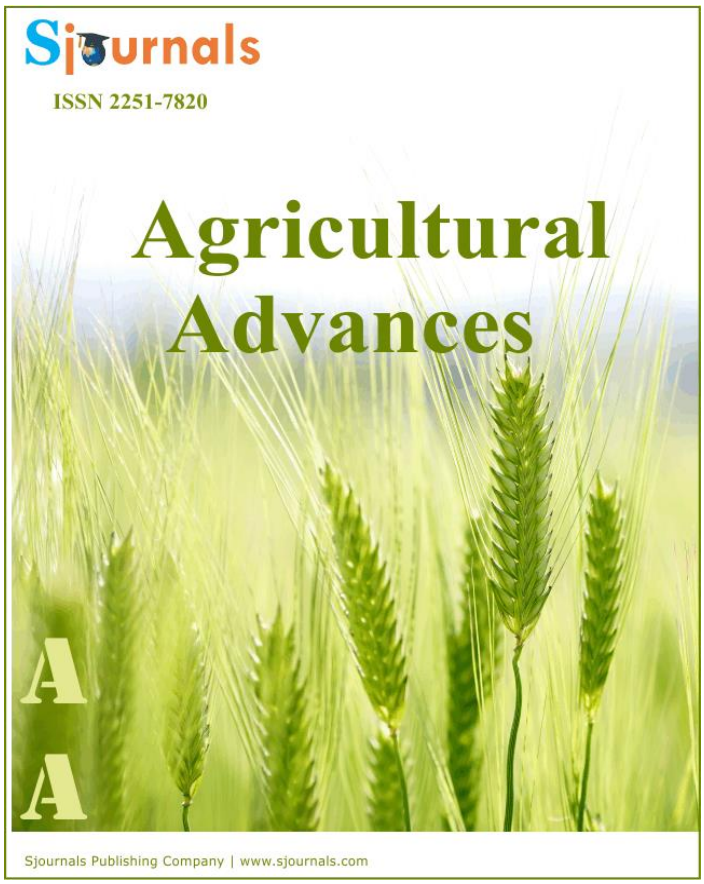

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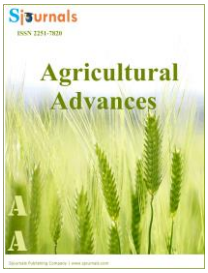

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Review article

African agricultural research and development in support of food production in the African food systems

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ABSTRACT

African agricultural R&D is a decisive component of agricultural and food production in African food systems (AFS). However, despite efforts to conduct agricultural R&D through the decades, its impact on the continent's food systems has been questioned due to its shortcomings in generating visible agricultural production gains. African agricultural R&D initiatives have failed to address the perennial food production problems and improve African food systems. These concerns need to be addressed by making food systems more efficient, inclusive, and resilient through re-examining African Agriculture's R&D agenda. The realignment of the African Agricultural R&D that focuses on the agriculture and food production needs of the greater small-scale farming sector who are the majority becomes critical in improving the continent's food systems. On the other hand, due to the advent of climate change, any Agricultural R&D that target the promotion of local animal genetic resources will minimize exposure of the smallholder farming sector more to climate change risks. Mini-livestock is a small niche in smallholder agriculture that can contribute immensely to smallholder agriculture food production package. Of late urbanization has been a real demographic threat that seems to be consuming Africa, hence cannot ignore. Regularized program of action grounded on appropriate African Agricultural R&D initiatives will

enable urban agriculture to significantly contribute to the optimization of urban food production on a sustainable and environmentally sound basis. However, Africa should be wary of any inappropriate prescriptive agricultural R&D agendas that miss the intended benefits to enhance its food production capacity later on improved African food systems. The purpose of the discussion is to explore how African agricultural research and development can support food production initiatives in the AFS.

