The Role and Perspective of Climate Smart Agriculture in Africa: A Scientific Review

Victor O. Abegunde 1,* and Ajuruchukwu Obi 2

1 Department of Agriculture, University of Zululand, KwaDlangezwa 3886, South Africa
2 Department of Agricultural Economics & Extension, University of Fort Hare, Alice 5700, South Africa; aobi@ufh.ac.za
* Correspondence: overcomers001.av@gmail.com; Tel.: +27-(0)-63-405-9381

Abstract: Climate-smart agriculture (CSA) is gaining a wide acceptance as a laudable approach that can assist farmers to maximize the potential of the farming systems in Africa. A number of practices have been identified as CSA practices, and successful outcomes of CSA technologies are being reported. However, CSA uptake among African farmers remains low despite its proven potential. The aim of this paper is to analyse the state of CSA in Africa and identify the constraints to the uptake of the practices among smallholder farmers. This paper synthesizes a subset of literature between 2010 and 2020. The key findings are that the response to climate change and the pattern and extent of adoption of CSAs differs from one macro-area to another. Factors such as resource constraints, institutional instruments, climate and ecological settings, and farmers’ characteristics, such as farmers’ experience and access to extension services, are significant determinants of CSA adoption. Socioeconomic constraints, poor availability of data and mastery of CSA approach, inadequate labour, and the wide diversity of the farming systems in Africa are challenges militating CSA uptake in the system. This paper argues that it is crucial to ensure that limited resources available are systematically harnessed to achieve the triple-win benefits of CSA. Furthermore, there is the need to identify and prioritize locally suitable CSA practices and provide an enabling environment needed for CSA uptake and sustenance in the African farming systems.

Keywords: Africa; challenges; climate change; climate-smart agriculture; factors

1. Introduction

As the development challenges facing the bulk of African countries worsen, the crucial role of agriculture for food security, employment, and enhancement of overall livelihoods becomes more glaring [1–4]. Africa’s agricultural households are mostly rural dwellers who depend directly or indirectly on agriculture for their livelihoods. Gollin [5] notes that smallholder farming is critical to household food security and rural development in Africa. Smallholders account for the majority of the labour force of developing economies and they are key drivers in the agricultural sector in many African countries [6,7]. Smallholder farmers produce not less than 80 percent of the food and claim about 60 percent of the land in Sub-Saharan Africa [8]. For example, out of the 20.7 percent of South Africa’s households involved in agriculture in 2014, 65 percent were smallholder and resource-poor farmers [9], a situation that is not much changed today. Any phenomenon that threatens the sector is therefore likely to have profound implications for the economy as a whole. Many developing countries have therefore identified smallholder farming as the most important and effective platform to combat food insecurity and rural poverty and contribute to wider economic development [6,7].

It is in the light of the foregoing that the current threat posed by climate change is disturbing and raises concern about the direction in which the agricultural transformation process might go. Farmers, more especially the smallholders, are very susceptible to the adverse effects of climate change and variability [10]. The vulnerability of farmers
to changing climatic conditions is one of the major threats facing farmers, particularly smallholder farmers, because of the high dependence on rain-fed agricultural systems [11].

It has been observed that a key impact of the climate change is manifesting as increasing pressure on land and water resources which expectedly has adverse impact on farming activities, particularly crop production on smallholder farms [12,13]. The evidence is that the effects of changing climatic conditions coupled with poor agricultural practices have degraded soil fertility to such an extent that farm output has plummeted as a consequence [11]. Other drivers of farmers’ vulnerability include limited access to inputs and weak institutional support, which weaken their capacity for adaptation, thereby reducing their productivity [14].

To respond to the challenges posed by changing climatic conditions, climate-smart agriculture (CSA) has been recommended to the extent that is expected to allow farmers to cope with those challenges [15,16]. Climate-smart agriculture aims to transmute and reorient agricultural development in the face of the realities of climate change [17,18]. Climate-smart agriculture encompasses agricultural techniques or methods that can sustainably increase productivity, reduce or remove greenhouse gases (GHGs), and enhance the attainment of food security and agricultural development goals [19,20]. In this way, CSA concurrently addresses problems of food insecurity, climate change, and ecosystem management [20]. The consensus, therefore, is that the concept of CSA enhances adaptive capacity through efficient mobilization of resources and the development of agricultural systems that can survive the challenges posed by climate change [16]. This means that climate-smart agriculture addresses economic, environmental, and social issues with consideration given to location for the successful uptake of farm techniques and practices [19].

The question of what constitutes CSA has also preoccupied researchers and policy-makers. In that regard, the concept of CSA covers activities that involve more contextually appropriate land use patterns and conservation of soil and water in an effort to positively influence productivity and mitigate the adverse effects of climate change and variability [21]. The approach to landscape, which emphasizes ecosystem management and water and land use sustainability, is crucial in CSA [22]. There is growing advocacy for the acceptance of CSA, given the necessity of climate change adaptation and mitigation [23]. It is now recognized that CSA acts through the three pillars of sustainably enhancing farm productivity and incomes, adaptation and resilience to climate change, and reduction or removal of GHGs. One key means for determining whether an agricultural technique or practice is climate-smart is to examine the extent to which the aforementioned pillars are present, and the triple benefits of the practices can be recognized [24–26]. Over and above those benefits, there is agreement that climate-smart agriculture enhances farmers’ resilience to climatic shocks and attainment of food security at a household level [27].

In recent times, CSA is being promoted as a laudable approach that can help farmers maximize the potential of the farming sector and enhance food security, despite the challenges posed by climate change [28]. While CSA is still under study, different agricultural techniques or practices that align with the goals of CSA have been noted, and successful outcomes of CSA technologies have been reported [29–31]. However, CSA uptake among farmers in many African countries is still relatively low for one reason or another [32]. This paper investigates the state of CSA in Africa. The paper advances current scholarship on CSA in three different ways. First, it highlights the contribution of CSA to the farming system in Africa. Second, it analyses CSA adoption among African farmers. Third, it highlights the challenges militating against CSA uptake among farmers in Africa. The next section of the paper presents the methodology employed for this review. Following that, the results are presented and discussed before the paper winds up with a conclusion.

2. Materials and Methods

This paper synthesizes a subset of the literature addressing CSA. The paper considered different search areas to retrieve scientific documents addressing CSA in Africa. As much as possible, the search themes were defined for a wide coverage of the scope and topics
on CSA. The ScienceDirect database was employed for literature identification. Searches were conducted on article titles, abstracts, and keywords for the identification of literature addressing CSA issues in Africa. The search was restricted to peer-reviewed literature including reviews, scientific articles, book chapters, books, and miscellaneous editorial materials dated from 2010 to 2020. Gray literature, such as newsletters and bulletins of poor standing with respect to policy implications, were excluded. Search results were filtered through reading of abstracts and titles, and removal of duplicates. A search was conducted on “climate-smart agriculture” and “Africa” to retrieve relevant literature. The search yielded a total of 255 documents which were subsequently pruned to 100 based on discretion with respect to relevant criteria and the ranking of the documents in the database. The retrieved documents were co-authored by researchers across different countries, including those from outside the African continent. The documents include research and review papers, policy analyses, and technical papers. The inclusion/exclusion criteria in the review are presented in Table 1.

