The significance of soybean production in the face of changing climates in Africa

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Abstract: The paper is aimed at reviewing literature on the significance of soybeans production in the face of the changing climates in Africa. Using literature from the secondary sources, the paper reviewed how Africa can alleviate poverty by growing soybeans amongst the many legumes due to its multiplicity effect (including easily accessed market due to its high demand, enhancing soil fertility, easy to manage, high protein levels which rural people need most as it is cheaper compared to meat). Africa’s majority population gets their livelihoods from agriculture and this in itself shows how important the sector is, yet the continent is faced with food insecurities, poor livelihoods, and high malnutrition levels in the midst of changing climate that is compounding their productivity levels. Achieving sustainable food security and livelihoods for millions of poor producers and consumers across Africa where people are living on $2 a day or less, remains a serious problem, exacerbated by the challenges of malnutrition, climate change, and poor technologies. Soybeans as a legume can play an important role in ensuring sustainable food security for both the current and future generations across the continent. Soybeans farming is important in Africa, where small-scale agricultural systems dominate the food production landscape, as it is a source of inexpensive protein and nutrients to rural households as well as natural fertilization for the soil. Also, the symbiotic nitrogen fixation properties of legumes (soybeans) mean that they are suitable for cultivation on a wide variety of soils in changing climates. Despite this, small-scale farmers are still faced with the following

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PUBLIC INTEREST STATEMENT

The manuscript addresses the importance of soybeans production in the face of the changing climates in Africa. The paper is significant to the African governments, development stakeholders, and the small-scale farmers themselves as they are the majority vulnerable members of the communities in SSA. The paper argues that from the many legumes known by the farmers, investment in soybean especially must be stressed more due to its multiplicity effect and the capacity to alleviate poverty from its neck. The importance of soybean cannot be overemphasized because SSA countries have fertile land and the climate despite the changes is still conducive to the cultivation of this crop compared to traditional crops like maize. Soybean has already an available and competitive market and this is an opportunity for the vulnerable rural farmers who are the majority in SSA.
factors; lack of credit funds, recycling of seeds as tested seeds are way too expensive, among which hinders their adoption levels of soybean production.

**Subjects:** Development Studies; Development Policy; Environment & the Developing World; Humanities

**Keywords:** Adaptation; climate change; legumes; Resilience; soybeans production; vulnerabilities

1. **Background**

Population growth and increasing consumption have led to a global increase in food demand while fertile agricultural land is becoming scarcer (Rulli et al., 2013; Yu et al., 2013). Different development actors have reacted differently in the quest to enhance livelihoods amongst the most vulnerable members of the communities to climate change. Despite this trend, developing countries have all been propagating an aspect of crop diversification that strengthens the fall-back strategies of the vulnerable members of the communities especially those in rural areas. Among the many and varying adaptation strategies aimed at enhancing the livelihoods of the farmers, developing countries have supported the production of soybeans due to its multiplicity effect. In this regard, soybeans can both be an adaptation and a mitigation strategy in ever-changing climates. Historically, soybean (G. max (L.) Merr.) originated in China, is a major source of protein for humans, and is also a high-quality animal feed (FAO, 2009).

Moreover, the high demand for soybean production has been due to the presence of important food supplements in soybeans and the growing consumption. Soybeans were originally domesticated in China, with about 23,000 cultivars in Asia, and were subsequently introduced into the USA and Brazil (López-López et al., 2010). The world soybean production was projected at 311.1 million metric tons in 2020 and 371.3 million metric tons in 2030. The annual growth rates are 2.9% from 2005–2010 and were projected to be 2.5% from 2010 to 2020, and 1.8% from 2020 to 2030. Nevertheless, the quantity level in 2030 is estimated approximately to be 1.7 times greater than that of 2005–2010. The United States of America, Brazil, and Argentina are the top largest producers of soybean in the world (Masuda & Goldsmith, 2009). Generally, the term soybean refers to the bean from which soy sauce is manufactured.

Southern Africa, in particular, is prone to frequent droughts and uneven rainfall distribution in both time and space (Kinuthia, 1997), hence, considering the frequent occurrence of droughts in the region, it makes the production of soybean feasible due to its resilience levels. Thus, in some years, the contribution of agriculture to food security and national economies in this region is reduced due to these climatic factors. Like many other parts of the world, the climate of southern Africa is also highly variable and unpredictable. Soybeans production is one of the worlds’ booming industries with an increase of 200 million tons in global consumption since the 1970s (Garrett et al., 2013). Climatic extremes including droughts and floods characterize the climate of the region and these often result in poor crop yields, hence, the need for drought resistance crops (Martin et al., 2000).

