Climate-Smart Agriculture Approaches and Concepts for Food Systems Transformation in Sub-Saharan Africa: Realities and Myths

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1 Introduction

CSA as a concept has gained momentum as a sustainable solution to transform and reorient agriculture under the occurrence of climate change (Adolph et al. 2020; Schaafsma et al. 2018). Presently, climate change threatens and will continue to devastate agricultural systems globally (Jansson and Hofmockel 2020; Zakaria et al. 2020; Konapala et al. 2020). With the current severity of climate change, CSA aims to; (i) sustainably increase agriculture productivity, raise farmers' incomes, ensure long-term food security, (ii) enhance sustainable agriculture adaptation to climate impacts, and (iii) reduce agriculture GHG emissions (Zakaria et al. 2020; Adolph et al. 2020).

In the CSA discourse, major contestations include; (i) considering which practices and technologies as CSA and (ii) uncertainty of trade-offs of CSA are issues that require attention (Andrieu et al. 2020; Partey et al. 2018). Despite these contestations, several CSA innovations, tools, and policies already integrated with indigenous activities and approaches have helped farmers build climate resilience and increase

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productivity (Martey et al. 2020; Branca et al. 2020). Also, the advancement of new technologies, approaches, tools, and policies through research is helping achieve CSA goals through field demonstrations and on-farm trials (Zakaria et al. 2020; Partey et al. 2018).

In SSA, many agricultural intensifications options; including drought-tolerant crop and livestock breeds, small-scale irrigations, agroforestry, crop diversification, conservation agriculture, weather-based insurance, and soil fertility management, are promoted as CSA practices and technologies (Branca et al. 2020; Clay and Zimmerer 2020; Partey et al. 2018). The positive outcomes of these practices are relevant in advancing agricultural progress in SSA under increasing climatic stress. Nonetheless, CSA can only be efficient and effective with maximum societal impacts if the practices are adopted by many farmers globally (Etwire et al. 2020; Andrieu et al. 2020). The impacts of CSA, mostly on the vulnerable, require strengthening efforts at institutional levels to broaden adoption. The uptake of CSA in SSA stays low and unsatisfactory impeding sustainable development (Andrieu et al. 2020; Etwire et al. 2020; Partey et al. 2018). Context-specific CSA options can promote efficient up-scaling and out-scaling of CSA while enhancing the incorporation of CSA into international negotiations. In this paper, we discuss; (1) the need for CSA in SSA (2) potential CSA practices and their successes in SSA (3) Challenges to CSA implementation, and potential areas for improvement, (4) sustainability and gender differentiation in CSA.

2 Materials and Methods

2.1 Data and Analysis

A content analysis approach was employed in collecting and presenting information about CSA in SSA. The content analysis approach allows for in-depth assessment of information and identification of patterns in both printed and recorded communications (Lindgren et al. 2020). For this study, a detailed review of journal articles, reports, and web content on CSA was conducted. The approach was employed because CSA is a growing concept in SSA, thereby providing an opportunity to assess the myths and realities through currently available content information. Information on the myths and realities of CSA in Africa is imperative to influence practical action and create an understanding of the dynamics of CSA implementation. In conducting the content analysis, important issues considered included practices considered as CSA in SSA, successes and failures of CSA practices, challenges of CSA implementation, CSA contribution to sustainability and gender inclusion. Subsequently, interviews were conducted among farmers who have participated in CSA implementation. The interviews sought to promote a bottom-up policy of CSA implementation by understanding CSA from the farmers' perspective. A total of thirty farmers (30) were included in the interviews, and both male and female farmers participated.

The interviews were interpreted and used to support the narratives from the content analysis. The interviews were conducted in five (5) SSA countries, thus, Ghana, Benin, Togo, Nigeria, and Burkina Faso. The inclusion of these countries was based on the availability and readiness of farmers to participate in interviews. Aside from farmers, local government officials, agriculture extension officers and representatives from ministries of food and agriculture of the various countries were interviewed to provide a policy perspective on CSA implementation. In the study, participants (P) is used to represent the interpretation of information from an interviewee/participant.