Table 1. Criteria for literature selection for review.

| Criteria for Document Inclusion in the Review | Criteria for Document Exclusion in the Review |
|-----------------------------------------------|-----------------------------------------------|
| Language of documentation is English          | Language of documentation is not English      |
| Emphasis is on agriculture                    | Emphasis is not on agriculture                |
| Addresses the goals of CSA                    | Addresses none of the goals of CSA            |
| Peer-reviewed literature such as review papers, book chapters, books, policy analysis, and technical papers | Gray literatures such as bulletins and newsletters of poor policy standing |
| The document covers pertinent details needed for the study | The document lacks sufficient details relevant for the study |

Source: Authors (2020).

3. Results and Discussion

3.1. Climate Change Impact on Agriculture in Africa

Studies highlighting the pattern of climate change across Africa suggest the existence of distinct macro-areas which correspond to the geographical division of the continent into West, East, and Southern African regions. The reviewed literature upholds equally clear differences in the patterns of response to climate change and CSA adoption from one macro-area to the other [18,23]. The literature also suggests that a clear regional pattern is discernible in the manner in which the warming of temperatures and associated changes in precipitation have trended; while it seems that temperatures have gone up uniformly by about 0.7 °C across the different regions, rainfall levels appear to have declined in the semi-arid regions and increased in the eastern and central parts of the continent [10]. There is a 2 and 7 percent increase in rainfall in West Africa and East Africa, respectively, while an average decrease of about 4 percent seems to have occurred in the Southern Africa region [10].

Africa is noted to be highly vulnerable to climate change impacts [33,34]. Climate change has highly impacted the agricultural livelihoods, food system, and the health system in Africa [35]. It has also resulted in more severe droughts, rise in sea level, irregular yields of agricultural produce, and changes in the incidence and prevalence of diseases. In addition, there has been an increase in extreme bioeconomic occurrences influenced by changing climatic conditions. The changes are projected to worsen the prevailing food and water insecurity, weak economic growth, and poverty plaguing many countries in Africa [35–37]. Empowering farmers to reduce vulnerability and build resilience against climate change should be prioritized in climate policy in Africa. Responses to the impacts of climate change by farmers in different settlements, particularly the rural communities,
coupled with the efforts of civil society and international organizations, reflect the capacity for innovation to adapt to climate change from local to regional levels in Africa [38].

The African agricultural system shows more vulnerability to the changing climatic conditions when compared with the agricultural system in other regions [10]. Africa is already embattled with harsh climate conditions, which include low and varying precipitation, and warm baseline temperatures [39,40]. The impacts of all these are made more severe by limited irrigation opportunities and low levels of adoption of improved technologies, which can be attributed to limitations posed by poor economic conditions [41]. Juana et al. [42] project high vulnerability to global warming for Africa, given the experience of high temperature in the region. According to the FAO [41], the vulnerability of agricultural systems in African countries is a result of the degrading environment and changing precipitation patterns, while climate change worsens food insecurity and poverty. Calzadilla et al. [43] project a decline in the yield of most crops in Africa, except for situations where there are technological interventions, stating that in the absence of adaptation, temperature rise will significantly lower crop yields.

Climate change significantly threatens food security as a result of its substantial adverse effect on dryland cropping or rain-fed farming, which forms the basis of the small-scale farming systems over much of Africa [44,45]. While small-scale farmers have seriously been affected by climate change, some of their counterparts in the large-scale sector may have enjoyed some benefits due to the fact that temperature rise could bring about increase in the yields of crops cultivated through irrigation [44]. Tibesigwa et al. [40] reveal that increased warmth and dryness will negatively influence net farm revenues and can lead to food insecurity. They further project a fall in agricultural productivity, which is attributed to climate change, and state that surge in food price will reduce food availability and give rise to more malnourished children who experience greater vulnerability to the adverse conditions.

Climate change impacts agriculture primarily through its effects on precipitation patterns, temperatures, carbon dioxide fertilization, variation in weather patterns, and the increased runoff of surface water [46]. Changes in temperature and rainfall pattern have direct impact on crop production. Precipitation, as the primary source of freshwater, determines the moisture level of the soil and is therefore a significant determinant of crop growth [43]. Descheemaeker et al. [47] reveal that an increase in precipitation level can bring about reduction in the variability in crop yield. Therefore, a stable and high level of rainfall reduces the disparity in yields between rain-fed farming and irrigation farming. However, excessive increase in precipitation levels can lead to unfavourable conditions such as flooding and waterlogging, which are highly detrimental to farming activities [43].

Temperature and soil moisture have effects on crop development, water requirements, and the growing season. A rise in temperature reduces frost periods, thereby boosting farming activities in cool-climate croplands. On the contrary, a rise in temperature in the arid and semi-arid regions results in the shortening of crop cycle and reduction in yields of crops [46]. Increases in the concentrations of carbon dioxide in the atmosphere improve plant growth and enhance water use efficiency, thereby affecting water availability positively [43]. Calzadilla et al. [43] also assert that varying climatic conditions, particularly instability in rainfall patterns, are highly injurious to rain-fed farming systems. Low soil moisture is a precursor to a fall in crop productivity and escalates the risks attached to production in rain-fed agriculture. Despite the efforts to reduce the instability caused by changing climatic conditions, irrigation-fed agriculture still depends on surface runoff or the availability of groundwater, which are also affected by climate change.

As previously highlighted at the beginning of this section, the trend of climate change in Africa shows a warming temperature with a drop in rainfall level in the larger part of the semi-arid region, but an increase in rainfall level in the eastern and central regions [10,42]. The mean annual temperature in the western region of Ethiopia increases by 0.096 °C every year, while yearly rainfall in the same region declines by about 46.75 mm per year [48]. These trends are expected to continue with a rise in sea level and increased level of drought
and flood incidences [49]. There is also a rise in temperature and rainfall trend in West and East Africa, and a decreasing trend in precipitation pattern in Southern Africa [49]. Different studies projected a general decline in precipitation and water availability [10,48]. There is a 40 to 60 percent reduction in the average release of rivers in West Africa, while more than 370 million people in Africa are projected to encounter worse water stress by the end of the first quarter of the 21st century [49].