1. Introduction

For Africa, population growth is expected to remain the dominant driver of agricultural food demand. Here, there is a need to boost food production through research and development to keep up with the rapid population growth on the continent. By 2050, Africa will experience the largest population growth, which is approximated at 1.3 billion people, ranked the highest compared with other regions in the world (Lazuta, 2013), and continue growing to 4.5 billion by 2100, hence the implications for food demand are unfavorable. The food situation on the continent is expected to worsen due to the emerging climate change effect on agriculture and food production. Climate change is the greatest challenge that could bring down agricultural productivity considerably in Sub-Saharan Africa due to its vulnerability and low adaptive capacity (IPCC, 2007). The combination of advancing climate change and already vulnerable African food systems pose a calamitous situation that threatens small-scale farmers' agriculture and food production and livelihoods and Africa's food supply. According to United Nations Environmental Program [3] small scale food producers produce 70% of the total global food production[3], while constituting the majority of food producers making up to 80 percent. This implies that agricultural R&D targeted on small-scale agriculture and food production will have a considerable impact on African food systems and might be one of the solutions to offset Africa's food crisis. It has been approximated that small-scale farms represent 80% of all farms in Sub-Saharan Africa (NEPAD, 2013). By examining the factors that are associated with small-scale agriculture and food production, agricultural R&D policy can be better informed and tailored to respond to the challenges of food production among this important group of producers. This study explores the missing links in agricultural research in addressing food production and improved African food systems include, but not limited to the following issues: agricultural R&D priorities incompatible within the realities in African food systems, refocusing on climate-smart agricultural R&D, intensification of the development and promotion of indigenous animal genetic resources as an important initiative in smallholder agrarian food production systems and regularization of urban agriculture. This study explores these areas as they relate to agricultural R&D, in this case, initiatives, and its failure to spruce agricultural food production, which is an essential requisite to improved African food systems.

2. Human population, food production and African food systems dynamics

As Sub Saharan Africa faces a future of increased population and climate change, the current challenges of agriculture and food production and hunger will only become more salient. For Sub Saharan Africa, the population is projected to double by 2050, growing at 2.7% a year, which is more than twice as fast as South Asia (1.2 percent) and Latin America (0.9 percent) (United Nations, 2004). Figure 1 shows the extent of growth of the world population in developed countries against the developing countries. There is a clear indication that developing countries will experience greater population growth than developed countries. If Africa does not step up its food production agenda, the number of hungry people on the continent will increase as the years' progress to 2100. At present 20 percent of all citizens in Sub Saharan Africa are considered undernourished and 277 million people out of the continent's 1.28 billion population faces severe food insecurity (Henderson, 2020), while in 2019, 21.3 percent of the Sub-Saharan Africa population experienced severe food insecurity (Sasu, 2021).

For Africa, population growth is expected to remain the dominant driver of total agricultural food demand in the future. Here, there is a need to boost food production to keep up with the rapid population growth on the

continent. The explosive population growth will put more pressure on Africa's food supply. This case is disturbing because food production on the continent is already under threat from multiple stressors, namely, shortage of fresh water, soil depletion, and climate change. The UN Food and Agriculture Organization (FAO) approximates that farmers will have to produce 70 percent more food by 2050 to meet the needs of the world's expected 9-billion-strong population (UN, 2015).

Sub-Saharan Africa is ranked the lowest in terms of agricultural productivity and the highest percentage of people living in poverty in the world (World Bank, 2007). Africa's agricultural productivity is low, averaging 300 to 500 kg/ha compared to 2.5 tons/ha in the United States, for example. To a great extent, sunken yields are a result of poverty. Figure 2 shows how Africa featured in the world per capita food production; it has been the least on the global food productivity landscape. Because of low productivity, Africa holds the largest proportion of food-insecure people, with one in four people undernourished and 16 percent of the population in developing countries remains undernourished (UN, 2009). FAO (2010) estimates that if current trends continue, the percentage of hungry people in the developing world will be 13% - shy of the targeted 11.8% mark (half of the estimated 23.6% figure from 1990-1992). Latin America and East and Southeast Asia have made dramatic improvements to reduce their regional hunger rates, for Sub-Saharan Africa lags (IFPRI, 2009). Roughly one-quarter of all people in sub-Saharan Africa remain undernourished. For years, many pundits have wondered why Africa seems increasingly unable to feed itself, despite having much of the world's remaining unutilized arable land.