2.2 Contextualizing CSA in SSA

CSA has seemingly been controversial in its role to address multiple objectives (Andrieu et al. 2020; Clay and Zimmerer 2020). CSA is heavily criticized as a single-sided agenda as it continuously neglects mitigation issues (Westermann et al. 2018; Aggarwal et al. 2018). The clarity of CSA can be achieved with data-based information on mitigation goals and building strong synergies for adaptation and mitigation. Also, the main global contributors to climate change are encouraged to consider co-opting CSA practices (Pimbert 2015). For others, CSA has an inadequate focus on the agro-ecological and socio-technical practices employed by farmers towards climate change adaptation (Saj et al. 2017). Across SSA, mainstreaming CSA into national development plans has been slow yet progressive (Clay and Zimmerer 2020; Etwire et al. 2020; Partey et al. 2018). Different CSA projects coordinated by national governments, development partners, civil society organizations, and sometimes a combination of all have targeted rural agriculture transformation. For instance, agroforestry in Niger improved the livelihoods of about 1.25 million households and enhanced carbon sequestration (Pretty et al. 2011). Maize-legume intercropping supported yields improvement in Malawi (Ngwira et al. 2012). Climate-smart villages in *Yatenga* (Burkina Faso), *Lawra-Jirapa* (Ghana), *Borana* (Ethiopia), *Wote,* and *Nyando* (Kenya) by the World Bank and FAO supported rural livelihoods transformation (Wattel and Asseldonk 2018).

3 Results and Discussion

3.1 Practices (Some) Promoted as CSA in SSA

The literature shows several CSA options promoted across different countries in SSA with their contribution to adaptation and mitigation. Some of the practices are improved practices from indigenous knowledge that farmers have already been engaged in spontaneously. Others were planned CSA options from new technologies introduced to farmers. We discussed nine (9) common practices found in the literature.

3.1.1 Agroforestry

Agroforestry is an extensive agricultural activity in SSA that aims to increase tree cover, above and below-ground biomass, including soil carbon (Partey et al. 2018). Agroforestry activities, together with agro-silviculture with tree species (*Magnifera indica, Anacardium occidentale, Tectonagrandis* teak, and *Maringa oleifera*), are grown on croplands in Ghana, Mali, Niger, and other several SSA countries (Andrieu et al. 2020; Wattel and Asseldonk 2018). Boundary and hedge tree planting not to mention borders and roadsides create favourable microclimates for crops and serve as windbreaks, and also stabilizes the soil. These systems increase soil productivity through increased litter inputs, soil nutrient availability, improved green manure and fallowing practices. Trees provide fodder that serves as an integral feedstock for livestock. The integration of agroforestry in cropland and livestock builds farmers' adaptive capacity, improves yields, and promotes climate change mitigation (Clay and Zimmerer 2020). Apart from agro-silviculture, farmer-managed natural regeneration (FMNR) remains a relevant agroforestry practice in SSA (Kibru et al. 2020; Iiyama et al. 2017). In SSA, FMNR reduces desertification, improves soil productivity, and provides biomass for household energy (Garrity et al. 2010). An interviewee elaborated;

> Planting trees on the farm has helped to improve crop productivity. For the past three years, I (farmer) have received training from different organizations on planting different species of trees on my farm. The trees are planted around the farm on the boundaries. Now, I (farmer) harvest fruits from some of the trees planted for sale and household use (P04, Benin).