Various studies on Sub-Saharan Africa reveal losses to crop farming and livestock production due to changes in climate conditions [37,50]. Some studies have shown the influence of climate change on farm revenues by highlighting how changes in temperature and precipitation impact revenues from crop farming [50]. A rise in temperature by 2.5 °C is projected to bring about losses in farming in Africa of USD 23 billion, while a 5 °C increase in temperature will result in about USD 38 billion in loss [10,44]. A decrease in precipitation of 7 and 14 percent is projected to bring about USD 4 and USD 9 billion losses in net revenues, respectively [10]. Tibesigwa et al. [40] found out that crop farming is most vulnerable to climate change, while mixed farming is least vulnerable. The aggregate effect of climate change would show significant variation across countries. Season and location are crucial determinants of the probable influence of climate variability on the cultivation of crops [40].

Other studies addressing the effect climate change has on livestock farming noted the possibility of a negative impact on net revenues. However, availability of substitute animals that are tolerant to heat on farms could alleviate the adverse effect of climate change on farm net revenues [51,52]. Wetter conditions could result in increase in the incidence of diseases for livestock and could be more disadvantageous to grazing animals if there is a change in vegetation from grasslands to forests [52]. Tibesigwa et al. [53] notes that climate change would influence the agricultural productivity of mixed farms in many countries in Africa. Climate variability poses a significant risk to the African agricultural sector [50]. Smallholder farmers are reported to be more vulnerable to the adverse effect of climate change than their counterparts who are into commercial production [40].

3.2. Contribution of Climate-Smart Agriculture to the Farming System in Africa

Reports have shown that Africa is highly vulnerable to climate change, and the vulnerability is due to the high dependence on rain-fed systems [11]. The effects of climate change on the farming system of African countries are complicated by the rapidly growing population in the continent [10]. Climate change is a growing threat to development in Africa. Reports have shown a declining trend in precipitation and increase in temperature in many regions in Africa [50]. Crop production and farmers’ livelihood are reported to be highly affected by drought, temperature rise, and flooding in western, central, and southern regions of Africa [54,55]. The impacts of climate change on the farming system are expressed in different forms. Irregularity in level and frequency of precipitation, increase in radioactivity, and build-up of carbon dioxide will impede the survival, growth, and yield of crops [56]. Climate change also affects livestock production through heat and water stress, vectors and diseases, the quantity and quality of feeds, and the quality of systems and livelihoods [56,57].

With the growing threats from climate change, efforts to find solutions to the problems are intensifying. Climate-smart agriculture can assist farmers in their mitigation and adaptation capacity [20]. The adoption of CSA improves the resilience of farming systems by providing a balance while prioritizing adaptation, mitigation, and food security [58]. Climate-smart agriculture jointly offers the benefits of increased productivity and enhanced climate change adaptation and mitigation. An increase in productivity through efficient resource use is crucial for agricultural growth [41]. A flourishing agro-ecosystem is highly beneficial to farmers as it enhances agricultural productivity, alleviates poverty, and improves food access and availability [11].

To date, agriculture in Africa is predominantly rain-fed, making the continent’s agricultural system highly vulnerable to climate change [59]. Varying climatic conditions and
climate extremes induce crop failures, collapse of fish farms, and high livestock mortality, thereby exacerbating food insecurity and poverty [50]. Farmers in many African countries have adapted some agricultural techniques or strategies that fit into the CSA profile [16]. Some farmers have adapted techniques such as crop diversification, mixed cropping, and conservation agriculture. Farmers in areas with low rainfall have substituted cultivating high-water-demanding crops with the cultivation of low-water-demanding crops, while farmers in locations affected by recurrent flooding have adopted the cultivation of short cycle crops [27].

Climate-smart agriculture as a strategic approach encompasses a wide range of techniques that can advance increased productivity, climate change adaptation, and mitigation [50]. With CSA adoption, the farmers attempt to maximize benefits and minimize undesirable trade-offs across multiple goals [59]. Small-scale farmers can facilitate a higher level of household food security, higher revenues, and stronger resilience [27]. The practices and technologies that are categorized as CSA are suitable for African households that depend on rain-fed farming system [61,62]. The concept of CSA also includes activities within broader systems and policy frameworks [63]. Climate-smart agriculture as an approach is more holistic in addressing climate change problems [24]. The contribution of CSA to the farming system is illustrated in Figure 1.

![Figure 1. Contribution of CSA to farming system.](image)

The main goals of CSA are increased productivity, climate change adaptation, and resilience, and the reduction or total removal of greenhouse gases. The agricultural practices that align with the CSA goals are recognized as CSA practices [23]. Agricultural practices such as crop diversification, planting of cover crops, conservation agriculture, planting of heat- and drought-tolerant crops, agroforestry, and crop rotation align with CSA framework and as such are recognized as CSA practices. Innovations such as weather prediction and climate risk insurance can also be categorized as CSA [36]. The adoption of CSA could be of immense benefit to the agricultural system in Africa by helping farmers maximize the potentials locked up within the small-scale farming system [11].

Climate-smart agriculture accentuates the significance of gathering evidence to highlight climate-friendly farming techniques which can serve as substitutes for farming techniques that are not climate-friendly. The concept of CSA engenders activities that enhance improved productivity and a more climate-friendly environment. Agricultural techniques that fit into the profile of CSA support the ecosystem in such a way that, ultimately, they mitigate the adverse effect of climate change on the farming system. The concept of CSA
also refers to smart farming, which does not only improve productivity but also enhances climate change adaptation and mitigation [20,32]. Through CSA uptake in the agricultural system, farmers and other relevant stakeholders in the agricultural sector are armed with techniques and management styles to manage challenging production systems.

The aim of the concept of CSA is to support farmers’ livelihood by improving their productivity and ensuring food security at a household level, and to manage and utilize natural resources efficiently [16,64]. Mainstreaming CSA also promotes the adoption of suitable approaches to produce, process, and market agricultural supplies [64]. Through CSA, many African countries attempt to entrench climate change adaptation into their farming systems. The positive response to the advocacy for CSA in Africa is probably the reason for the impressive results in mainstreaming the concept in many African countries [50]. The ecosystem is better managed when there is enhanced climate change adaptation and resilience in the agricultural system. Improved agricultural productivity enhances food security, particularly at farm level, but the extent to which this occurs in any particular location depends on factors that are unique to that particular setting. Thus, prescriptions for the adoption of the approach must be informed by location-specific assessments focusing on the social, economic, and ecological situations of different areas which allow for the identification of what is appropriate [64].

3.3. CSA Adoption in the African Farming System

The growing concern and advocacy for a sustainable development in the African farming system has resulted in the promotion of CSA among farmers, particularly the small-scale farmers [32]. CSA has been introduced as a concept that has the potential to effectively boost farm output, despite changes in climatic condition [17,26]. The core elements of CSA are adequate land use, soil and water conservation, and efficient residual management which are affected by climate variability but are fundamental to productivity [21]. The adoption of CSA brings about increased levels of adaptive capacity through efficient resource utilization and the establishment of agricultural systems that can withstand the threats of climate change [17]. For small-scale farming households, CSA is noted to enhance household food security, facilitate increase in revenues, and promote stronger resilience [27].