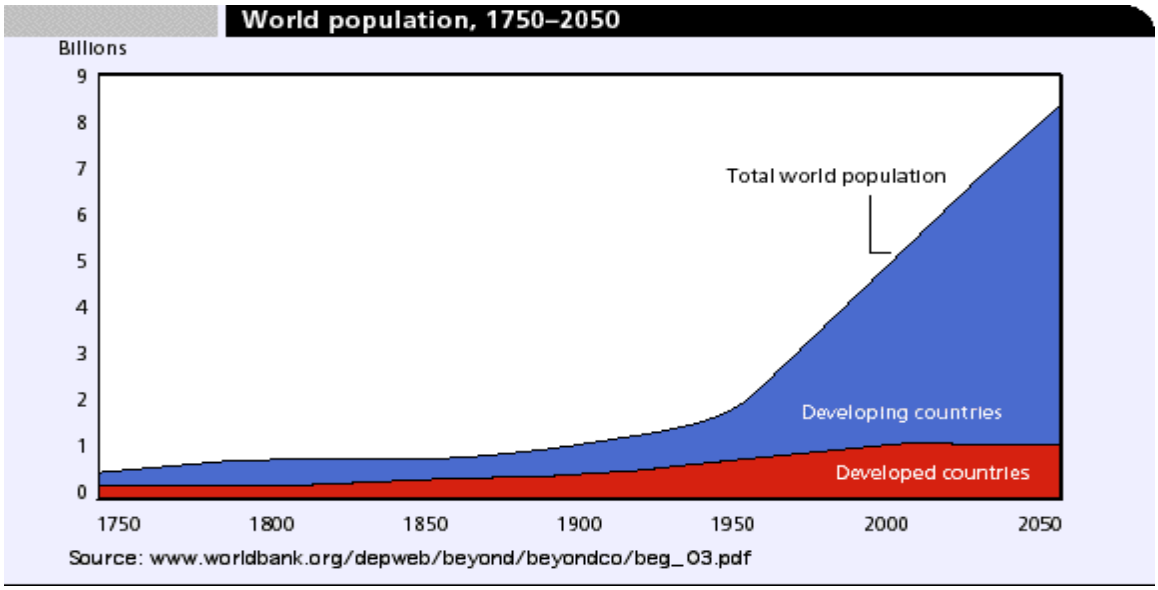

Fig. 1. World population growth 1750-2050.

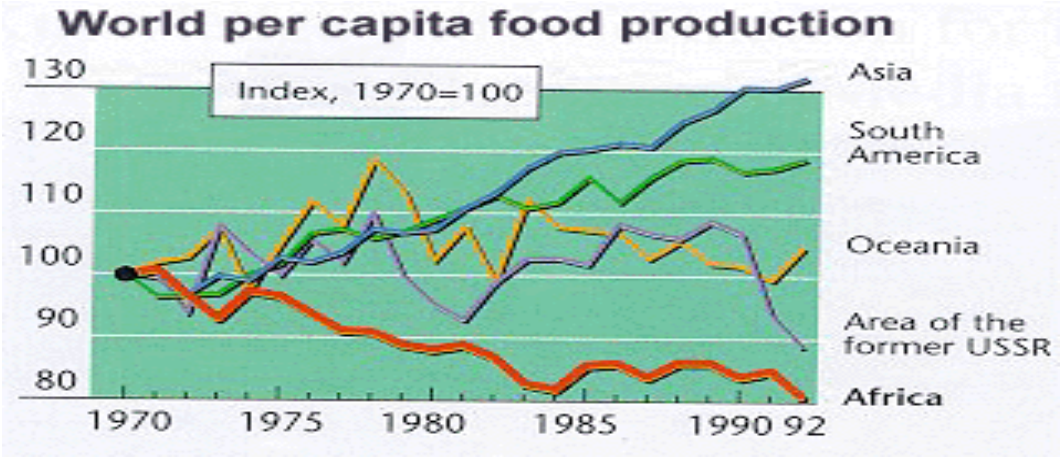

Fig. 2. World per capita food production per region.

3. Agricultural R&D agenda and African food systems

Small-scale producers are the dominant participants in food production in African food systems as a result maximum benefits for African food systems, research and development themes should be derived from a multiplicity of constraints which characterize small-scale farming systems. During the past five decades' agricultural collaboration on agricultural R&D on food production with external partners has played a pivotal role in the development and dissemination of agricultural food production technologies in Africa, however, despite all this effort, Africa remains hungry, why? The pertinent question is will this collaborative work, why is the agricultural production still low on the continent? Agricultural production science and research have been growing for decades, however, despite that Africa need not lose focus on the need to adopt a research agenda that enables agricultural science and research to interact and collaborate with its larger smallholder-farming population. A major effort is needed to enhance food production and improve African food systems through strong continental agricultural R&D agendas, - an effort that requires innovative strategies by Africans themselves and support by international development partners based on themes compatible with the realities of agricultural production issues on the ground. Here, Africa should be wary of any inappropriate prescriptive agricultural R&D agendas that miss the intended benefits to enhance its food production capacity later on improved African food systems.