3.1.2 Integrated Nutrient Management (INM)

Soil degradation and nutrient depletion are major threats to SSA's agriculture (Garrity et al. 2010; Wattel and Asseldonk 2018). The soil in some countries in SSA has limited nutrients with low potency leading to the rapid decline of productivity once cropping commences (Kibru et al. 2020; Iiyama et al. 2017). Integrated nutrient management (INM) as a CSA option is the optimization of organic, inorganic, and biological components in an integrated manner to improve soil fertility and plant nutrient supply (Wattel and Asseldonk 2018). INM is best workable with context-specific biophysical resources, economic feasibility, and social acceptability. It has been recognized that SSA soils are more responsive to INM as compared to a single nutrient source (Clay and Zimmerer 2020; Wattel and Asseldonk 2018). The use of only N and P fertilizers is discouraged in SSA as they decrease soil organic content, cause acidification, decrease base saturation, and cause a large increase in exchangeable aluminium (Holden 2018). Organic intensification measures including manure and crop residue application on farms have been established to improve soil fertility (Beeby et al. 2020). Nonetheless, the limited availability of these sources (Wattel and Asseldonk 2018), competing uses (Beeby et al. 2020), and price or financial risk challenge farmers' capacity to fully employ these measures. Therefore, it is imperative to consider multiple sources of nutrients.

3.1.3 Crop Association/Intercropping

Growing crops or genotypes together in a whole growing season is a functional diversity mechanism used in an agroecosystem (Brooker et al. 2016). Additionally, intercropping has significant benefits, including; enhancing crop rate of production, simultaneously decreasing the risk of total crop production, and weed control (Clay and Zimmerer 2020; Wattel and Asseldonk 2018). In SSA, simultaneously growing crops engenders the diversity of grower production, and/but expands and increases food options for households (Partey et al. 2018). For example, a study on the efficacy of intercropping in Africa showed that intercropping can increase crop yields by 23% when appropriately implemented (Himmelstein et al. 2017).

Intercropping has, however, been less promoted by developmental projects in SSA due to difficulties in choosing appropriate combinations, complexities of selecting intercropping combinations, limited information on best crops to associate, and inadequate complementary inputs such as herbicides and field access difficulties (Himmelstein et al. 2017; Brooker et al. 2016). In some SSA countries, there is a huge gap in technical reports regarding the effects of intercropping on yield and profitability that limit the motivation of development agencies.

> Several farmers in this area (semi-arid Ghana) are engaged in intercropping. At first, we (farmers) used to intercrop with maize, millet and sorghum but from training and demonstrations received from organizations, cowpea, Bambara beans and vegetables are now included in the intercropping. The residue from the Bambara beans and cowpea are used for preparing compost (P14, Ghana).

3.1.4 Soil Fertility Management (Composting and Mulching)

Mulching is a key strategy to retain moisture and create humus. Mulch materials can be cardboard, paper, seaweed, leaves, degraded manure, old cotton or wool clothes, plastic sheets, sawdust, and old carpets (Masvaya et al. 2017). Mulching is usually done at the beginning of the vegetative season and repeated as much as necessary. The initial purpose is to help retain the heat of the soil, which allows sowing and early transplanting of certain crops and stimulates faster growth. As the season progresses, the clogging has different effects on the ground, including; stabilizing the temperature, reducing evaporation, preventing weeds and pests from germinating due to lack of sunlight, and adding nutrients to the soil due to the decomposition of the material. Compost for instance converts animal and plant wastes to humus through chemical and biological decomposition. On records long fallowing, burning and grazing are the traditional ways to utilize available biomass in SSA (Masvaya et al. 2017; Rodriguez et al. 2017). Compost and mulch (with crop residues, weeds and legumes) have historically increased crop production, reduced soil erosion, and leaching (Rodenburg et al. 2020). A study by (Roose and Barthes 2019) in West Africa, established that mulch and compost reduced carbon losses, erosion, and leaching between 10 and 100 kg C ha^{-1} in soils depending on annual rainfall and vegetation cover.