Different studies have reported successful outcomes of CSA techniques that have been used [29–31]. A number of CSA practices have been identified to improve productivity, income, and food security in different areas. Such practices include conservation agriculture, use of wetland, cultivation of drought-tolerant crops, use of organic compost, and integrated crop–livestock farming and management practices such as mulching. Farmers have increased their yields and income and enhanced their food security by shifting to the cultivation of stress-adapted crop varieties [23,65,66]. Makate et al. [23] report an improvement in crop and livestock yields as a result of diversification of farming systems. The adoption of conservation agriculture has helped farmers to enhance their yields and livelihood [26,67,68], while agroforestry has been noted to improve incomes, livestock holdings, and household nutrition [69].

Despite the potential benefits of CSA, its uptake among African farmers is still low, particularly among small farmers [62,70,71]. Among the factors hindering CSA uptake, resource constraint has been identified as a major barrier [72]. Factors such as inadequate access to land, labour, and financial capital are also noted as reasons for low CSA adoption rates, particularly among small-scale farmers [70,72]. Studies by Akrofi-Atitianti et al. [32], Murray et al. [36], and Ojoko et al. [73] unveiled farmers’ characteristics such as age, education, membership of a social group, access to credit, access to extension services, farmers’ experience, and farm location as determining factors of CSA adoption.

Small-scale farmers are particularly concerned about the applicability of CSA and the short-term gains they stand to enjoy from CSA adoption. A farmer would prioritize higher productivity and improved adaptive capacity over emission. The applicability of CSA techniques encompasses the suitability of the techniques with respect to the biophysical
and societal conditions of the area where they are considered for adoption [74]. Beyond the farmers’ characteristics which have been identified to be key determinants in CSA adoption, the adoption of CSA techniques is also affected by the interface between the attributes of the techniques and a range of prevailing conditions in the area under consideration [59]. CSA uptake could also be influenced by factors and characteristics inherent in CSA practices; social, economic, technical, and environmental compatibility of the CSA practices [59].

It is important to place into consideration the heterogenous characteristics of the African farming system for a successful CSA uptake among African farmers, particularly the small-scale farmers [11]. Farmers in Africa are at different levels of market orientation and access to land other resources [23,71]. The assumption of homogeneity in the farming system while designing and implementing plans for CSA uptake could hinder the successful mainstreaming of CSA in the African farming system. The structures of the farming system differ at the micro and macro levels, while the factors that act as promoters and inhibitors in the system also differ [23,75,76]. The factors affecting CSA adoption in the African farming system that have been analysed are summarized in Table 2.

Table 2. Criteria for literature selection for review.

| Categories of Factors Affecting CSA Adoption | Literature Sources |
|--------------------------------------------|--------------------|
| Socioeconomic factors                      | Onyeneke et al. [16]; Makate et al. [23]; Maguze-Tembo et al. [27]; Akrofi-Atitianti et al. [32]; Murray et al. [36]; Abegunde et al. [59]; Ojoko et al. [73] |
| Resource tenancy                           | Makate et al. [23]; Maguze-Tembo et al. [27]; Sova et al. [62]; Brown et al. [70]; Westermann et al. [71]; Bell et al. [72] |
| Institutional instruments                   | Williams et al. [22]; Makate et al. [23]; Murray et al. [36]; Abegunde et al. [59]; Mwongera et al. [74]; Wekesa et al. [75] |
| Climate and ecological setting             | Williams et al. [22]; Makate et al. [23]; Abegunde et al. [59]; Vera et al. [76] |

Source: Authors (2020).

### 3.4. Challenges Facing CSA Uptake in the African Farming System

Despite the contributions of CSA to the farming system in Africa, CSA mainstreaming and uptake are still confronted by many challenges. For a successful implementation of initiatives to facilitate CSA uptake, there is a need to understand and acknowledge the context and location-specific attributes of CSA [15]. Furthermore, the rising pressure of food demand has called for stronger consideration of agricultural intensification. However, embracing intensification can give rise to activities that may increase greenhouse gas emission, instead of reducing it. As farmers are concerned with how to improve on meeting the growing food demands, policymakers would have to be mindful of what strategies to deploy so as to achieve a win-win situation [11].

While knowledge about CSA continues to grow, there are still areas where clarity is needed with respect to what techniques and practices should be considered as CSA and which of the objectives of CSA (increased productivity, climate change adaptation and resilience, and climate change mitigation) should be prioritized in any given context. Farming systems in Africa are diverse [15]. It is uncertain that a CSA practice would fit well into all agro-ecologies [22]. As the advocacy for mainstreaming CSA grows, it is important for policymakers to drive a more comprehensive understanding of the context-specific attributes of CSA while designing and implementing ideas that promote CSA uptake.

There is limited information on the set of CSA practices or technologies which are very successful in African countries. There is a dearth of documentation on the context in which many CSA practices turn out to be successful and for whom and for how long they are successful. Thus far, agroforestry and conservation agriculture are the most recognized practices identified to fit into CSA profile [15,76]. However, there is limited study on the economic implications of both practices. Apart from the challenge of limited study that
has been highlighted, there are many challenges facing the adoption of agroforestry and conservation agriculture, making the development of a business case for both practices a difficult task [77]. There is the need for a better documentation of successful CSA practices and a good business case for investment in CSA to be able to attract investments from the private sectors and governments in African countries.

Many of the farming systems in Africa are challenged with water constraints and poor soil fertility. Given the long-term rise in temperature, changes in rainfall pattern, and increase in the frequency of droughts, innovative ideas are needed to achieve sustainable agricultural productivity [77]. Agricultural techniques that are strategic with respect to planting dates, crop varieties, and water harvesting techniques can alleviate the projected adverse impacts of climate change [76]. Reports have also revealed how integrated crop–livestock systems enhance the adaptive capacity of farmers to climate change [78]. For a successful CSA mainstreaming and uptake, it is pertinent to consider widening the scope for provision of CSA solutions.

There are already existing policies and frameworks in different African countries for addressing climate change, but their impacts have been limited and need thorough review in order to allow for the integration of CSA framework. For one thing, there are enormous challenges in mainstreaming CSA into already existing policy frameworks. As a result of this, new policies which may inform or be informed by CSA are needed. Although many farmers in Africa are managing climate risks in their own way, using their knowledge and resources, it may be difficult to distinguish their efforts from other social and economic factors that influence their livelihood [79]. The adoption of CSA as a systematic approach to respond to climate change is faced with some other challenges, as discussed below.