External agricultural R&D agendas that has not been thoroughly scrutinized will likely pose some challenges as an outcome of the research. This is despite their excellent presentation, while the implementation may fail to meet the actual intention. To give a good example in this regard, is the crossbreeding of exotic and indigenous animal genetic resources, most programs on crossbreeding across Africa have been abandoned due to their disastrous outcome. crossbreeding per se has many benefits if the implementers have adequate resources such as land, water, nutrition, and improved management, and these factors are not obvious in African agriculture. Crossbreeding is a relevant example where African Agricultural Research suffers from prescriptive external research agendas, which are weaned from the real issues concerning the smallholder farmers' research gaps as a result the benefits for improved production are missed. Any agricultural R&D agenda that is meant to enhance agricultural production to improve African food systems should start with a systematic understanding of how critical factors of the agricultural research system impact its capacity to produce, diffuse and use for its food systems improvement. This move helps ensure the agricultural production of scientific evidence that is based on critical analyses of Africa's food systems development and policy challenges. Misappropriated agricultural research agendas will miss the opportunity to accelerate the drive for food production in turn improves the African food systems.

The agricultural R&D agenda should be based on known local research gaps, such research will have any impact on food systems improvement. This implies appropriate research diagnosis should be carried to verify the applicability The Agricultural R&D agenda before implementation; hence the research outcome will have relevancy on the issues be delving African food systems. Most of the African Agricultural R&D agendas in African food system improvement exist, they partly overlap an indication that researchers do not completely understand the African food systems and may emanate due to various reasons. Agricultural R&D agendas should take into account he different socio-economic, cultural, and environmental conditions which influence the outcome of any research. Most community-based Agricultural R&D agendas suffers from a lack of understanding of socio-economic, cultural, and environmental conditions factors as a result failure of R&D to generate visible gains.

Excellent agricultural research proposals meant to improve African food systems have fallen short of their applicability to the continent's food systems. Various possible reasons include a) major partners who do not understand African food systems prescribe inappropriate research agendas which African food experts blindly follow. In certain cases, African food systems research experts are to blame, they propose what they know the international agricultural research partners will fund although it's not of any significance in the improvement of the food production systems.

4. Climate-smart agriculture research and African food systems

Sub Saharan Africa is the most vulnerable continent to climate change (UN, 2021) and the complexity of the vulnerability of agriculture to climate change on the continent is driven by the interaction of various processes such as biophysical, economic, socio-cultural, geographical, ecological, institutional, technological and governance and can together reduce farmers' agricultural adaptive capacity (Nyasimi et al., 2014). Climate-smart agriculture

research is the solution to counter the impacts of climate change in turn offering the highest returns on agricultural research investments. This implies that climate-smart agriculture practices are feasible options to offer the best chance to enhance agriculture and food production and security in African food systems, while imparting resilience and adaptive capacity in the long term. It has been noted that farmers are already adapting to climate change, and now the question lies on what kinds of climate-smart agriculture research investment and how much is needed to enhance farmers' adaptive capacity, and what can be done to increase adoption and scale up climate-smart agriculture practices. Climate-smart agriculture research and development will unlock Africa's agricultural and food production potentials for transformation to scale.

Climate change is a substantive modification in global temperature, precipitation, wind patterns, and other factors of climate that arise over many decades or longer. These alterations will continue to frustrate the agriculture and food production in African food systems with implications that much wider the effects on the environment. The risks associated with climate change on agriculture and food production in the African food systems will be attested most directly through its influence on crops, livestock, soils, weeds, and insects, and diseases to the components of the climate to which they are most responsive. Rainfall and temperature are the climate change drivers that are the most sensitive to change across agriculture and food production in African food systems. Because Africa food systems depend on small-scale producers, the continent will increasingly become vulnerable to a spectrum of emerging climatic risks and challenges with the likelihood of reduced food per capita production. Not only does the occurrence of climate change threaten the fragile food production systems, but small-scale farmers are to maintain more subsistence-oriented agriculture and food production practices, thus causing smallholder poverty (Dercon, 2009) and food shortages to persist. Due to Africa's small-scale rural farmers' high reliance on climate-dependent agriculture, are inclined to be more vulnerable to climate change incidences of extreme weather changes. Africa is vulnerable to climate change because of limited resources and incapacitation for mitigating and adapting to the effects of climate change (Harvey et al., 2014).

