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Climate Smart Agriculture and Its Implementation Challenges in Africa

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Authors' contributions

This work was carried out in collaboration among all authors. Author BLK wrote the protocol and the first draft of the manuscript. Authors JAU and and MNH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The changing climate is hitting smallholder farmers hard. It is doing so especial in the African continent which is regularly pronounced as most vulnerable to the impacts of climate change. Climate change brings droughts and floods, pests and diseases; it means poorer crops, less food, and lower incomes. Agriculture in Africa must undergo a major transformation in the coming decades in order to meet the intertwined challenges of achieving food security, reducing poverty and responding to climate change without depletion of the natural resource base. Climate-smart agriculture seeks to increase productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change, and reduce agriculture's contribution to climate change by reducing greenhouse gas emissions and increasing carbon storage on farmland. Climate-smart agriculture includes practical techniques including mulching, conservation agriculture, integrated crop-livestock management, crop rotation, intercropping, agro forestry, improved grazing, and improved of water management system. In spite of the potential of Climate Smart Agriculture to improve resilience and to enhance agricultural production and rural livelihoods, systematic response

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to climate change through adoption of Climate Smart Agriculture practices and technologies is still very limited in Africa for a host of reasons. some of the challenges facing Climate-smart agriculture in Africa includes, Lack of practical understanding of the approach; Lack of data and information and appropriate analytical tools at local and national levels; Inadequate coordinated, supportive and enabling policy frameworks; Lack of adequate and innovative financing mechanisms and effective risk-sharing schemes; Limited credit and finance and Poor physical and social infrastructure to mention few. To support the implementation of climate-smart agriculture and resolve the challenges in Africa, it is necessary to improve the coordination of policies and strengthen local, national and regional institutions.

Keywords: Climate smart agriculture; climate change; resilience; conservation agriculture.

1. INTRODUCTION

Currently, about 48% of Africa's population or approximately 450 million people live in extreme poverty, on less than US$1.25 per day, with 63% of the continent's poor live in rural areas depending on agriculture for their livelihoods [1].

Climate Smart agriculture (CSA) is a concept developed by FAO, is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change [2]. Climate change and variability are emerging as the major threats to development across the continent impacting adversely on agriculture and livelihoods. Similarly, Africa's population continues to grow with an estimated annual growth of 2.4% and the population is predicted to double from its current 0.9 billion people by 2050. According to the Food and Agriculture Organization of the United Nations (FAO) in [2], more than a quarter of Sub-Saharan Africa's people are currently undernourished. Crop production needs to increase by 260% by 2050 to feed the continent's projected population growth. Thus Africa's agriculture must undergo a significant transformation to meet the simultaneous challenges of climate change, food insecurity, poverty and environmental degradation. Climate-Smart Agriculture should be part of the solution in addressing this problem [3].

In order to feed the growing population sustainably in the context of climate change, agricultural productivity needs to grow. Africa has a great potential to increase its crop production. It has around 60 % of the world's uncultivated arable land, suitable for crop production, and the highest margins for improving the productivity in already cultivated land. It is mandatory, however, that this increase in production and productivity happens in a climate-smart way [4,5]. Climate smart Agriculture includes proven practical techniques, such as mulching, intercropping, conservation agriculture, integrated crop-livestock management, crop rotation, agro-forestry, improved grazing as well as improved water management system and innovative practices, for instance better weather forecasting, more resilient food crops and risk insurance [6]. CSA shares many of the practices of conservation agriculture (CA). Milder, et al. [7] define conservation agriculture (CA) as a farming approach that fosters natural ecological processes to increase agricultural yields and sustainability by minimizing soil disturbance, maintaining permanent soil cover, and diversifying crop rotations.

The bulk of agricultural systems in Sub Saharan Africa (SSA) are highly climate-dependent, more than 95 % of farmed land grows crops from rain fed agriculture. The countries in this region are already suffering from food insecurity due to low productivity because of degraded soils, droughts, floods and a lack of effective water management, among other factors. The largest proportion of food-insecure people is located in SSA, where more than a quarter of the population was undernourished in the period 2010-2012 [8]. CSA focuses on a sustainable increase of agricultural production, while synergistically adapting to climate change and mitigating GHG emissions [2].