3.4.1. Socioeconomic Constraints

In many parts of Sub-Saharan Africa, farmers, particularly small-scale farmers have poor access to water and land by virtue of holding weak and unsecured rights to water and land [79]. Access to land is complicated by customary and institutional factors in addition to new promoters of development, albeit outside agriculture, such as large-scale investment on agricultural land which results in the displacement of many agricultural communities [22,80]. Smallholder farmers are faced with limitations when it comes to gaining access to markets at the domestic, regional, or international level [80]. Inadequate information, access to inputs, and extension services are limiting factors to farmers’ ability to assess the risks and benefits of CSA.

Farmers in Africa not only have the adverse effects of climate change to deal with, but they also have to manage the risks that come with adopting new technologies in terms of increasing costs. Many farmers are constrained by access to credit, microfinancing, or insurance [78]. Many African countries that require new investments for CSA uptake have not fully mapped out plans to finance the process [78]. Farmers can also have difficulty gaining access to important resources such as land, water, and mobility. This challenge also serves as a barrier to successful CSA uptake [64].

3.4.2. Limited Access to Equipment, Input, and Finance

Limited access to farm equipment which is specific to CSA could be a significant challenge militating against CSA uptake in Africa [73]. Ordinarily, CSA may not require the use of more equipment when compared with conventional agriculture. However, some equipment is specific to CSA adoption and implementation, and it may not be available [79]. Often, the disparity in equipment use is in land preparation and seeding. However, some equipment used for conventional agriculture can be used for CSA, while others need to undergo some modifications to be applicable for CSA. One of the benefits of CSA is that it can facilitate improved agricultural productivity through management practices that improve soil fertility and provide pest and weed control with little or no agrochemicals [55]. However, constraint in accessing seeds, pesticides, and herbicides has been noted as one of the limitations to successful CSA uptake in the African farming system [79].
CSA uptake promises more long-term benefits than short-term benefits when viewed in relation to conventional agriculture [55]. Many smallholder farmers that are interested in CSA adoption are limited by inadequate funds for equipment, labour, and other farm inputs. Achieving the long-term benefits of CSA requires heavy initial investment which could be expensive for smallholder farmers. While some farmers could enjoy the benefits of CSA in their first year of engagement, others may have to wait for three to seven years [78]. Farmers may abandon CSA technology if they have to wait too long before enjoying any benefit from the adoption. Farmers will likely embrace long-term adoption of CSA if they have the capacity for the initial investment required for successful adoption and will benefit in the first or second year of engagement [81].

3.4.3. Inadequate Labour

The availability of labour is a significant driving force in the agricultural system in Africa. However, the demand for labour in many African countries often outweighs the available supply. This constitutes a major challenge in the farming system, particularly the smallholder farming system. The availability of labour for agricultural activities is affected by youth participation in agriculture, migration of potential labour force from the rural areas to the urban areas, aging of farm labour suppliers, malnutrition, and poor wage rate [78]. The adoption of CSA practices in some areas involves activities that may have high labour requirements. For example, in some CSA practices, there is the need to dig deep to penetrate the soil crusts. Such a task may be highly demanding and may require more labour for implementation.

It is common that weeding and land preparation in CSA would require more labour than what is available. Farmers will need more labour if they choose not to use herbicide [73]. Another example is Zai pits, which is a conservation technology but requires high use of labour. Zai pits technology is used to conserve soil moisture and improve fertility. However, it has high requirements for labour. There are reports of increase in the output of biomass by 200 percent in Niger due to the use of Zai pits innovation. There is also a growing acceptance of the innovation in West Africa and a high rate of adoption in Eastern and Southern Africa [79]. However, high costs and labour requirements have been identified as a major barrier to its adoption. For example, in some West African countries, women do not adopt Zai pits because of its demand on physical strength and their poor access to appropriate tools for the innovation.

3.4.4. Poor Availability of Data, Analytical Tools, and Mastery of CSA Approach

Many African countries are challenged by dearth of data on several subjects of concern. Where some data exist, they are not readily available, as they are scattered and not easily retrievable. There are no long-term data on climatic and landscape levels. The models for climate change at the global level are at a scale that are difficult to work with at the local, national, or regional level [55]. Many of the countries in Africa lack the capacity and analytical tools for downscaling models at global level to regional and national levels. This has led to the lack of comprehensive knowledge of the existing and probable effects of climate change in African countries and what it means for their agricultural activities and food security [58].

It is important to understand the protocols surrounding CSA adoption so as to be able to clearly communicate relevant messages to farmers. As a result, the effort to scale up CSA initiatives is a function of the comprehensive understanding of the concept of CSA by policymakers and relevant stakeholders [64]. This will make allowance for smooth feedback mechanisms among policymakers, stakeholders, and farmers. The concept of CSA is, without a doubt, promising, but concrete examples of successful implementation are needed in different agro-ecologies, given the heterogeneous characteristics of the farming systems in Africa.
3.4.5. Poor Infrastructure

Physical infrastructure is highly critical to a successful CSA uptake in the relevant farming systems. Farmers need infrastructure such as water management structures, communication facilities, storage, and processing facilities. Various studies have noted infrastructure, market availability, and market accessibility as promoters of development for smallholder farming in African [64,81]. Therefore, when these structures are missing in the picture, there is a major barrier to CSA uptake.

4. Conclusions

This paper reviewed the literature to investigate the state of CSA in the African agricultural systems. The review synthesized a subset of literature retrieved from the ScienceDirect database. However, it may not be the total coverage of literature from the 2010 to 2020 timeframe due to imposition of additional restrictions such as specific focus on smallholder farming and the ranking of the publication/journal. The paper highlights the contribution of CSA to agriculture in Africa and analyses CSA adoption and the challenges militating against its uptake among farmers in Africa. Mainstreaming CSA is intrinsic to enhancing agricultural productivity under climate change and variability. The adoption of CSA would enhance food security and help in the reduction of greenhouse gas emissions. The popular CSA practices in Africa are conservation agriculture, cultivation of drought tolerant crops, use of wetland, and integrated crop–livestock farming. The challenges facing CSA uptake in the African farming systems include socioeconomic constraints, limited access to equipment, input and finance, inadequate labour, and poor availability of data and lack of mastery of the CSA approach.

The adoption of CSA practices, despite the benefits, will not happen without facilitation due to the aforementioned constraints. Hence, this paper argues for more attention to the significant factors influencing CSA uptake in the farming system, particularly resource constraints. Since farming systems in Africa are complex, it is needful for research to play active roles in informing and supporting adaptation decision-making. It is important to ensure that limited resources available are systematically harnessed to augment the triple-win benefits of CSA. There is the need to identify and prioritize locally suitable CSA practices and provide an enabling environment needed for CSA uptake and sustenance in the farming system.