The union of advancing climate change and a fragile and vulnerable African food system is an "impeccable storm" that jeopardizes agriculture and food production and Africa's food supply. Addressing the impending threats accentuated by rapid climate change requires a fundamental shift in the African R&D agenda that can buffer African agriculture and food producers from climate damage and assist make agriculture and food production more resilient and sustainable for the long term. Climate change with expected long-term changes in rainfall patterns and shifting temperature zones is expected to have significant negative effects on agriculture and food production in Africa (DFID, 2004; Kinuthia, 1997). The effect of climate change on food production is broadly in the form of both direct and indirect impacts, hence the reduction in agricultural activities. FAO's (2018) projection is that Africa should double its food production by 2050 to feed the impending huge population growth to avert the food crisis. However, attaining such a target becomes problematic because there is the mounting opposite impact of climate change that is anticipated to considerably reduce food production capacity on the continent. This case becomes even critical because Africa's reliant on the small-scale food production sector which is the most vulnerable agriculture sector to climate change. Therefore, Africa design and implement climate change-related agricultural research and development innovative strategies to support food production to meet the demand of the continent's growing population.

Long-term impacts of climate change on food systems will be most heavily felt in smallholder agriculture resource-poor with fragile food systems and rural economies. The smallholders constitute the backbone of global agriculture and therefore extremely important for ensuring the food and nutritional security of the ever-increasing population, which is 9.5-10 billion by 2050. Nevertheless, the most vulnerable group in terms of adaptation and mitigation to the increased frequencies and intensities of the adverse effects due to climate change and therefore jeopardizing agricultural sustainability as a whole. Due to the climatic change in African food systems, especially the component of food production will continue to face many challenges that threaten its viability. Hence there is a need to target agricultural R&D agenda that has a potential of an inclusive mitigative thrust in confronting climate change in African food production systems. Climate change mitigation R&D in both crops and livestock should take the central stage in defining African food systems, there is a greater need to focus on smart climate-smart agricultural research. This case will be in addition to the stress on what type of livestock species and crop to promote in the production chain. The promotion of adapted livestock species and crop varieties in local communities will be critical in sustaining food production in the advent of climate change. Climate-smart animal agriculture should target promoting local animal genetic resources, because the use of exotic animal species that

cannot easily adapt to the climate change effects on the continent, expose smallholder to more to climate change risks.

5. Agricultural R&D, small-scale producers, and African food systems

Small-scale rural agriculture and food production systems continue to play a key role in African food systems. Africa's food systems are heavily dependent on small-scale traditional agricultural and food landscape characterized by mosaics of small-scale poor resourced farmers working on small land units designated as family farms for their agricultural and food needs and livelihoods. The improvement of African food systems can be more rapid if the agricultural R&D agenda is targeted on the smallholder-farming sector. Agricultural R&D agendas need to be strengthened to support smallholder agriculture production with an emphasis on improved African food systems. It is essential to identify agricultural R&D agendas that have a capacity effect outcome to spruce agricultural production and supply sufficient food in reasonable balance to the people's requirements to overcome their food limitations in sound agriculture production and sustainable ways. The prospects for improving African food systems are reduced because of continued low production in subsistence agriculture, which has implications on trends of industrialization and however not forgetting the rapid rates of African population growth and raging urban population. Therefore, any agricultural R&D strategy that is modeled on enhancing food production in smallholder agrarian systems will have an immensely positive impact on African food systems. Enhancing the agriculture and food production capacity of small-scale serves as the entry point to meet the food demand of the growing population in Africa.

The agriculture and food production choices by small-scale farmers make and their outcomes will impact on different African food systems. Therefore, African R&D policies and investments that are targeted at strengthening small-scale resource-poor farming systems will be pivotal to sustaining food production and improving African food systems. In most cases, the African Agricultural R&D agenda has suffered from a fragmented and incoherent policy in the areas of small-scale agriculture and food production. An attempt should be made to improve agriculture and food production in sub Saharan Africa, this can only be achieved through agricultural R&D agendas that support production in small-scale farming sector by making the sector more vibrant, sustainable, and reliable.