Nevertheless, fifty years ago, soybean was a niche crop that lacked processing and consumer markets and it was underutilized. Despite it being underutilized in the past, the crop has increased to about 13-fold in global production since 1961 to over 340 million metric tonnes (MMT) in 2016 (FAOSTAT, 2017). And today, soybean production is one of the most important crops across the globe, even though SSA countries have not fully realized the benefits of soybean compared to the developed world. Generally, currently, soybean importation and exportation values have outstripped major crops like wheat and rice even without the inclusion of soybean oil or other processed forms. The ever-increasing demand for soybean in Africa saw an increase in the land dedicated to soybean cultivation in 2016 exceeding 1.5 million hectares. The development of new rust-resistant varieties and high-yielding lines that have adapted to production in African climates now faces a sellers’ market. This is more so, for soybean oil for cooking and high-protein meal cake, which is a much sought-after ingredient in poultry and other animal feeds (Ncube, Roberts, & Zengeni, 2016).
The world at the moment and especially the developing countries needs effective adaptation actions to mitigate the harmful impacts of climate change and enhance the livelihoods of the vulnerable members of the communities. Climate change has the potential to allow a significant increase in soybean production in Africa, irrespective of which production scenario becomes reality in the future (Fodor et al., 2017). The increasing demand for soybean production in recent years has made the crop to be regarded as Africa’s Cinderella crop (Kolapo, 2011).

Masuda and Goldsmith (2009) estimated that the yearly production of soybean will be at 2.2% and approach a yearly production of 371.3 million tons by 2030. Also, Masuda and Goldsmith projected that the production and area harvested of soybean worldwide is going to increase due to the increasing demand for soybean products. The yearly rate of increase of soybean was at 4.6% from 1961 to 2007, with an average yearly production of 217.6 million tons in 2005–2007.

It is, therefore, worth noting that soybean is among the 16 major crops (barley, cassava, groundnut, maize, millet, potato, oil palm, rapeseed, rice, rye, sorghum, soybean, sugar beet, sugarcane, sunflower, and wheat) cultivated worldwide (Foley et al., 2011). Thus, policymakers and land managers must improve soybean research (Masuda & Goldsmith, 2009). Production and supply, stock levels, and soybean prices have changed along with the high demand for soybean by the population (MAPA, 2015; Masuda & Goldsmith, 2009). The production of soybean in the USA has been at its highest rate (89,507 million tons), over 33,640 million hectares since 2005 (USDA, 2013).

Even though, soybean (Glycine max (L.) Merr.) is one of the most feasible legumes in the prevailing climates in Africa, the crop is a non-native and non-staple crop in SSA. Although it is a non-staple crop in Africa, it has the potential to become a commercial crop owing to its wide range of uses as food, feed, and industrial raw material. Soybean has a relatively brief history of introduction and commercial cultivation in SSA countries (Mpepereki et al., 2000). It was introduced to SSA in the 19th century by Chinese traders along the east coast of Africa (Giller & Dashiel, 2006). Until now, the production potential has not been reached yet by the majority of African countries despite the environmental conduciveness.

The soybean area has expanded recently in Eastern and Southern Africa and this is expected to continue to do so because of the increased demand for soybean products. Outstandingly, the region shares similar climatic characteristics with the Cerrado region where much of the Latin American soybean comes from. Similar climatic conditions include the same latitude, solar radiation rates, rainfall patterns (wet summers) and total annual precipitation volumes, macro-climatic patterns driven by ocean water currents (Gasparri et al., 2016; TechnoServe, 2011). If soybean is a relatively simple crop to grow with a short growing season, it, therefore, means that room for yield improvement exists. Especially in most East and Southern African areas where the crop has the potential to be an important and viable crop for the small-scale farmers who are the most vulnerable members of the communities (Sinclair et al., 2014).

With the enormous impacts of climate change on rural farmers in developing countries, soybean production has the potential of enhancing their income levels through trade within and amongst the farmers. This trade is helping farmers to adapt to the ever-changing climate. The trade-in soybeans, as an important animal feed product, exemplifies the environmental and socio-economic impact of global markets and global agricultural policy. Soybean has the potential of expanding trade amongst farmers in their rural setups in the form of butter systems in ensuring food availability. That is if most farmers are to fully focus on the production of soybean in its entirety (comparative advantage), then the local demand by other farmers offers the opportunity for trading amongst and within themselves. But at another stage, there is an increasing demand for soybean products globally and this offers a feasible market to the producers of soybean. Nevertheless, the success of soybean lies within its multiple usages: soybeans can be used in food products (for example, tofu, soybean sauce), an edible vegetable oil, biofuel, and most importantly, its meal can be used as a protein source in livestock feeds (Garrett et al., 2013).
2. Methodology
This paper is aimed at reviewing the literature on the importance of soybean production in the face of the changing climate in Africa. The paper solely used literature from secondary sources in reviewing the importance of soybean production in Africa. The following objectives were examined and discussed; firstly, a review of the underpinnings of climate change; secondly, a discussion of why Africans, especially farmers, need increased soybean production in the face of climate change which has affected their productivity levels thereby directly impacting food security, increasing malnutrition rate and subsequently paralyzing their livelihoods. Thirdly, the paper reviewed the literature on soybean production and poverty alleviation, and last but not least, reviewed the perceived challenges faced by small-scale farmers in the production of soybeans. Recommendations based on the findings of this piece of work were made. Conceptually, the paper is driven by the following concepts, climate change adaptation, small-scale farmers’ vulnerabilities, and Soybean resilience. Small-scale farmers have largely been affected by the ever-changing climate and in response, farmers have been adapting to these changes in climate variously. In this case, the author focuses on the climate change adaptation using soybeans production by small-scale farmers. Soybean production has enhanced the livelihoods of the majority of farmers developed world due to its multiplicity effect and its resilience levels to climate change. The author, therefore, argues that increasing soybean production among small-scale farmers has the potential of alleviating poverty in rural areas.