Furthermore, the adoption of multiple CSA techniques can help in building a sustainable agricultural production system, particularly in the smallholder farming system. The positive correlation of the adoption of CSA with agricultural productivity establishes one of the objectives of CSA, which is improving productivity. This review, based on its findings, therefore argues that mainstreaming CSA in agricultural-oriented policies and programmes will help promote agricultural development and sustainability, particularly in smallholder agriculture in this era of climate change. Policymakers and stakeholders should, therefore, intensify the campaign on CSA adoption among farmers. There is the need for a strong awareness on CSA as a practical solution to the management of the adverse effects of climate change. Governments and stakeholders in African countries should make the requisite resources more available and accessible for successful CSA uptake. It will also be of immense benefit to provide incentives to encourage smallholder farmers to adopt CSA practices.

Author Contributions: V.O.A. and A.O. have joint responsibility for the conceptualization, scientific review, and writing of the manuscript. A.O. and V.O.A. contributed equally to the revision of the manuscript and undertook all necessary editorial interventions. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The authors acknowledge the opportunity afforded by the Forum for Agricultural Research in Africa for them to participate in the conference to which this paper is a contribution.
Conflicts of Interest: The authors declare no conflict of interest.

References

1. Mugi-Ngenga, E.; Mucheru-Muna, M.; Mugwe, J.; Ngetich, F.; Mairura, F.; Mugendi, D. Household’s socio-economic factors influencing the level of adaptation to climate variability in the dry zones of Eastern Kenya. *J. Rural Stud.* 2016, 43, 49–60. [CrossRef]

2. Idris, M. Understanding agricultural productivity growth in Sub-Saharan Africa: An analysis of the Nigerian economy. *Int. J. Econ. Financ. Res.* 2020, 6, 147–158. [CrossRef]

3. Ziervogel, G.; New, M.; van Garderen, E.A.; Midgley, G.; Taylor, A.; Hamann, R.; Stuart-Hill, S.; Myers, J.; Warburton, M. Climate change impacts and adaptation in South Africa. *Wiley Interdiscip. Rev. Clim. Chang.* 2014, 5, 605–620. [CrossRef]

4. World Bank. *Climate Smart Agriculture, Successes in Africa*; World Bank Group: Washington, DC, USA, 2016.

5. Gollin, D. *Smallholder Agriculture in Africa: An Overview and Implications for Policy*; International Institute for Environment and Development: London, UK, 2014.

6. Msangi, J.P. *Food Security Among Small-Scale Agricultural Producers in Southern Africa*; Springer: Cham, Switzerland, 2014.

7. Louhichi, K.; Riesgo, L.; Paloma, S.; Gomez, Y. *The Role of Smallholder Farmers in Food and Nutrition Security*; Springer Nature: Cham, Switzerland, 2020.

8. World Bank. *World Development Indicators*; World Bank Group: Washington, DC, USA, 2017.

9. Republic of South Africa. *National Policy on Food Nutrition Security*; Republic of South Africa Government Printing Works: Pretoria, South Africa, 2014.

10. Serdeczny, O.; Adams, S.; Baarsch, F.; Coumou, D.; Robinson, A.; Hare, W.; Schaeffer, M.; Perrette, M.; Reinhardt, J. Climate change impacts in Sub-Saharan Africa: From physical changes to their social repercussions. *Reg. Environ. Chang.* 2016, 17, 1585–1600. [CrossRef]

11. Abegunde, V.O.; Sibanda, M.; Obi, A. The dynamics of climate change adaptation in Sub-Saharan Africa: A review of climate-smart agriculture among small-scale farmers. *Climate 2019, 7, 132. [CrossRef]*

12. Pillay, S.E. The Impact of a Change in Climate on Small-Scale Farmers: Case Studies of the Khokhwane, Sizanenjana and Richmond Communities in KwaZulu-Natal, South Africa. Master’s Thesis, University of KwaZulu-Natal, Pietermaritzburg, South Africa, 2016.

13. Food and Agriculture Organization (FAO). 2015–2016 El Nino: Early Action and Response for Agriculture, Food Security and Nutrition; Food and Agriculture Organization of the United Nations: Rome, Italy, 2016.

14. Below, T.B.; Schmid, J.C.; Sieber, S. Farmers’ knowledge and perception of climatic risks and options for climate change adaptation: A case study from two Tanzanian villages. *Reg. Environ. Chang.* 2015, 15, 1169–1180. [CrossRef]

15. Parrey, S.T.; Zougmore, R.B.; Ouédraogo, M.; Campbell, B.M. Developing climate-smart agriculture to face climate variability in West Africa: Challenges and lessons learnt. *J. Clean. Prod.* 2018, 187, 285–295. [CrossRef]

16. Onyenekwe, R.U.; Igberi, C.O.; Uwadoka, C.O.; Aligbe, J.O. Status of climate-smart agriculture in southeast Nigeria. *Geojournal 2018, 83, 333–346. [CrossRef]*

17. Lipper, L.; Thornton, P.; Campbell, B.M.; Baedeker, T.; Braimoh, A.K.; Bwalya, M.; Caron, P.; Cattaneo, A.; Garrity, D.P.; Henry, K.; et al. Climate-smart agriculture for food security. *Nat. Clim. Chang.* 2014, 4, 1068–1072. [CrossRef]

18. Totin, E.; Segnon, A.; Schut, M.; Affognon, H.; Zougmore, R.; Rosenstock, T.; Thornton, P.K. Institutional perspectives of climate-smart agriculture: A systematic literature review. *Sustainability 2018*, 10, 1990. [CrossRef]

19. Food and Agriculture Organization (FAO). *Climate-Smart Agriculture Sourcebook*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2013.

20. Lipper, L.; Zilberman, D. *A Short History of the Evolution of the Climate Smart Agriculture Approach and Its Links to Climate Change and Sustainable Agriculture Debates*; Springer: Cham, Switzerland, 2018.

21. Kitsao, E.Z. Adoption of Climate Smart Agriculture (CSA) Technologies Among Female Smallholder Farmers in Malawi. Master’s Thesis, Norwegian University of Life Sciences, Ås, Norway, 2016.

22. Williams, T.; Mul, M.; Cofie, O.; Kinyangi, I.; Zougmore, R.; Wamukoya, G.; Nyasimi, M.; Mapfumo, P.; Sperranza, C.I.; Amwata, D.; et al. Climate smart agriculture in the African context. In Proceedings of the Feeding Africa Conference—Unlocking Africa’s Agricultural Potentials for Transformation to Scale, Dakar, Senegal, 21–23 October 2015.

23. Makate, C.; Makate, M.; Mango, N. Farm household typology and adoption of climate-smart agriculture practices in smallholder farming systems of southern Africa. *Afr. J. Sci. Technol. Innov. Dev.* 2018, 10, 421–439. [CrossRef]

24. Mathews, J.A.; Kruger, L.; Wentink, G.J. Climate-smart agriculture for sustainable agricultural sectors: The case of Mooftein. *Jamb&i Dis. Risk Stud.* 2018, 10, 492. [CrossRef] [PubMed]

25. Dooley, E.; Chapman, S. *Climate-Smart Agriculture and REDD+ Implementation in Kenya*; University of Cambridge: Cambridge, UK, 2014.