3.1.5 Tillage Management (No/Reduced Tillage)

No or reduced tillage limits disturbance and allows for more residue to remain in soil (Zakaria et al. 2020; Partey et al. 2018). Economically, it directly saves the farmer machinery cost, fuel and labour (Branca et al. 2020). Environmentally, crop residue prevents soil erosion, thus, conserving the valuable topsoil and soil. Minimum/no-tillage reduces disturbances on soil microbial organisms, increasing their numbers for better soil aeration and soil structure improves in the absence of heavy machinery. Tillage management also reduces the amount of fossil fuel use on farms thereby reducing CO_2 emissions from agriculture (Clay and Zimmerer 2020). In rural farms in Malawi, no-till increased soil water content by (0–60 cm) and reduced sediment runoff compared to deep tillage (TerAvest et al. 2015). In humid and sub-humid regions of Africa, no-tillage with crop residue mulch helps to control soil compaction. However, no/reduced tillage limits the mixture of soil amendments such as limestone leading to stratification of soil nutrients and pH (Liebenberg et al. 2020).

3.1.6 Residue Management (Residue Incorporation)

Crop residue is the most readily and available form of crop biomass for farmers. The biomass that remains after harvesting crops is an important source of soil organic matter for agricultural soils (Radicett et al. 2020). Common crops grown in SSA including maize, beans, cowpea, sweet potatoes, rice, wheat, and groundnuts, have high generated residues (Adolph et al. 2020; Schaafsma et al. 2018). The incorporation of crop residues in farms helps to improve microclimatic conditions that optimize decomposition and mineralization of organic matter, enhance soil carbon sequestration and prevent soil erosion. Some studies in SSA (Zakaria et al. 2020; Konapala et al. 2020; Andrieu et al. 2020; Partey et al. 2018) established positive outcomes of crop residue retention on soil moisture, soil quality, and soil organic matter. For instance, higher crop productivity was found in residue retained areas in Ghana, Benin, Mali, and Cote d'Ivoire whereas lower productivity was obtained in residue removed areas (Wattel and Asseldonk 2018). Residual retention has shortcomings, especially in areas where farmers have inadequate knowledge and understanding in implementing the practice. Inappropriate introduction of residue retention or incorporation could result in nitrogen immobilization, waterlogging and decreased soil temperature (Turmel et al. 2015).

3.1.7 Improve Varieties (Crop and Livestock)

The use of scientifically designed advanced varieties to meet area-specific needs and conditions has gained momentum in SSA (Haggar et al. 2020; Partey et al. 2018; Wattel and Asseldonk 2018). Traditional crop varieties are attributed to low yield due to their vulnerability to drought, heat, diseases, and other climatic stressors (Partey et al. 2018; Wattel and Asseldonk 2018). On the contrary, improved varieties are capable of offering higher and stable yields, and are also resistant to drought, diseases, and pests. The growing interest of SSA in improved varieties has resulted in collaborations to develop improved varieties such as new maize varieties (Grace and ZM521) for smallholder farmers in South Africa (Setimela 2017; Sibanda et al. 2016). Also, the Improved Maize for African Soils (IMAS) project) has developed drought-tolerant and insect-protected maize varieties for adoption by smallholder farmers across SSA (Setimela 2017). Recent studies (Partey et al. 2018; Wattel and Asseldonk 2018) in SSA have established positive outcomes of improved varieties in different countries of the region. Jaleta et al. (2018) evaluated and established that improved maize varieties enhanced household food security in Tanzania. In Kenya, Sinyolo (2020) found using hybrid maize seed positively influenced incomes and assets, poverty, and inequality reduction.

3.1.8 Organic Fertilization

A practice commonly categorised as part of conventional agriculture is synthetic fertilizer use on agricultural soils (Leitner et al. 2020). Synthetic fertilizers are artificial soil inputs derived from the composition of chemicals (nitrogen, phosphorous, potassium, calcium, magnesium, etc.) and inorganic substances (Mosier et al. 2013). Synthetic fertilizers supply nutrients to the soil but at a high risk. The high mineral salt content in synthetic fertilizers can kill crop roots and soil microbes and reduce organic matter content in soil (Leitner et al. 2020; Mosier et al. 2013). CSA embraces the use of internal organic resources including green manure, compost and biological pest control (Partey et al. 2018; Wattel and Asseldonk 2018). Smallholder farmers in SSA mainly derive manure and compost from their livestock and feedlots or a neighbouring farm. Higher crop yields have been observed under organic-oriented fertilization (Epule et al. 2015). In Gambia, Madagascar, and Sierra Leone, studies have shown that average rice yield grown under the inorganic fertilization method is lower than observed under organic fertilizer rice intensification (Partey et al. 2018; Wattel and Asseldonk 2018; Epule et al. 2015).