3. Climate change underpinnings
Climate change in this paper is defined as a change in the state of the climate that can be identified (for example, by statistical tests) changes in the mean and/or variability of its properties that persist for an extended period, typically decades, or longer as viewed by the Intergovernmental Panel on Climate Change IPCC (2007b). Also, climate change may be due to natural internal processes or external forces, or persistent anthropogenic changes in the composition of the atmosphere or land use. Climate variability on the other hand refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, e.g.) of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC, 2007bb). Drawing from the IPCC (2007b), one of the main drivers of climate change is global warming which is regarded as warming of the climate system unequivocally as evidenced by observed increases in average air and ocean temperatures, widespread melting of snow and ice as well as rising global average sea level.

Changes in the climate directly implicate the agricultural productivity of the small-scale farmers who have weak fall-back strategies. Largely, the majority of the people in developing countries find their livelihoods from agriculture. It is good to indicate that agriculture from which the majority derive their livelihoods, is essentially a man-made adjunct to natural ecosystems, weather, and climate-dependent. The changes in variability, seasonality, mean precipitation, and water availability, and the emergence of new pathogens and diseases cause climate change impacts on agriculture (Fischlin et al., 2007). Nevertheless, the greater production losses result from increased frequency and intensity of extreme events, such as floods, droughts, heatwaves, and windstorms than any increase in mean temperature (Porter & Semenov, 2005). The impacts are more in developing countries like Sub-Saharan Africa with weak fall-back strategies in terms of shocks, trends, and seasonality.

Therefore, many studies had predicted and showed that crop yields in African would likely be decreasing under current climate occurrences and new countries in SSA are facing the realities directly implicating the livelihoods of the small-scale farmers (DEAT (Department of Environment Affairs and Tourism), 2000; Turpie et al., 2002; Jones & Thornton, 2003; Meadows, 2006; IPCC, 2007bb; Schlenker & Lobell, 2010). Therefore, African communities, in particular, those in the Sub-Saharan region, are thought to be the most vulnerable (Adger et al., 2003; Barrios et al., 2008; Challinor et al., 2007; IPCC, 2007bb; Mertz et al., 2009) because of multiple stressors and limited adaptive capacity. Besides, Kurukulasuriya et al. (2006) attribute the vulnerability of the Sub-Saharan African region to the fact that the region already experiences high temperatures, low
and highly variable rainfall, countries' high economies dependency on agriculture as well as, their low adoption of modern technology. Tubiello and Rosenzweig (2008) in their review and synthesis of agricultural impacts of climate change, concluded that moderate warming (up to 2°C) in the first part of the 21st century may benefit crop and pasture yields in the temperate regions, but have an opposite effect of reducing crop yields in the semi-arid and tropical regions.

However, further warming that is expected during the second half of the century will likely reduce crop yields in all regions (Hertel & Rosch, 2010). Schlenker and Lobell (2010) in their analysis of effects of climate change on African crop yields, using historical climate and crop production data estimated a reduction in the production of 22, 17, 17, 18, and 8% for maize, sorghum, millet, groundnuts, and cassava, respectively. Makado (1996) found varied simulated maize yield in response to climate change across four sites in four different Natural Regions (also called Agro-ecological Regions) of Zimbabwe, under rain-fed maize production. There is consensus that climate is changing (IPCC, 2007bb) mainly as a result of global warming, caused by both natural causes and human activity.

Generally, countries and development stakeholders have to understand that the challenging state of affairs of global warming increasing greenhouse gas emissions is disadvantageous the agriculture sector. It is due to this state of affairs that the world is now locked into global warming and inevitable changes to climatic patterns which are already exacerbating the existing rainfall variabilities and increasing the frequency of climatic extremes in SSA (IPCC, 2007). The continuous occurrences of extreme weather events call for effective adaptation mechanisms.