26. Mango, N.; Makate, C.; Tamene, L.; Mponela, P.; Ndengu, G. Adoption of small-scale irrigation farming as a climate-smart agriculture practice and its influence on household income in the Chinyanja triangle, Southern Africa. *Land 2018, 7, 49. [CrossRef]*

27. Maguza-Tembo, F.; Mangison, J.; Edris, A.K.; Kenamu, E. Determinants of adoption of multiple climate change adaptation strategies in Southern Malawi: An ordered probit analysis. *J. Dev. Agric. Econ.* 2017, 9, 1–7.
28. Ouédraogo, M.; Houessonon, P.; Zougmore, R.B.; Parthey, S.T. Uptake of climate-smart agricultural technologies and practices: Actual and potential adoption rates in the climate-smart village site of Mali. *Sustainability* 2019, 11, 4710. [CrossRef]

29. Sanou, J.; Bationo, B.A.; Barry, S.; Nabie, L.D.; Bayala, J.; Zougmore, R. Combining soil fertilization, cropping systems and improved varieties to minimize climate risks on farming productivity in northern region of Burkina Faso. *Agric. Food Secur.* 2016, 5, 20. [CrossRef]

30. Andrieu, N.; Sogoba, B.; Zougmore, R.; Howland, F.; Samake, O.; Bonilla-Findji, O.; Lizarrazo, M.; Nowak, A.; Dembele, C.; Corner-Dolloff, C. Prioritizing investments for climate-smart agriculture: Lessons learned from Mali. *Agric. Syst.* 2017, 154, 13–24. [CrossRef]

31. Traore, K.; Sidibé, D.K.; Coulibaly, H.; Bayala, J. Optimizing yield of improved varieties of millet and sorghum under highly variable rainfall conditions using contour ridges in Cinzana, Mali. *Agric. Food Secur.* 2017, 6, 11. [CrossRef]

32. Akrofi-Atitianti, F.; Speranza, C.I.; Bockel, L.; Asare, R. Assessing climate smart agriculture and its determinants of practice in Ghana: A case of the cocoa production system. *Agric. Environ. Manag.* 2018, 7, 30. [CrossRef]

33. Niang, I.; Ruppel, O.; Abdurabo, M.; Essel, A.; Lennard, C.; Padgham, J.; Urquhart, P. Africa. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*; Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Barros, V., Field, C., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014.

34. Porter, J.R.; Xie, L.; Challinor, A.J.; Cochrane, K.; Howden, S.M.; Iqbal, M.M. Food security and food production systems. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*; Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Barros, V., Field, C., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 485–533.

35. Adenle, A.A.; Azadi, H.; Arabi, J. Global assessment of technological innovation for climate change adaptation and mitigation in developing world. *J. Environ. Manag.* 2015, 161, 261–275. [CrossRef]

36. Murray, U.; Gebremedhin, Z.; Brychkova, G.; Spillane, C. Smallholder farmers and climate smart agriculture: Technology and labor-productivity constraints amongst women smallholders in Malawi. *Gender Technol. Dev.* 2016, 20, 117–148. [CrossRef] [PubMed]

37. Neube, M.; Madubula, N.; Ngwenya, H.; Zinyengere, N.; Zhou, L.; Francis, J.; Mthunzi, T.; Olivier, C.; Madzivhandila, T. Climate change, household vulnerability and smart agriculture: The case of two South African provinces. *Jamb. J. Disaster Risk Stud.* 2016, 8, 1–14. [CrossRef] [PubMed]

38. Ojo, T.; Baiyegunhi, L. Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. *Land Use Policy* 2020, 95, 103946. [CrossRef]

39. Intergovernmental Panel on Climate Change (IPCC). Available online: https://archive.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-FrontMatterB_FINAL.pdf (accessed on 30 August 2021).

40. Tibesigwa, B.; Visser, M.; Collinson, M.; Twine, W. Investigating the sensitivity of household food security to agriculture-related shocks and the implication of social and natural capital. *Sustain. Sci.* 2015, 11, 193–214. [CrossRef]

41. Food and Agriculture Organization (FAO). *The State of Food and Agriculture*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2014.

42. Juana, J.S.; Kahaka, Z.; Okurut, F.N. Farmers’ perceptions and adaptations to climate change in Sub-Saharan Africa: A systematic review. *J. Environ. Earth Sci.* 2016, 5, 121. [CrossRef]

43. Calzadilla, A.; Zhu, T.; Rehdanz, K.; Tol, R.; Ringler, C. Climate change and agriculture: Impacts and adaptation options in South Africa. *Water Resour. Econ.* 2014, 5, 24–48. [CrossRef]

44. Turpie, J.; Visser, M. The impact of climate change on South Africa’s rural areas. *Financ. Fisc. Comm.* 2013, 14, 100–160.

45. Tshuma, M.C. Understanding the small-scale agricultural sector as a precondition for promoting rural development in South Africa. *Afr. J. Agric. Res.* 2014, 9, 2409–2418. [CrossRef]

46. Arakelyan, I.; Wreford, A.; Moran, D.; Ninan, K.; Inoue, M. Can agriculture be climate smart? In *Building a Climate Resilient Economy and Society*; Edward Elgar Publishing: Cheltenham, UK, 2017; pp. 115–131.

47. Descheemaeker, K.; Oosting, S.J.; Tui, S.H.K.; Masikati, P.; Falconnier, G.N.; Giller, K.E. Climate change adaptation and mitigation in smallholder crop-livestock systems in sub-Saharan Africa: A call for integrated impact assessments. *Reg. Environ. Chang.* 2016, 16, 2331–2343. [CrossRef]

48. Sani, S.; Haji, J.; Goshu, D. Climate change adaptation strategies of smallholder farmers: The case of Assosa District, Western Ethiopia. *J. Environ. Earth Sci.* 2016, 7, 9–15.

49. Sani, S.; Chalchisa, T. Farmers’ perception, impact and adaptation strategies to climate change among smallholder farmers in Sub-Saharan Africa: A systematic review. *J. Resour. Dev. Manag.* 2016, 26, 1–8.