To make agriculture climate-smart, the coordinated use of different, complementary approaches and techniques is necessary, for example multi-cropping techniques, ensuring farmers' access to improved seeds and managing landscapes. In addition, a multi-stakeholder, inter-sectorial approach to policies and investments is also a prerequisite [4]. Sustainable production intensification (SPI) is an important tool for increasing production in climate-smart systems. SPI saves natural resources, time and money by increasing the efficiency of farming systems. More is produced with fewer inputs by applying appropriate inputs at the right time and in the right amount, optimizing resource use and reducing waste. Sustainable production intensification (SPI) uses knowledge-intensive approaches, such as conservation agriculture, integrated plant nutrient management, integrated pest management, water management and pollination management [2]. However, Climate Smart Agriculture faces a number of challenges related to the conceptual understanding, practice, policy environment and financing of the approach. Therefore, the objective of this review is to clearly describe the nature of CSA and its associated challenges in the context of Africa.

2. CONCEPTS OF CLIMATE SMART AGRICULTURE

Climate Smart agriculture is an integrated approach which uses a combination of technologies and practices to meet food security goals while adapting to, and mitigating, climate change. In practice, it means having access to agricultural technologies such as crop varieties and livestock breeds that are more adapted to a changing climate, improved water management techniques to use water more efficiently, and practicing agro-forestry, crop rotation, mulching, intercropping, integrated crop-livestock management, and improved grazing to help conserve water and carbon in the soil [9]. Similarly, [10] stated that Climate-smart agriculture involves the use of different 'climate-smart' farming techniques to produce crops or livestock, which could help reduce pressure on forests for agricultural use as well as potentially maintain or enhance productivity, build resilience to climate change and mitigate the sector's high emissions. CSA is a harmonized way of addressing the multiple challenges faced by agricultural systems [11].

According to CSA [12], CSA is conceptualized as a continuous and iterative process that aims to combine food security, agricultural development and climate change objectives. However, proponents of climate-smart agriculture acknowledge the limits and negative consequences of an approach which focuses solely on production and does not take long-term environmental sustainability into account. This explains why sustainably increasing agricultural productivity and incomes is the first pillar on which the concept of 'climate-smart agriculture' is based [2]. This concept is further developed in the Alliance's Framework Document, which promotes sustainable increases in the productivity of food systems, by a sustainable use of natural resources, the adaptation of people's livelihoods that are threatened by climate change, and agricultural practices that contribute to reduced emissions and less deforestation as a result of agriculture [13].

3. APPROACHES TO MAKE AGRICULTURE CLIMATE SMART

As farming systems approaches have considerably evolved during the last four decades, several approaches towards sustainable agriculture, indicative of the specific aspects of sustainable development were grappling [14]. These approaches have brought to light insights related to institutions and policy participation, multi-stakeholders partnerships and people's rights, environment and agro-ecosystems as well as multidisciplinary and multispectral mechanisms and their interdependence.

Some of the approaches currently used relate to practices at farm level for instance, sustainable intensification, whereas some others relate to comprehensive, holistic approaches such as Climate Smart Agriculture [15]. Some of them promote a more nature-driven agriculture like eco-intensive agriculture or agro-ecology, while some others support a more technology driven agriculture like precision agriculture [4]. In principle, all such approaches are complementary, and they can be gathered under the Sustainable Agriculture (SA) umbrella, including green agriculture [16]. Climate Smart Agriculture, agro-ecology, ecosystem-based adaptation (EBA) for food security, the landscape approach, eco-intensive agriculture and sustainable intensification, amongst others. In the quest for finding the best possible options for use within African divergent contexts and scenarios, it is of utmost importance to build more complementarities among so many good available methods while seeking new knowledge and avoiding getting stuck in debates about definitions and boundaries of different approaches [14]. There is a wide variety of climate-smart techniques, including conservation agriculture and the landscape approach. Other approaches in the CSA portfolio include "agro-forestry" and "sustainable intensification [4].

3.1 Agro-forestry

Agro forestry is a comprehensive, climate-smart system that combines shorter-term production from agriculture activities (for example crops and pasture) with longer-term production by trees (e.g. timber) on the same land management unit [17], "Sustainable intensification" looks at optimizing production (in quality and in quantity) relative to inputs (e.g. land water, fertilizer, labor) and improving the livelihoods of farmers, while minimizing negative externalities (e.g. pollution or deforestation). It is a management system that integrates perennial and annual crops in a two canopy or multi-canopy production system. This guarantees better exploitation of light, water and soil nutrients and protects soil more effectively from erosion and leaching. It leads to a more diversified and sustainable production system than many treeless alternatives and provides increased social, economic and environmental benefits for land users (Sanchez et al.) [18].