This paper agrees to a larger extent with Van Valkengoed and Steg (2019) that adaptation to climate change by individuals and/or communities is therefore no longer a secondary and long-term adaptation option to be considered as a last resort. Adaptation to new agricultural technologies like that of new crop resilient crops is now an urgent prevalent and imperative for the majority of the communities that are already vulnerable to the impacts of present-day climatic change hazards (International Institute for Sustainable Development International Institute for Sustainable Development (IISD), 2003. Therefore, this paper argues that climate change adaptation is fundamental for building ecological systems and resilient socio-economic. Organization for Economic Co-operation and Development Organisation for Economic Co-operation and Development (OECD) (2019) stated that farmers are already responding to these changes by adopting new practices, such as changed cropping dates or crop varieties, economic diversification, and more efficient use of agricultural inputs. However, there are many barriers to adaptation in the agricultural sector, including lack of information, policy distortions, and market failures (Ignaciuk & Mason-D'Croz, 2014).

Wreford et al. (2017) argued that adapting agriculture and broader food production systems to climate change is instrumental in achieving Sustainable Development Goals (SDG) 2: Zero Hunger as well as the goals of the Paris Agreement. In this regard, climate change is projected to negatively affect growth rates of yields for most crops by the second half of the 21st century, especially at higher levels of temperature rise and at low latitudes. Emerging from this, many institutions, and funding agencies addressing, identifying, and promoting climate change adaptation strategies for the diverse farming systems are faced with the challenges of climate extremes.

In the medium to longer-term and as climate change becomes more obvious in the medium to long-term, both in its identification and impact, farmers at large will have to adapt to the new set of weather-induced risks and opportunities farming systems. It is for this reason that most of the research on climate change impacts related to food in Africa focuses on changes in crop yields and food production (Niang et al., 2014; Porter et al., 2014). This paper, therefore, argues that food security goes beyond just food production to include food accessibility, utilization, and stability (Misselhorn, 2005). Hence, adapting to more resilient crops in the changing climates will not only ensure food availability but also enhance accessibility, utilization, and stability as it will improve
farmers’ diversification levels and income levels. With enhanced income levels amongst the vulnerable communities, households will be able to command nutrition and food security.

While food security is a fundamental requirement for human sustenance, there are other aspects of livelihoods including income, health, and assets that influence peoples’ well-being (Bashir & Schilizzi, 2013). The author does not imply that small-scale farmers should only focus on the production of soybean but that, special attention must be paid considering the multiplicity effect of the crop compared to other traditional crops like maize and cotton. Soybeans production has high demand and this implies more income compared to traditional crops and it is in this regard that, the crop has a high potential of enhancing food security because farmers will have the potential to command access to other foods which they would not otherwise access with poor incomes. Besides, soybean production also has the potential agronomic benefit of rejuvenating soils. Soybean canopies protect the soil from recurrent erosion, fix atmospheric nitrogen into the soil and decaying root residues improve soil fertility (Siamabele, 2019). Therefore, there is an urgent need for the production of resilient crops and legumes that have both the capacity to enhance farmers’ livelihoods (incomes, health, assets) together with improving the fertility of the soil and to some extent a crop that can provide a protective cover to the land to avoid soil erosion.

Therefore, adverse impacts from climatic shocks can be decreased through adaptation efforts, which range from slight to significant changes in approach that can bring about transformation in the farming systems. Even though there are various ways of building adaptive capacity, an ecosystem is an essential component within the agricultural system that enhances resilience, access to breeds of livestock, and varieties of crops that have a higher tolerance for heat, drought, and flood. Generally, ecosystems improve water storage systems; and builds institutional capacity for the enhancement of collective action, the dissemination of knowledge, and undertaking local adaptation planning (Bennett et al., 2014).

Adaptation to climate change is key in Africa’s development as the majority of people depend on farm products for their livelihoods. This means agriculture is the main industry in SSA, employing 65% according to the World Bank (2008), and 60% as of 2020 according to Sakho-Jimbira and Ibrahima (2020) of Africa’s labor force. The agricultural sector in Africa is accounting for about a third of its gross domestic product. The majority of this labor force in the agricultural sector are the small-scale farmers with 2 hectares or less representing 80% of all SSA farmers. The small-scale farmers contribute up to 90% of the production in most SSA countries (Wiggins, 2009; Wiggins & Sharda, 2013). In Southern Africa for example, 76% of the population depends on subsistence agriculture in Botswana while 85% in Kenya, 90% in Malawi, and 70–80% in Zimbabwe, (Ngigi, 2011; Rockstrom, 2003).

Focusing on SSA which is highly dominated by small-scale farmers, this paper is reviewing the literature on why small-scale farmers must adapt and increase the production of soybeans produced in the face of the changing climates and poor livelihoods. Largely, soybeans production worldwide has been considered one of the legumes that can enhance soil fertility and at the same time enhance the livelihoods of the farmers. Interest in the impact of agriculture on soil structure or changing soil species in-habitats has increased (Pagano et al., 2011; Wall & Nielsen, 2012). Amongst, the many legumes known by farmers, soybean affects different aspects of the ecosystem including the soil microbes. Accordingly, concerning the high cultivation of soybean crop world-wide, some of the most important parameters related to the production of soybean are presented among which the soil biota including rhizobia and mycorrhizal fungi are of great significance.