6. Smallholder farming, indigenous animal genetic resources and Africa food systems

The Smallholder agriculture sector is the habitat of the largest populations of livestock and poultry types in African food systems, and most of these are of indigenous animal genetic resources group. It is common knowledge that management of indigenous livestock and poultry types is a dominant agricultural activity in the smallholder agriculture sector in Africa, which is considered a key asset for the most rural population and contributes to the livelihoods and nutrition of purely subsistence households. Despite their low productivity they have continued to support the African subsistence food systems, of interest is that some of the animal groups are increasing in the population regardless of the adverse effects of climate change. The local animal genetic resources have been neglected when it comes to agricultural R&D, despite their critical role in food production. There has been a conspiracy to undermine the usage of the local animal genetic resources which has been effectively done through lack of R&D support toward this class of animals. With the impending adverse effects of climate change on agriculture and food production, the future of animal agriculture is hinged on the development and promotion of local animal genetic resources. Many measures need to be explored to make the smallholder livestock systems become the driving forces of African economies. Some of the strategic steps that can be adopted for future viable smallholder livestock production systems include the following: promotion of gender equality and equity in smallholder livestock production systems, and intensifying activities that support or encourage the usage of indigenous livestock genetic resources in smallholder livestock production systems. Therefore, it is against this background that livestock species that remarkably possess distinctive qualities enabling them to excel efficiently in the context of the uncertainties of climatic variability need to be promoted to reduce vulnerability in smallholder livestock production systems. By improving and expanding African food systems production segments-poultry, livestock, crop, fisheries-smallholder farming sectors become the hubs of improved food systems.

7. Mini-livestock, small-scale producers, and Africa food systems

Mini-livestock is the little-known small animals however with potential socio-economic and environmental benefits. The major groups of mini livestock species that have shown promising attributes for food security include chickens (poultry), domesticated rabbits, beekeeping, snail production, rodents, guinea pigs, pigeons, and many others found in different parts of the world. The potential for mini livestock to contribute to agriculture and food production is through their easy integration or as part of agricultural diversification in smallholder agriculture. The rural food landscape can improve immensely through the promotion and development of mini-livestock. However, many R&D initiatives have been conducted to document the production of mini livestock. Mini-livestock is a small niche in smallholder agriculture that can contribute immensely to smallholder agriculture food production package. Given the economic, social, and ecological advantages of mini livestock farming, it is arguably deserving even greater attention. Mini livestock production apart from acting as a food source has diverse economic and social functions in African food systems. The conventional livestock production sector has been facing multiple challenges because of the rise in the human population, urbanization, and climate change. This trend has led to a rise in demand for livestock products, which means meat productivity or the number of meat animals will have to increase to meet the animal protein demand.

8. Agricultural R&D, urban agriculture and African food systems

Africa is currently experiencing rapid urbanization with far more implications on its food landscape, and food systems, hence the need to take agriculture to the urban areas. Urban agriculture can positively change the African food production landscape, and food systems. The concept is that agricultural and food production should be pursued in cities themselves, where the population is expanding. Due to rural-urban migration, the urban population in Africa is increasing considerably concerning the general population (Awumbila, 2017), and by 2025, nearly 55 percent of Africa's population will be found in urban centers, compared to 30 percent at present (FAO, 1994). Figure 3, shows the extent of rural versus urban population growth in developed versus underdeveloped countries. This demographic change will create a huge food demand in urban areas, as a result, if food production supply is not enhanced will result in food shortages in urban areas. The proposition is the efficiency of food supply will be dependent on bringing food production to the urban setup, hence, the need to regularize urban agriculture. A probable intervention on the food production supply side is to devise an agricultural R&D agenda that supports food production in urban vicinity.