50. Zougmore, R.B.; Parthey, S.; Ouédraogo, M.; Torquebiau, E.; Campbell, B.M. Facing climate variability in Sub-Saharan Africa: Analysis of climate-smart agriculture opportunities to manage climate-related risks. *Cah. Agric.* 2018, 27, 34001. [CrossRef]

51. Thornton, P.K.; Herrero, M. Climate change adaptation in mixed crop–livestock systems in developing countries. *Glob. Food Secur.* 2014, 3, 99–107. [CrossRef]

52. Shikuku, K.M.; Valdivia, R.; Paul, B.K.; Mwongera, C.; Winowiecki, L.; Läderach, P.; Herrero, M.; Silvestri, S. Prioritizing climate-smart livestock technologies in rural Tanzania: A minimum data approach. *Agric. Syst.* 2017, 151, 204–216. [CrossRef]
53. Tibesigwa, B.; Visser, M.; Turpie, J. Climate change and South Africa’s commercial farms: An assessment of impacts on specialised horticulture, crop, livestock and mixed farming systems. *Environ. Dev. Sustain.* 2017, 19, 607–636. [CrossRef]

54. Zougmore, R.; Partey, S.; Ouédraogo, M.; Omitoyin, B.; Thomas, T.; Ayantunde, A.; Erickson, P.; Said, M.; Jalloh, A. Toward climate-smart agriculture in West Africa: A review of climate change impacts, adaptation strategies and policy developments for the livestock, fishery and crop production sectors. *Agric. Food Secur.* 2016, 5, 26. [CrossRef]

55. Makate, C. Effective scaling of climate smart agriculture innovations in African smallholder agriculture: A review of approaches, policy and institutional strategy needs. *Environ. Sci. Policy* 2019, 96, 37–51. [CrossRef]

56. Setimela, P.S.; Magorokosho, C.; Lunduka, R.; Gasura, E.; Makumbi, D.; Tarekegne, A.; Cairns, J.; Ndhlela, T.; Erenstein, O.; Lunduka, R.W.; Mateva, K.I.; Magorokosho, C.; Manjeru, P. Impact of adoption of drought-tolerant maize varieties on total maize production systems: Micro-level evidence from Kenya. *Agric. Food Secur.* 2018, 165, 283–293. [CrossRef]

57. Chandra, A.; McNamara, K.; Dargusch, P. Climate-smart agriculture: Perspectives and framings. *Clim. Policy* 2018, 18, 526–541. [CrossRef]

58. Thornton, P.K.; Whitbread, A.; Baedeker, T.; Cairns, J.; Claessens, L.; Baethgen, W.; Bunn, C.; Friedmann, M.; Giller, K.E.; Herrero, M.; et al. A framework for priority-setting in climate smart agriculture research. *Agric. Syst.* 2018, 167, 161–175. [CrossRef]

59. Abegunde, V.O.; Sibanda, M.; Obi, A. Determinants of the adoption of climate-smart agricultural practices by small-scale farming households in King Cetshwayo District Municipality, South Africa. *Sustainability* 2019, 12, 195. [CrossRef]

60. CCAPS. What is Climate-Smart Agriculture? Climate-Smart Agriculture Guide. Available online: https://csaguide/csa/what-is-climate-smart-agriculture (accessed on 15 March 2020).

61. Huang, J.; Wang, Y. Financing sustainable agriculture under climate change with a specific focus on foreign aid. In *Aid Effectiveness for Environmental Sustainability*; Huang, Y., Pascual, U., Eds.; Palgrave Macmillan: Singapore, 2018.

62. Sova, C.A.; Grosjean, G.; Baedeker, T.; Nguyen, T.N.; Wallner, M.; Jarvis, A.; Nowak, A.; Corner-Dolloff, C.; Girvetz, E.; Setimela, P.S.; Magorokosho, C.; Lunduka, R.; Gasura, E.; Makumbi, D.; Tarekegne, A.; Cairns, J.; Ndhlala, T.; Erenstein, O.; Mwangi, W. On-farm yield gains with stress-tolerant maize in eastern and Southern Africa. *Agron. J.* 2017, 109, 406–417. [CrossRef]

63. Kiboi, M.; Ngetich, K.; Diels, J.; Mucheru-Muna, M.; Mugwe, J.; Mugendi, D. Minimum tillage, tied ridging and mulching for better maize yield and yield stability in the Central Highlands of Kenya. *Soil Tillage Res.* 2017, 170, 157–166. [CrossRef]

64. Michler, J.D.; Baylis, K.; Arends-Kuenning, M.; Mazvimavi, K. Conservation agriculture and climate resilience. *J. Environ. Econ. Manag.* 2019, 93, 148–169. [CrossRef] [PubMed]

65. Mwangi, W. On-farm yield gains with stress-tolerant maize in eastern and Southern Africa. *Agron. J.* 2017, 109, 26. [CrossRef]

66. Barasa, P.; Botai, C.; Botai, J.; Mabhlaudhi, T. A review of climate-smart agriculture research and applications in Africa. *Agronomy* 2021, 11, 1255. [CrossRef]

67. Westermann, O.; Förch, W.; Thornton, P.; Jana, K.; Laura, C.; Bruce, C. Scaling up agricultural interventions: Case studies of climate-smart agriculture. *Agric. Syst.* 2017, 151, 192–203. [CrossRef]

68. Ojoko, E.A.; Akinwunmi, J.A.; Yusuf, S.A.; Oni, O.A. Factors influencing the level of use of climate-smart agricultural practices (CSAPs) in Sokoto state, Nigeria. *J. Agric. Sci.* 2017, 62, 315–327. [CrossRef]

69. Ojoko, E.A.; Akinwunmi, J.A.; Yusuf, S.A.; Oni, O.A. Factors influencing the level of use of climate-smart agricultural practices (CSAPs) in Sokoto state, Nigeria. *J. Agric. Sci.* 2017, 62, 315–327. [CrossRef]

70. Mwongera, C.; Shikuku, K.M.; Twyman, J.; Läderach, P.; Ampaire, E.; van Asten, P.; Twomlow, S.; Winowiecki, L.A. Climate smart agriculture rapid appraisal (CSA-RA): A tool for prioritizing context-specific climate smart agriculture technologies. *Agric. Syst.* 2017, 151, 192–203. [CrossRef]

71. Mapfumo, P.; Onyango, M.; Honkonen, S.K.; El Mzouri, E.H.; Githeko, A.; Rabeharisoa, L.; Obando, J.; Omolo, N.; Majule, A.; Denton, F.; et al. Pathways to transformational change in the face of climate impacts: An analytical framework. *Clim. Dev.* 2017, 9, 439–451. [CrossRef]
79. Kaptymer, B.L.; Ute, J.A.; Hule, M.N. Climate smart agriculture and its implementation challenges in Africa. *Curr. J. Appl. Sci. Technol.* 2019, 38, 1–13. [CrossRef]

80. Williams, T.O.; Gyampoh, B.; Kizito, F.; Namara, R. Water implications of largescale land acquisitions in Ghana. *Water Altern.* 2012, 5, 243–265.

81. Knaepen, H.; Torres, C.; Rampa, F. *Making Agriculture in Africa Climate-Smart: From Continental Policies to Local Practices. Briefing Note 80*; European Centre for Development Policy Management: Maastricht, The Netherlands, 2015; pp. 1–20.