Furthermore, Siamabele (2019) showed how the production of soybeans has the potential in alleviating poverty among rural farmers as the crop is referred to as one of the miracle crops which provide cheap and affordable quality oil and vegetable protein. This makes the crop a good adaptation option for small-scale farmers whose income levels are not only low but weak to find other survival strategies when faced with climate changes. Soybeans are classified under the
oilseed category of edible oil which is produced in large quantities. The crop embraces diverse climatic conditions and different types of soil making it a versatile crop, something not common in many traditional crops like maize, cotton, and sorghum to mention a few. Even though SSA has conducive environmental conditions for the production of soybean, the crop can withstand drought to some extent compared to traditional crops but it is somehow weak to flooding stress (Hou & Thseng, 1991). Nevertheless, the soybean crop with its multiplicity effect can do well in the African climatic systems compared to other parts of the world and this is why this paper argues for more investment in the soybean crop.

4. A review of why Africans need soybeans in adapting to climate change

Generally, Sub-Saharan Africa accounts for more than 950 million people and approximately 13% of the global population. By 2050, this share is projected to increase to almost 22% or 2.1 billion. Undernourishment has been a long-standing challenge, with uneven progress across the region. Despite being reduced from 33% in 1990–92 to 23% in 2014–16, the percentage of undernourishment remains the highest among developing regions (Food and Agriculture Organization (FAO), IFAD and WFP, 2015).

The important role of the agricultural sector in contributing to food security is reflected in its prioritization in the development agenda. The Comprehensive African Agricultural Development Program (CAADP) is an integral part of the New Partnership for Africa's Development (NEPAD) and the sector’s prominence in the region is seen in its high contribution to the different countries’ total GDP. On average, agriculture contributes 15% of total GDP, however, it ranges from below 3% in Botswana and South Africa to more than 50% in Chad, implying a diverse range of economic structures. As argued in the preceding paragraphs, the agriculture sector in Africa employs more than half of the total labour force (IMF (International Monetary Fund), 2012) and within the rural population, provides a livelihood for multitudes of rural households. Smallholder farms constitute approximately 80% of all farms in SSA and employ about 175 million people directly (Alliance for a Green Revolution in Africa, 2014). In many SSA countries, women comprise at least half of the labour force (FAO, IFAD, and WFP., 2015). This implies that the production of soybean amongst the small-scale farmers shall ensure effective incomes in the households since women are the managers of a household.

Also, the Intergovernmental Panel on Climate Change (2007) report provided an extensive assessment of the expected effects of climate change on agriculture in African. This directly implicates the livelihoods of the women, children, and youths who are the most vulnerable members of communities in SSA. IPCC further estimated that Africa would be the most vulnerable to climate change globally, due to the multiple stresses of poor infrastructure, poverty, and governance. FAO (2009) projected that temperatures would increase to between 1.5°C and 4°C in the 21st century and it is now proving so as nearly all the SSA countries are experiencing high temperatures and enormous droughts. In the same line, it is projected that countries would experience a drop of up to 50% in crop yields and a fall in crop revenue of about 90% by 2100 (FAO, 2009). Hence, the much-needed crop adaptation mostly has the potential to enhance the environmental and food security of the much affected small-scale farmers.

Despite the implications of existing poor agricultural policies and poor political will to implement the sound-formulated policies in Africa, agriculture has been affected by many factors and one of which this paper focuses on is climate change. Climate change is emerging as a major challenge to agricultural development in Africa and other developing countries, given the increasingly unpredictable and erratic nature of weather systems on the continent. This has placed an extra burden on food security and rural livelihoods. There are two main strategies to reduce the expected negative impact of climate change: mitigation and adaptation. Mitigation in this regard is the process of reducing emissions or increasing the sequestration of greenhouse gases to reduce or reverse further global warming (IPCC, 2014a).
While this paper agrees with the IPCC (2001; 2007a) on the definition of adaptation to climate change which is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation involves the process of making changes to human or natural systems to reduce the observed or expected negative effects of climate change and take advantage of the positive effects (IPCC, 2014a). In this paper, adaptation may be classified as autonomous or planned adaptation. Autonomous adaptation (also referred to as spontaneous adaptation) refers to adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems (IPCC, 2001, 2007). It takes place without directed intervention from a public or private agency (Aguilar, 2001). Planned adaptation, on the other hand, is “the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return, maintain, or achieve a desired state” (IPCC, 2001; 2007a).