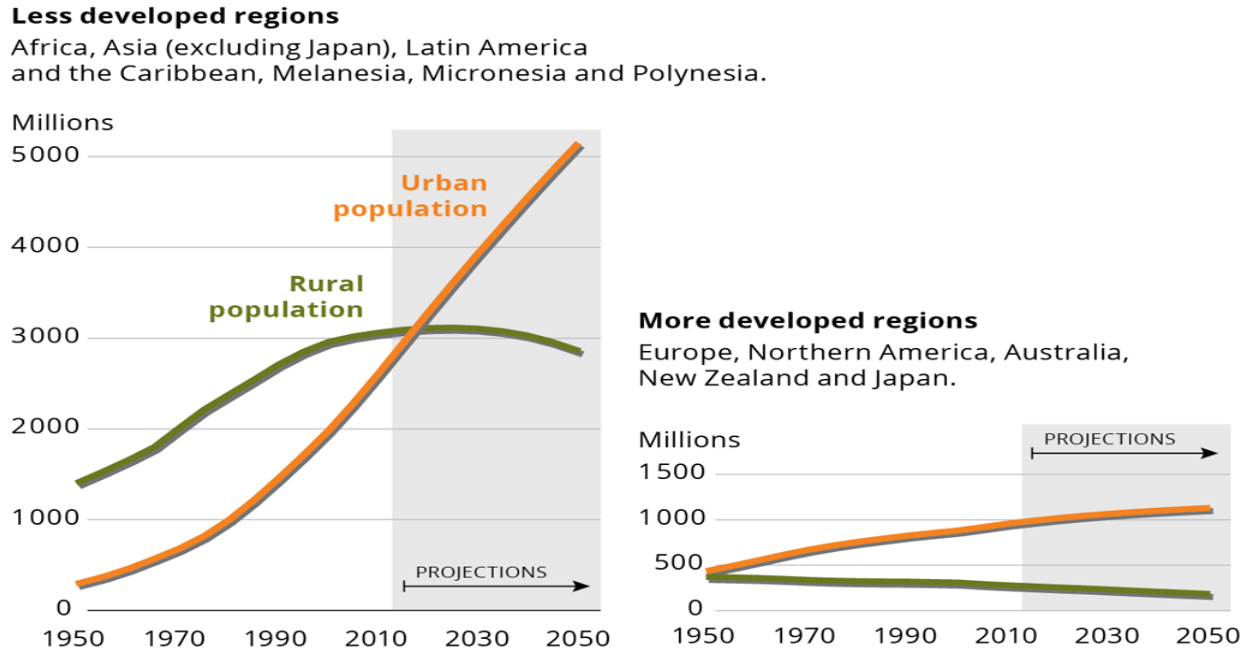

Fig. 3. Urban and rural population in developed and less developed regions.

Urban agriculture proffer multiple benefits (Figure), apart from urban agriculture supplying fresh food and nutrition, it proffers various socio-economic and ecological benefits. Many employment opportunities for the growing urban population, with the possibility of playing a major role in vitalizing the food supply chain. Bringing agriculture and food production to urban areas facilitates the shortening of the food supply chain, which is vital to improve African food systems. Urban agriculture shows great potential in the fulfillment of basic human needs, it not only provides food but also ensures a sustainable distribution and production system thereby creating employment opportunities, and regular income for individuals. The figure 4 shows that apart from agriculture and food benefits, urban agriculture provides other benefits, namely, environmental, economic, and ecological benefits. Restoration of biodiversity is one of the important environmental benefits of urban agriculture. Horticultural plants are cultivated in these gardens, such as ornamental crops, herbs, medicinal plants, flowers, garlic, and different types of vegetables (Chazovachii and Mutami, 2013).