3.2 Agro-ecology

Agro ecology is defined as the application of ecological concepts and principles to the design and management of sustainable agro-ecosystems [19]. Agro-ecology can be considered as farming practices that mimic nature by, for instance, adding organic material to the soil, planting trees on cropped fields and using natural enemies to attack insect pests. According to many observers, agro-ecological approaches have proven to improve the yields, livelihoods and environment for small-scale farmers in the face of climate change [20]. Some consider agro-ecology as the most effective means of adaptation; healthy soils - especially those that receive compost and manure - are rich in soil carbon, since they have captured carbon dioxide from the atmosphere [19]. According to its defenders, it leaves room for partnerships between farmers using agro-ecological methods and private sector actors who do not limit themselves to simply selling seeds and fertilizers to farmers [20]. Similarly, ecosystem-based adaptation (EBA) for food security refers to the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change across all scales.

According to FAO [2], CSA is a more comprehensive development concept compared to agro-ecology. At its launch (2010), it was however heavily criticized, especially by civil society and farmer's organizations, for lacking specific indicators, thereby also risking focusing too narrowly on mitigation instead of adaptation that is more urgent in poor developing countries. CSA now links environmental, social and economic pillars of sustainability, and covers farm level practices, landscape level approaches, and institutional/policy level frameworks [21,22]. The CSA concept is relatively flexible and is still "work in progress", since the approach remains context-specific and needs to be always tailored to local and regional realities.

3.3 Sustainable Intensification

Intensification increases the amount of crops or livestock grown on the same piece of land by planting more crops (eg. intercropping between rows with other plants) or achieving higher yields from individual crops (eg. from using new seed varieties, more fertilizer application or irrigation [23]. Two examples of climate-smart agricultural practices which could contribute to sustainable intensification could be intercropping with nitrogen-fixing legumes (CSAS, 2013) and composting [23].Both are intensive farming practices which support soil fertility management and could help farmers to produce more on existing farmland [24]. The potential adaptation, food security, and mitigation benefits of both intercropping and composting are;

3.3.1 Adaptation benefits

Adaptation to storms with heavy rainfall, which are projected to increase in frequency and intensity under climate change [25], could result from more soil cover and roots to prevent erosion. Drought resistance could be increased through building up soil organic matter (USDA, 2013) and soil cover for moisture retention [24].

3.3.2 Food security benefits

Intercropping could provide more food from the same plot (legumes are useful for livestock feed as well), whilst both composting and intercropping could increase crop yields via improved soil fertility [26].

3.3.3 Mitigation benefits

The amount of chemical fertilizers needed could be reduced since composting and legumes contribute nutrients to the soil, which could reduce GHG emissions from application and manufacture of the fertilizers [27]. Additionally, intercropping and composting can increase biomass both above and below the ground, supporting soil carbon sequestration.

3.4 Conservation Agriculture

Conservation agriculture promotes minimal disturbance of the soil by tillage (zero tillage), balanced application of chemical inputs (only as required for improved soil quality and healthy crop and animal production), and careful management of residues and wastes [28]. Conservation agriculture (CA) is a model of sustainable agriculture as it leads to profitable crops production while protecting and even restoring natural resources. CA benefits farmers because it reduces production costs and increases yields through the betterment of soil fertility, improvement of water quality, reduction of soil erosion and mitigation of climate change by increasing carbon sequestration [29]. Similarly (Tesfay *et al.,* 2010) stated that CA can be a possible technique to mitigate the reduction in soil quality, to reduce runoff and soil erosion, and can increase in situ moisture conservation, thereby increasing crop yield. CA systems are also less sensitive to extreme climatic events and therefore contribute to the adaptation to climate change and the resilience of agricultural systems. Hence, CA becomes a fundamental element of sustainable production intensification, combining high production with the provision of environmental services.