> The government organic fertilizer project has provided incentives for the preparation and utilization of organic fertilizer. For instance, compost is provided by the government to support organic farming. Farmers have also learned to prepare their own compost and minimized the use of synthetic fertilizer (P06, Burkina Faso).

3.1.9 Drip Irrigation

Unavailability of safe and quality water in most areas of SSA is a limitation to the efforts of achieving the UN Sustainable Development Goals (SDGs) of reducing extreme poverty and malnutrition (Jansson and Hofmockel 2020; Zakaria et al. 2020; Konapala et al. 2020). Likewise, estimations indicate that about 80% of the rural population in SSA strongly depend on water for both domestic and agricultural purposes (FAO 2018). Additionally, these areas experience low accessibility to freshwater needed to produce the biomass (Partey et al. 2018; Wattel and Asseldonk 2018). Nonetheless, recent studies (Nigussie et al. 2020; Nakawuka et al. 2018) have shown through supplementary irrigation, there can be progress with substantial water productivity. Ghana, Kenya, Zimbabwe, and South Africa have recorded an increase in the usage of simple drip irrigation kits (Friedlander et al. 2013).

Drip irrigation supplies water directly to the roots of crops to improve soil moisture, increase yield outcomes, and promote water savings to about 40–80% compared to conventional irrigation (Nigussie et al. 2020; Nakawuka et al. 2018). For instance, in Northern Mali, drip irrigation led to an increase in access and capacity of rural farmers' income and social insurance (Dillon 2011). Likewise, in Northern Senegal, all-year-round vegetable farming through canal irrigation improved the availability of nutritional options for households (Diallo et al. 2020; Van den Broeck et al. 2017). In most communities, drip irrigation practices empowered women in northern Senegal to utilize solar-powered pumps, rather than hauling water by hand in rural off-grid areas (Diallo et al. 2020; Van den Broeck et al. 2017). Given this, government programs, private purchases, and non-governmental organizations (NGOs) initiatives should facilitate access to low-pressure drip irrigation kits to farmers.

> Drip irrigation is currently helping us (farmers) to cultivate. There is prolonged drought, and inconsistent rainfall. Drip irrigation is easy to practice and less expensive. Female farmers can engage in vegetable farming through drip irrigation. Women supply vegetables which are cultivated mostly from drip irrigation to supermarkets and other places. (P18, Mali).

3.2 Limitations to CSA Implementation in SSA

As CSA presents several positive outcomes in transforming agriculture in SSA, it is important to up-scale and out-scale the CSA options with higher efficacies. More importantly, SSA farmers need to embrace CSA and efficiently implement viable options. Efforts have emanated from different directions to incorporate and make CSA a progressive approach. Nonetheless, several setbacks limit the operationalization of CSA. Aggarwal et al. (2018) attributed the low adoption of CSA to inadequate empirical evidence on the successes of CSA as a practical solution for agriculture transformation. High dependency of CSA initiatives on donor funding, weak institutions, and inadequate supportive policy strategies also limit CSA implementation in various countries (Ajayi et al. 2018). In this section, we discuss the limitations of CSA operationalization in SSA.

3.2.1 Inadequate Understanding of CSA Concept and Framework

CSA has received criticism for not presenting enough clarity on what exactly constitutes CSA (Andrieu et al. 2020; Partey et al. 2018). Moreover, different stakeholders conceptualized CSA in different ways based on their understanding and available information. Recent literature (Adolph et al. 2020; Aggarwal et al. 2018) calls for the development and implementation of context-specific CSA, but the limitation is inadequate clarity on which practices constitute CSA. Smallholder farmers in SSA countries continue to receive information and training from different sources yet differences in approaches and techniques complicate implementation (Andrieu et al. 2020; Partey et al. 2018).