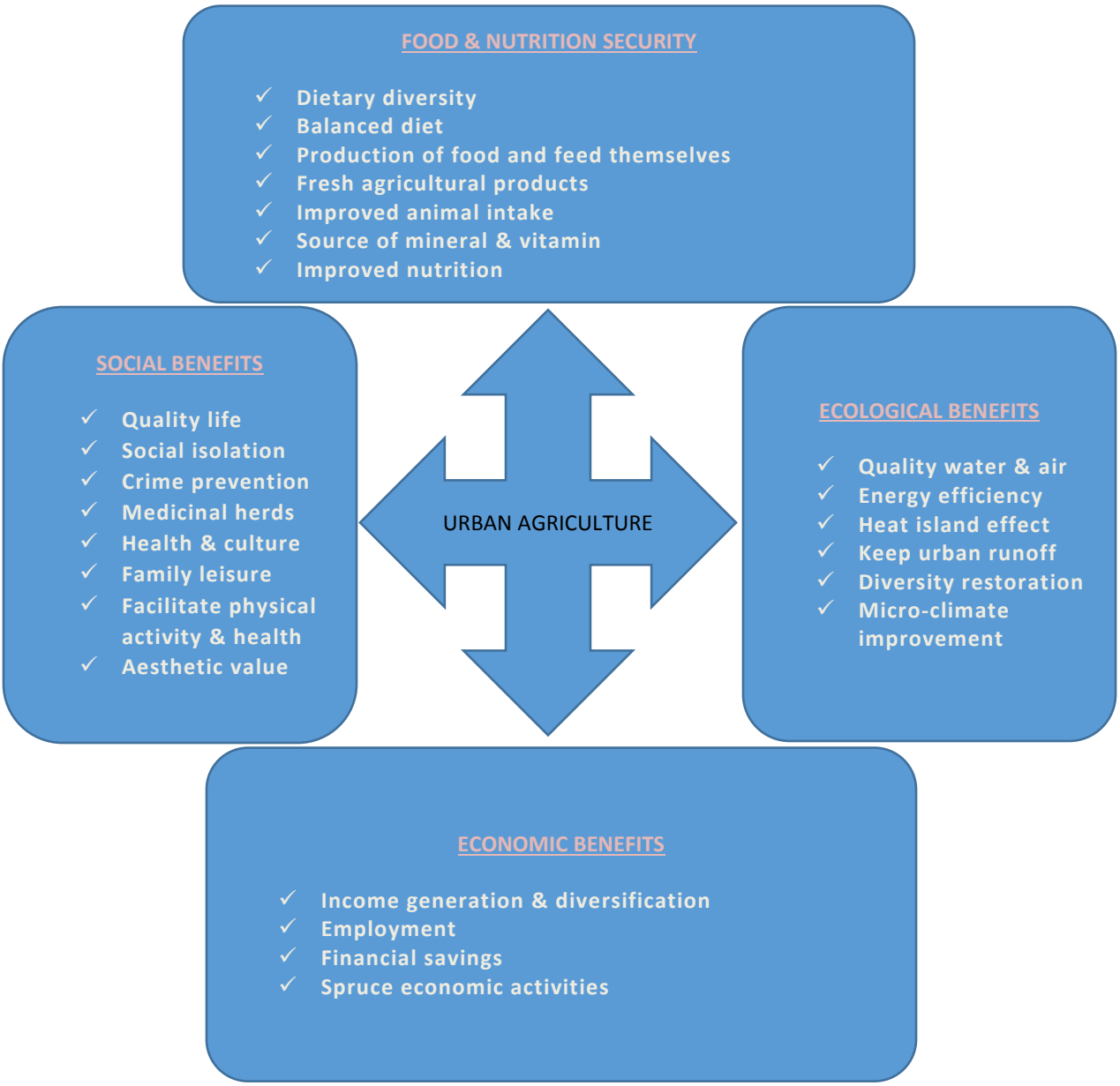

Fig. 4. Environmental, economic, food and nutritional and ecosystem service benefits of urban agriculture (Source: Author).

Urban agriculture exhibits immense potential in the attainment of basic population food needs and ensuring a sustainable distribution and production system that impacts African food systems. Therefore, broadening urban agriculture-focused research within a regulated environment will go a long way to promote food production in urban agriculture. Urban agriculture has a greater role to play in complementing the food production in Africa. In this case, dependent on its contribution to the food package of a proportion of the urban population, in turn, significantly contributes to the total food production deficit on the continent.

9. Conclusion

African agricultural R&D must undergo a significant transformation to meet the challenges of agriculture and food production and security and climate change effect. Fortunately, opportunities exist that can help to achieve this transformation where government, international aid, and private sector partners must invest in climate-smart agriculture research to build upon and scale to alleviate Africa's present and future food crisis. Africa's agriculture and food production will need to be enhanced if the food demands for a growing population are to be met, against a background of emerging climate change adversity, urbanization, and present shortcomings of the African Agricultural R&D agenda. To build smallholder farmers' resilience to climate change there needs to be greater adoption of integrated climate-smart agriculture technologies. The continued low per capita food production in Africa is an indication that the returns on investment of agricultural R&D on agriculture and food production have had minimal impact on the continent's food systems. This is against the background that agricultural R&D local diagnoses are indispensable for prioritizing research themes targeted on interventions and sequencing actions in small-scale food production. Small-scale agriculture is a critical component of Africa's food production equation, while regularized urban agriculture has immense complementary potential in the attainment of basic population food needs, and also ensuring a short supply food chain that impacts African urban food systems. Prioritization of research in support of African urban agriculture is a feasible strategy that has immense potential in the attainment of impending basic urban population food demands driven by the urban explosive population growth and also ensuring a sustainable distribution and production system that impacts positively on African food systems. An enabling institutional and policy environment is needed that supports African Agricultural R&D oriented to small-scale farmers' needs, as well as the regulating of urban agriculture systems. Small-scale farmers, can successfully adapt their agriculture and food production strategies to complement to meet the demands of Africa's growing population but need supportive agriculture research and development policy environment. Mini-livestock is more likely to adapt to climate change and improve the protein supply per unit area, especially in the rural communities, where the population is expected to increase drastically.

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