CA can help mitigate atmospheric greenhouse gas (GHG) accumulation, both by reducing existing emission sources and by sequestering net carbon [30]. Dendooven et al. [31] evaluated the effect of tillage practice and crop residue management on the net global warming potential (GWP) taking into account soil Carbon sequestration, emissions of greenhouse gasses from soil, i.e. CO_2, CH_4 and N_2O, and fuel used for farm operations (tillage, planting and fertilizer application, harvesting) and the production of fertilizer and seeds. The main characteristics of CA production systems are optimization of the crop yield, and farm income as well as minimization of the negative ecological impacts associated with conventional agriculture. Use of herbicides to control the weeds and soil management is an opportunity to minimize the production costs and to avoid negative effects through soil tillage [32]. It is also possible to have better water quality, soil erosion control; reduced GHG emissions etc. which are not possible with fully conventional tillage based agricultural land use [33].

3.5 Organic Agriculture

Organic agriculture refers to the increasing use of farming practices and technologies that maintain and increase farm productivity and profitability while ensuring the provision of food on a sustainable basis, reduce negative externalities and gradually lead to positive ones and rebuild ecological resources (soil, water, air and biodiversity) by reducing pollution and using resources more efficiently [34]. It is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil Biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system [35]. OA is not only a specific agricultural production system, it is also a systemic and encompassing approach to sustainable livelihoods in general, where due account is given to relevant factors of influence for sustainable development and vulnerability, be this on physical, economic, or socio-cultural levels [36]. Organic agriculture enhances biodiversity, protects our fragile soils, improves the nutritional quality of food, ensures high standards of animal welfare and provides increased employment in rural areas. At the same time, organic agriculture reduces green house gas emissions and fossil fuel energy use, cuts nutrient and pesticide pollution and stops potentially harmful pesticide residues entering our food chain [37].

Organic agriculture avoids nutrient exploitation and increases soil organic matter content. In consequence, soils under OA capture and store more water than soils under conventional cultivation (Niggli *et al*., 2008). Production in OA systems is thus less prone to extreme weather conditions, such as drought, flooding, and water logging. OA accordingly addresses key consequences of climate change, namely increased occurrence of extreme weather events, increased water stress and drought, and problems related to soil quality [38]. By its nature, organic agriculture is an adaptation strategy that can be targeted at improving the livelihoods of rural populations and those parts of societies that are especially vulnerable to the adverse effects of climate change and variability for example, the rural population in sub-Saharan Africa; and improvements via reduced financial risk, reduced indebtedness and increased diversity [36].

Farming practices and technologies that are instrumental in organic agriculture include: restoring and enhancing soil fertility through the increased use of naturally and sustainably produced nutrient inputs, diversified crop rotations, livestock and crop integration, reducing soil erosion and improving the efficiency of water use by applying minimum tillage and cover crop cultivation techniques, reducing chemical pesticide and herbicide use by implementing integrated biological pest and weed management practices and reducing food spoilage and loss by expanding the use of post-harvest storage and processing facilities [4].

3.6 An Integrated Crop-livestock System

Many regions of the world already face a scenario of food insecurity, which is projected to increase in the future. The current challenges of agriculture include circumventing the problems arising from decades of using farming practices with high environmental impact, mitigating emissions of greenhouse gases, reducing the erosion and loss of fertility of soils, reducing the silting of water courses and preventing soil and water pollution, among others. Integrated crop-livestock systems (ICLS) are considered to be a key among sustainable technologies to achieve these goals [39]. Integrated crop-livestock systems are characterized as systems designed to exploit synergisms and emergent properties that result from interactions in the soil-plant-animal- atmosphere compartments in areas that integrate crop and livestock production activities on different spatial-temporal scales, covering the exploitation of agricultural crops (farming and forestry) and animal production (e.g., meat, milk and wool, among others) in the same area concurrently or sequentially in rotation or succession [40]. Studies of integrated crop-livestock systems have been conducted in different environments and with different configurations of grain crops, forestry components, types of animals and associated forage substrates [41].

The benefits of integrated crop-livestock systems include:

- Improvement of the production processes, including improvements in the workforce, stability of economic factors and risk reduction,
- Greater chances of producers reaching their socio-cultural aspirations in an equitable way and
- Greater food security to meet the needs of consumers regarding the quality of the products and production processes [26]. Furthermore, a high level of biodiversity is maintained, which is essential to support the intensive agricultural systems required to achieve food security and reduce environmental degradation while concomitantly adapting agriculture to climate change.