Despite the various adaptation strategies adopted by many small-scale farmers in Africa, SSA is one of the regions where the human population increases faster than food production (Van Ittersum et al., 2016) and the population in the face of changing climates is putting more pressure on food supply. Food insecurity is, therefore, a major concern in SSA and is worse in the current generation due to a lot of impacts of climate change especially on already vulnerable small-scale farmers who depend on rain-fed irrigation. Due to the reduction in the production levels of small-scale farmers, access to protein from meat is way too expensive. Protein deficiency continues to exact a greater toll on infants, children, and pregnant and lactating women in SSA than anywhere else in the world, partially because starchy foods are widely consumed and animal protein often is too expensive and out of reach for low-income families.

There is, therefore, a greater need to increases protein production in SSA countries to address the challenges of food security through increasing income and improved human nutrition at the household level. To fill the gap between the demand and supply of food, especially protein, growing soybean as a tropical crop in SSA is an ideal solution (Hartmon et al., 2011; Kolapo, 2011; Masuda & Goldsmith, 2009; Sinclair et al., 2014). Soybean can also fix nitrogen even with native Bradyrhizobium strains and fits well into current crop rotations (Mapfumo et al., 2005; Nezomba et al., 2010). This clearly shows that adaptation must not only be done for the sake of improving productivity but it must be done to address the stressful problems of the households (like proteins, environmental, and soil fertility) while improving food security.

Adaptation to climate change is already taking place in most countries but this paper argues for more investment into the adoption of soybean amongst small-scale farmers (IPCC, 2007a; Kurukulasuriya et al., 2006; Nhachachena and Hassan, 2007) as farming communities have a long record of coping and adapting to the impacts of weather and climate. According to Adger et al. (2003) and Burton et al. (2005), farmers have always lived with changing climate and have shown considerable resilience to climate change and variability while IPCC (2007) points out that adapting to current climate variability can increase resilience to long-term climate change. However, although some adaptation to current climate variability is taking place, farmers may not necessarily display the same level of resilience in the future, particularly, since according to Burton et al. (2005), future climate changes are likely to occur at a rate faster than has been previously experienced in history. In most developing countries, farmers have now resorted to growing legumes like soybeans in adapting to climate change due to their multiplicity effect which poor households in Africa need most.

Moreover, in rotation with cereals such as maize and sorghum, soybean production has the potential to provide the bedrock of food and feed supply across Africa. Smallholders farmers that are eager to diversify their crop and animal production systems should utilize the growing demand for soybean and maize production as these crops provide diverse economic opportunities. With maize being a staple crop for the majority of the small-scale farmers in Africa, the author,
therefore, predicts sweeping changes in soybean production and use across Africa in the coming decades. This is because soybean rejuvenates the soil fertility which in turn works well for the production of maize especially that rural households cannot afford the expensive fertilizer inputs for maize. Development stakeholders must pay attention to the potential of “soybean bonanza” as it will help to support research on the genetic improvement of soybean and associated production technologies to support the adoption levels in Africa, especially in a changing climate. Traditional grain legume cultivation is predominant across Africa; however, substantial variations in production and yield outcomes exist, which reflect productivity ceilings due to soil fertility and moisture (Bill & Melinda Gates Foundation, 2012; Ortega et al., 2016; Tadele, 2017).

There is a steady increase in the soybean production area in Brazil, and soybean production is gradually moving west and north (from North America) into Canada as well as northwards from Northeast China into Russia, as varieties that are suitable for these more exacting climates become available. Soybean is poised to fill Africa’s widening gap in the demand for protein, oil, and animal feed legumes that have already uniquely elevated the profile of soybean across southern Africa. The author argues that soybean production has a bright future in Africa due to the emerging and increasing demand for soybean oil and feed for livestock by the middle class. However, Africa continues to rely on the investment of largely resource-poor smallholders for the majority of crop production. Such producers are inherently limited in their overall capacity to adopt the latest soybean technologies and overcome barriers stemming from market access and investment needs (Ray et al., 2013).

Small-scale farmers in Africa could earn a lot of benefits from growing soybeans as soy constitutes one of the largest sources of vegetable oil and animal protein feed in the world (Sugiyama et al., 2015). It has the highest protein content for the human diet (40–42%) of all other food crops and is second only to groundnut concerning the oil content (18–22%) among food legumes (Masuda & Goldsmith, 2009; Robert, 1986). Moreover, obesity and muscle fatigue can be prevented by soy protein (Agyei et al., 2015).

For example, South Africa and Nigeria currently dominate soybean production in Africa, comprising 70% of the total output in 2014 yet, these countries are still not meeting the local demand for soybeans (Akbode & Maredia, 2012). Another opportunity for exploring soy production lies in the ever-increasing demand for soybean cake for animal feed, as a consequence of the growth in the middle-class population in South Africa and other neighbouring countries (Bureau for Food and Agricultural Policy, 2017). The production from South Africa alone cannot meet the local market demand and currently, the production in South Africa is only 30% of crushing capacity to about approximately 2 MMT, with total demand at 3.5 MMT. Also, the recent rapid growth in the production of soybean in Malawi and Zambia shows the geographic expansion and diversification of farming systems in the region since the turn of the century (Akbode & Maredia, 2012).