3.7 Crop Rotation

Appropriate crop rotation increases organic matter in the soil, improves soil structure, reduces soil degradation, and can result in higher yields and greater farm profitability in the long-term (IFOAM, 2012). Similarly [42] stated that rotations provide an opportunity for improving soil physical quality, especially if the active growth period is expanded and the amount of tillage in the rotation is reduced. With careful selection, rotation crops can be targeted to help alleviate certain soil quality problems. Crop rotation has a number of agronomic, economic and environmental benefits compared to monoculture cropping. These include:

3.7.1 Reduced greenhouse gas emissions

Creating better nutrient management through crop rotation can decrease nitrogen fertilizer use by up to 100kg N per ha per year, substantially lowering related greenhouse gas emissions [43].Nitrous oxide has a global warming potential 310 times greater than CO_2. Reduced synthetic fertilizer use also leads to reduced greenhouse gas emissions from the manufacturing process and transportation.

3.7.2 Reduced water pollution

Limiting the input of large applications of synthetic fertilizers will decrease water pollution caused by nitrogen, which costs an estimated 70 to 120bn Euro per year [44]. Diversified rotations and rotations with a high share of crops and a low dependence on pesticides (eg. clover, Lucerne) also reduce pesticide use and potential run off into groundwater [45].

4. CHALLENGES OF CLIMATE SMART AGRICULTURE

Adapting to weather and climate is a characteristic of all human societies, but climate change is presenting new and increasing challenges. Already, smallholder farmers in Africa are using their knowledge, experience and resources to manage climate risks on their own account but these actions are not easily distinguished from a range of other social, demographic and economic factors influencing livelihood decisions and development trajectories [46]. In spite of the potential of CSA to improve resilience and to enhance agricultural production and rural livelihoods, systematic response to climate change through adoption of CSA practices and technologies is still very limited in Africa for a host of reasons. The barriers or factors that prevent adoption of CSA practices in Africa are listed and discussed below

4.1 Lack of Practical Understanding of the Approach

CSA approach is obviously attractive and compelling in principle, but its application under Africa's diverse agro-ecologies and highly heterogeneous farming systems, socio-economic conditions and policies still requires concrete examples of success. The evidence of how such successes are measured and achieved is of critical importance [47]. Gleaning clear empirical messages to inform farmers and policy makers and support any scaling up initiatives will depend on how the CSA concept is understood in practices, allowing for adaptations and continuous two-way feedback mechanisms between researchers and practitioners, farmers and policy makers.(ibid)

4.2 Lack of Data and Appropriate Analytical Tools at Local and National Levels

In many African countries, there are no long-term climatic and landscape level data. Where some data exist they are dispersed and difficult to access. Global models of climate change are at scale and resolution difficult for local, national or regional managers to work with [48]. Capacity and analytical tools to downscale the results of global models to regional, national and watershed scales are not readily available in most countries. As a result, decision makers lack knowledge of current and future projected effects of climate change in their country and the implications for agricultural practices, food security and natural resource management (ibid).

4.3 Inadequate Coordinated, Supportive and Enabling Policy Frameworks

Coordination and integration of policies and plans have proved problematic in Africa. For instance, a recent review of the regional agricultural investment program (RAIP) and national agricultural investment programs of 15 member states of the Economic Community of West African States revealed that only one country, Burkina Faso, explicit linked climate change adaptation to its national agricultural investment programs. The remaining 14 countries failed to mainstream climate change adaptation into their NAIPs [49]. There is lack of institutional arrangements that are needed for Climate Smart Agriculture to upscale from the farm to the landscape.

4.4 Socio-economic Constraints at the Farm Level

Millions of poor farmers, including women hold weak and unsecured water and land rights in many parts of SSA. Existing customary and institutional factors as well new drivers, for example, large-scale foreign investment in agricultural land that leads to the displacement of current poor land users have exacerbated this state of affairs [50]. At another level, lack of accurate and timely information and technical advisory services, unavailability and lack of access to inputs, including suitable crop varieties constrain their ability to assess the risks and benefits of CSA and make informed investment decisions. Competing resource use (e.g. labour, cash, biomass) at the farm scale have been a major constraining factor. Furthermore, smallholders in particular face obstacles in gaining access to domestic, regional and international markets [51].

In many countries there are not yet in place financing plans to promote the uptake of CSA, where the transition to climate-smart agricultural development pathways requires new investments. "As farmers in Africa face major risks arising from the effects of climatic hazards, they also face the challenge of managing risks associated with the high costs (at least initial costs) of adopting new technologies (e.g. conservation agriculture and agro-forestry) whose benefits often only come after several years/seasons) of production. Most of the farmers have little or no access to credit, micro-financing and/or insurance." [52].

4.5 Limited Access to Appropriate Farm Equipment, Tools, Inputs, Credit and Finance

Limited access to CSA-specific farm equipment and tools is a significant barrier to scaling up CSA in Africa [7]. CSA may not necessarily require more equipment and tools than conventional agriculture, but some of the equipment and tools are specific and may not always be available. The most significant differences tend to be in equipment and tools used for land preparation and seeding. In areas with silt or clay soils, the soil surface is penetrated only in precisely-targeted lines or pits that will be seeded. Seeds are then deposited into these areas or inserted directly into the ground through the mulch or ground cover layer. Some conventional agriculture equipment and tools can be used for CSA (e.g. certain weeding tools), while others can be modified for CSA (e.g. hand hoes can be made narrower to dig CSA planting basins or rows) (IIRR, 2005).

Limited access and ability to afford seeds, inorganic fertilizers, pesticides, and herbicides represent a constraint to the practice of CSA in a maximally productive manner [7]. However, one of the advantages of CSA is that it can increase yields by fostering biological processes and management practices that enhance soil fertility, pest and weed control where agrochemicals are not available or not affordable [53].

Non-availability and poor access to high-yielding seeds and breeds are also important barriers to the adoption of CSA. Often, CSA requires special seeds for cover crops or intercrops, which are more difficult to obtain if they are species that have not traditionally been grown locally [7]. Unless efficient and reliable input supply chains are established, input barriers will continue to be a hindrance to adoption of CSA.

Smallholder farmers aiming to adopt CSA practices often are constrained by inadequate cash to invest in the land, equipment, labor, seeds, breeds and other farm inputs. As noted by Milder *et al.* [7] CSA is generally more profitable in the long-term condition in compared to conventional farming technique, but achieving these long-term benefits requires initial investment, which is often prohibitively expensive or risky for small farmers to undertake on their own. Vulnerable farmers are especially risk averse due to household food security concerns, and there is little room for error. In addition, while many farmers reap benefits in the first year of practicing CSA, others do not realize increased yields or profitability for 3-7 years [54]. During this time, farmers sometimes choose to abandon CSA. Thus, long-term adoption is more likely when CSA provides significant benefits in the first or second year [55]. Such immediate benefit is more likely when CSA is promoted in conjunction with good agronomic practices, improved seeds, and sometimes inorganic fertilizers [7]. The lack of or inadequate financial means to acquire farm inputs constitute an important barrier to smallholder farmer adoption of CSA.

4.6 Shortages in Labor Supply

Availability of farm labor is a major constraint influencing decisions in most smallholder production systems. In many parts of Africa, the demand for labor tends to be greater than supply, at least seasonally. Labor is often in short supply due to rural urban migration (especially by young men), prevalence of HIV/AIDS and other diseases, and under-nutrition and malnutrition [56]. In some agro-ecological zones, CSA requires deep-digging to penetrate soil crusts, a task that is very arduous and may increase the initial labor requirements for land preparation [7]. In other zones however, land preparation in CSA requires less labor than in conventional agriculture since whole-field ploughing or tillage is not required. Soil type also affects the direction and magnitude of these differences. Even when total labor is less under CSA, labor requirements for women may be greater, or vice versa (ibid).

Milder *et al.* [7] endorsed that in the long-term, CSA very often reduces the labour required for farming, relative to conventional practice, although this is not universally the case. In the short-term, it is quite common for CSA to require increased labor, especially for weeding and land preparation. Tillage is an efficient way to control weeds, but with reduced tillage, weeding can require substantial initial increases in labor if herbicides are not used [7]. Zai pits are another conservation technology with labor implications. Zai pits are both a soil moisture conservation measure and a soil fertility improvement technique with high labor requirements. They are particularly applicable in degraded soils. Several environmental and human factors cause irreversible soil and land degradation, leading to reduced soil and water holding capacities. However, in situ moisture conservation technologies such as semi-bunds and zai pits retain rainwater and store it for crop production.