5. Soybeans production and poverty alleviation
Adaptation and mitigation to changes in climate are key to the enhancement of the vulnerable livelihoods of rural households in developing countries. These two strategies are complementary and equally necessary in alleviating poverty (IPCC, 2014a). Crops like soybeans when looked at in a short term, can be considered the best crop for adapting to climate change due to the available market for the farmers. Moreover, in terms of nitrogen-fixing levels in the soil, the crop can be a good legume for mitigating environmental degradation in developing countries especially amongst rural farmers with smaller hectares of land for production. The majority of these small-scale farmers plant their crops year in year out on the same land resulting in soil degradation. Mitigation is necessary because even the most effective adaptation efforts will not be able to counteract all the negative effects of climate change if greenhouse gas concentrations increase beyond a certain level (IPCC, 2014a). Adaptation is necessary because the planet will continue to warm up for centuries unless current net Carbon Dioxide (CO2) emissions are quickly replaced with net sequestration over a sustained period (IPCC, 2014a).
When describing adaptations in crop production, some authors such as Easterling (1996) have distinguished between long-term major changes, which they define as adaptations, and short-term, minor changes, which they define as adjustments. In this nomenclature system, adaptations are changes that transform crop production systems and require new research, technologies, market mechanisms, or government policies, including the introduction of new crops, the translocation of crops, and resource substitution (Easterling, 1996). Adjustments, on the other hand, involve changes that maintain the basic structure of crop production systems while making them more resilient to future disturbances and are immediately available to producers, such as changes in the timing of operations and cultivars planted (Easterling, 1996).

The uncertainties of climate change are increasing the risks of extreme weather conditions, pausing a lot of challenges on traditional cropping patterns, and leading to disease pressures but also pauses some opportunities for the successful expansion of soybean production across Africa (Lopez, 2012; Siddique et al., 2012). The potential agronomic and economic gains from the intensification of soybean production by smallholder farmers, therefore, hinge on the resilience of new soybean cultivars and their stabilities of yield in the face of biotic and abiotic challenges.

Soybean can establish tripartite symbiotic associations with rhizobia and arbuscular mycorrhizal (AM) fungi (Lisette et al., 2003); however, few results are available on their effects on plant growth, or their association with root architecture as well as with Nitrogen (N) and Phosphorus (P) availability. Due to lack of crop rotation and intercropping, land in most African countries has been degraded and soybean in this regard has the potential to fix the degraded soils with nitrogen and phosphorus. Xie et al. (1995) reported that soybean co-inoculation with japonicum 61-A-101 and mycorrhizal fungi results in more efficient colonization by Glomus mosseae, and increased N and P uptake by the host plant. In other words, the soil becomes more fertile for crop production, and to some extent, the fertility of the soil enhances the resilience of the soybean crop.

Soy production also has the potential agronomic benefit of rejuvenating soils. Soybean canopies protect the soil from recurrent erosion, fix atmospheric nitrogen into the soil, and decaying root residues improve soil fertility. Soil improvement leads to higher levels of sustainable agriculture with minimal input requirements. In addition to nitrogen fixation, soybean has the native Bradyrhizobium strains which fits well into current crop rotations because of its climatic resilience (Mapfumo et al., 2005). The market for soybean products for human consumption such as soy milk, chunks, burgers, sausages, hot dogs, mince, and polonies to mention but a few (Mapfumo et al., 2005).

Furthermore environmentally, soybeans improve soil fertility when rotated with traditional crops such as maize. Generally, soybean cultivation improves maize yields by about 10% to 20% by fixing nitrogen in the soil (TechnoServe, 2011). Value can be added to soybeans through processing via the crushing process and transformation into vegetable oil or meal for feed, input into the livestock industry. For small-scale farmers in developing countries with less or weak fall back strategies during the changing climates, soybean production could provide an opportunity to alleviate poverty as well as improve the environmental conservation for continuous agriculture productivity.

Soybean production is expected to dominate in the future in Africa due to its cash crop value from oil extraction and animal feed. Governmental and agro-industries can help provide the required economic opportunities through improved soybean-based supply chains involving consumers and producers. It is worth noting that the typical African farmer’s production efficiency can also be improved to address the current situation of lower than average yields and higher than average production costs by the support from nongovernmental agencies and research organizations, (Fayer et al., 2018).