Farmers use stone contour bunds to reduce the speed of run-off, allowing infiltration into the zai which collect and concentrate the run-off. Excess run-off is collected into a reservoir for other uses [57]. In West Africa, the zai system, with pits about 10-20 cm diameter and 10-15 cm deep, is a common practice [58]. The holes store rainwater for plant growth, and generally the density is about 10,000- 15,000 holes/ha depending on the crop chosen and the spacing between holes. The larger the planting pits and the wider the spacing, the more water can be harvested from the uncultivated micro-catchment areas between the pits. In Niger, zai has been reported to increase biomass yield by 200 percent [59]. Despite the high initial labor cost, the zai system has been adopted from the Sahel region of West Africa and is now commonly practised in Eastern and Southern Africa as well [57]. High labor needs and costs have been identified by OXFAM (2011) as an important barrier to adoption of zai pits. In West Africa, particularly in Burkina Faso, women do not use adaptation techniques such as zaipits or stone walls since they do not have the necessary physical strength and support. They also do not have access to the appropriate tools (which are reserved for men's plots). As a result, women's plots produce lower yields and are more vulnerable to climate change.

4.7 Poor Physical and Social Infrastructure

Physical and social infrastructures are important components in any society or development program. For smallholder farmers to easily adopt CSA and adapt to climate change, there is need for physical infrastructure such as irrigation water supply, water management structures, transport, markets, communication infrastructure as well as storage and processing structures [60]. Mati [61] identified infrastructure and availability of markets as the key drivers for success of smallholder development in Kenya. Their absence therefore, constitutes an important barrier to the adoption of CSA practices.

4.8 Low Volumes of Biomass

An agro-ecosystem related barrier with severe implications for CSA than with conventional agriculture is the availability of biomass for mulches or organic fertilizer. In many Sub Saharan Africa ecosystems, biomass is a critical barrier to adoption of CSA [7]. Availability and management of biomass, particularly crop residues and mulches is a critical component of CSA and a major barrier to its adoption in many African agro-ecosystems. Similarly, livestock is an important part of most smallholder farming systems, but the management of grazing livestock severely hinders CSA adoption. Crop residues plays an important source of livestock feed during the dry season, and farmers cannot afford to leave residues in the field while their animals go hungry. In addition, due to communal land tenure that characterizes many smallholder regions of Africa, farmers cannot choose unilaterally to exclude livestock from feeding on biomass available on their lands simply for the sake of implementing CSA. This decision must be made at the community levels, and it is often difficult to change long-standing rules and customs.

5. CONCLUSION

Climate-smart agriculture, a concept developed by FAO, is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. Climate change and variability are emerging as the major threats to development across the continent impacting adversely on agriculture and livelihood [62]. Therefore, Africa's agriculture must undergo a significant transformation to meet the simultaneous challenges of climate change, food insecurity, poverty and environmental degradation. Climate-smart agriculture should be part of the solution in addressing this problem. effective implementation of climate smart agriculture in Africa in some way, various approaches like Agro-forestry practices, Agro-ecology, Intensification, Conservation Agriculture, Organic agriculture, an integrated crop-livestock system and Crop rotation seems to make Agriculture climate Smart and bring sustainable agricultural development in the context of Africa.

Nonetheless, climate smart agriculture faces various challenges like lack of practical understanding of the approach, lack of data and information and appropriate analytical tools at local and national levels, inadequate coordinated, supportive and enabling policy frameworks, lack of adequate and innovative financing mechanisms and effective risk-sharing schemes, limited credit and finance and poor physical and social infrastructure.

6. THE WAY FORWARD

Investing in ecosystem-based approaches, new technologies and an enabling environment to enhance and facilitate uptake of Climate Smart Agriculture Creating awareness and raising the profile of Climate Smart Agriculture by promoting CSA success stories and opportunities to smallholder farmers. Improve coordination of policies and strengthen local national and regional institutions to support the implementation of climate-smart agriculture. Development of innovative financing schemes to unlock both agriculture and climate finance to improve access of smallholders, governments and private sector entrepreneurs to capital needed to develop and implement CSA. Focus should be directed towards adding value to climate change adaptation actions. Adaptation measures that have been successfully tested for wide application within a given region should be scaled up, depending on the context of the country, while taking agro-ecological zones into account.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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