6. Perceived challenges in soybeans production
Masuda and Goldsmith (2009) argued that the following are the major factors affecting soybean production; limitation of cultivable lands, and the need for investment by the public, private concerns, and farmers to increase soybean yield. Soybean cultivated field areas and production have increased to
about 36% and it is due to the crop rotation and substitution of the traditional crops, pasture, and native vegetation by the majority of small-scale farmers in developing countries. In cases where farmers have substituted cotton crops for soybean production, it is due to the capacity of the soybean crop in enhancing soil fertility, and also increased demand for soy implies more market to the small-scale farmers. In other words, substitutions have been motivated largely by the need to increase soil fertility and the lack of available markets for crops like cotton. Masuda and Goldsmith continued by stating the observed shift in the production area from the USA and Asia (China and India) to the USA and South America, including Argentina and Brazil. The United States, Brazil, and Argentina are the top major soybean-producing nations are. These three countries dominate global production, accounting for 80% of the world’s soybean supply (Cattelan & Dall’Agnol, 2018).

Despite the potential of soybean production in alleviating poverty in these changing climates, the crop has a lot of challenges that small-scale farmers face from production to consumption level in Africa. As argued by Siambrele (2019) challenges faced in soybean by small-scale farmers range from inputs accessibility, rainfall dependence, production to market. Some of the challenges faced by most small-scale farmers at the productivity level include climate change, a decline in soil fertility over time and low availability of improved seeds, and low usage of microbial inoculum (Mpepereki et al., 2000).

The significant contribution of the agricultural sector in terms of employment and gross domestic product (GDP) over the years is well acknowledged while less than 1% of commercial lending in Africa goes to agriculture (World Bank, 2008). Meanwhile, the larger share of the loans to the sector go to large-scale commercial farmers, unfortunately, smallholder farmers are most disadvantaged. Lack of access to finances limits the adoption of soybeans production by the small-scale farmers, compounded by lack of access to credit, agro-inputs, output market (Etwire et al., 2013).

Also, other challenges faced by farmers are labour-intensive especially at the harvesting time to avoid the loss of the crop. Many studies (Doss, 1999; Farrow, 2014) have discovered several of these challenges. Doss (1999) noted that access to labour, agro-inputs, and farmlands; among others were the common challenges faced by farmers especially women farmers. In addition, Farrow (2014), argued that factors that limit the adoption of legume technologies in Africa included but were not limited to access to land, capital, availability of labour, literacy of household members, access to seeds, the market for output, or products.

The author also argues that, despite the multiplicity effect of soybean, small-scale farmers might have another problem of access to food as soybean is not their staple crop in most African countries. This might emanate into challenges of food accessibility and utilization which is one of the problems households are faced with. African countries are not in a position of realizing the benefits of the free trade area due to the multiplicities of trade bottlenecks and some levels of protectionism in some countries. This goes beyond the country level to intra-trade as households in a country are not fully trading amongst one another. Soybean might have a lot of advantages as the paper argues above, but full concentration on the crop at the expense of the production of the staple foods might affect the concept of food availability, accessibility, and utilization not to talk of food stability in developing countries.

7. Conclusion
This paper concludes that incorporating soybeans as a major cash crop and animal-feed protein in African production systems is cost-effective and can address the dual challenges of malnutrition and climate change resilience that small-scale farmers are faced with. The paper also argues that Africa needs soybeans production more now than ever before because the continent at large has the potential to be a world leader in the production of soybeans as well as other key grain legumes. Sub-Saharan Africa is faced with the impacts of climate change, which is affecting farmers’ productivity levels thereby directly reducing farmers’ food security. Therefore, considering the multiplicity effect of soybeans (legume) and its capacity to renew the fertility of the soil impacted by soil erosion, African governments must strongly promote the production of soybeans by the small-scale farmers who are
the majority in agriculture in their quest to alleviate poverty and enhance their livelihoods. Regional and national agricultural policies must now be aimed at supporting and facilitating the production of legumes that can rejuvenate the fertility of the soil which has been destroyed by the changes in climate. More importantly, the literature argues that the agriculture sector contributes to global warming, while this paper agrees with this view, concludes that growing soybeans can help the continent in reducing global warming as it can absorb the CO2 in the atmosphere. Also, since it rejuvenates soil fertility, it helps farmers avoid the excessive use of fertilizer and other inputs during the crop rotation and intercropping as the soil becomes fertile for the production of crops like maize. In the long run, it reduces the emissions of CO2.

8. Recommendations
The writer recommends more investments in research and development for Africa to fully understand how small-scale farmers can enhance their livelihoods through the production of soybeans amongst the many legumes.

Also, governmental and agro-industries should help provide the required equal and effective economic opportunities through improved soybean-based supply chains involving consumers and producers. This must also go hand in hand with the engagement of the private sector.

Besides, there is a need for political will across all countries in Africa to strongly invest in new technologies beyond simply written policies. Africa has sound policies yet the implementation is poor due to a lack of political will to provide sustainable solutions to African problems. Governments must always remember and know that no one will ever provide sustainable solutions to ending hunger and malnutrition problems on their people other than themselves. Investing, facilitating, expanding, and supporting technologies will not only eliminate the recycling of tired seeds by rural farmers but also provide a complete and sound soybeans production value chain. A further research is recommended to investigate the performance of other various legumes in the prevailing climates in SSA countries.

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