3.2.2 Marginality of Agro-Ecological Regions in SSA

The different agro-ecologies and heterogeneous socio-cultural and socio-economic factors in SSA impede mainstreaming and implementation of CSA options (Andrieu et al. 2020). At the farm level, outcomes can significantly vary from farmers due to local agro-ecological conditions, institutional framework, household typology, and socio-economic factors (Adolph et al. 2020; Aggarwal et al. 2018). In resolving issues on lagging of scaling CSA options, developing context-specific options is required. Cultural dynamics of what the farmers already know, what they are willing to learn and assimilate, and what is right or wrong in a particular context also influence CSA implementation. CSA options and practices need to be feasible with reality, have the necessary resources and capacity to provide maximum net benefits at minimal risk (Martey et al. 2020; Branca et al. 2020). Concerning improving adoption, a clearer understanding of choices and feasible outcomes guarantees the integration of national and international policies at the farm level.

3.2.3 CSA Mainstreaming into Existing Policy Frameworks

Mainstreaming CSA remains challenging as already existing country-level policies, programs, plans, and strategies were initially developed without CSA reflection (Branca et al. 2020; Clay and Zimmerer 2020; Partey et al. 2018). Given these, the lack of consideration of CSA will require a thorough assessment, review, and adjustments to identify appropriate opportunities in the national, regional policies, plans, programs, and strategies to allow for the mainstreaming of CSA. However, opportunities for such reviews and revisions are hindered by compatibility challenges (Andrieu et al. 2020; Partey et al. 2018). Many African countries are still in the process to link climate change adaptation to national agriculture development plans (Williams et al. 2015).

> CSA is an excellent concept that promotes sustainable agriculture. In Ghana, efforts have been made to mainstream CSA into national policies and promote implementation at the farm level. For instance, Ghana has developed a CSA policy document that provides blueprints

> for CSA implementation. However, mainstreaming CSA is still slow in the country because space has to be created within various sectors to ensure successful mainstreaming. It has been difficult creating opportunities for CSA integration in various national policies (P22, Ghana).

3.2.4 Difficulty in Managing Trade-Offs

Upscaling and integrating CSA presents several trades-off associated with social, environmental, and economic concerns (Etwire et al. 2020; Andrieu et al. 2020). With the expectations of CSA reducing inequalities, improving agriculture literacy, and skills development, CSA has been insufficient in transforming livelihoods and promoting sustainable development (Clay and Zimmerer 2020; Etwire et al. 2020; Partey et al. 2018). Managing CSA trade-offs can result in situational conflicts. In Malawi, irrigated farming on river banks was expected to increase farm revenues but negatively affected siltation mitigation (Schaafsma et al. 2018). Shortage of labour and capital limited farmers in implementing the desired CSA strategy, such as the adoption of soil and water conservation measures, which contributed to the impoverished outturn in Ghana, Burkina Faso, and Malawi (Adolph et al. 2020). In West Africa, farmers are in an emotional conflict as they observed undesirable impacts of CSA, both immediate and futuristic (Adolph et al. 2020).

> Even though CSA is already providing ample benefits, people are thinking about the possibilities of future adverse effects and emergencies. Implementers may concentrate more on the economic aspects of CSA neglecting the equally important other aspects. This may generate environmental footprints which may not be sustainable in the long-term (P12, Nigeria).

3.2.5 Inadequate Financial Investments Towards Broadening CSA Packages

Agriculture transformation and resilience-building require a significant increase in capital investment for climate-smart agriculture (Garrity et al. 2010; Kibru et al. 2020; Wattel and Asseldonk 2018; Iiyama et al. 2017). In SSA, where CSA makes an enormous contribution to climate change adaptation and mitigation, more financial commitments are needed to increase its' implementation (Wattel and Asseldonk 2018). Access to capital for CSA has been a challenge due to low private sector investment, low national government commitments, and other climate-related issues that deserve global responses. The World Bank reports that stakeholders need to examine innovations for financial upgrades while delivering positive climate outcomes for CSA (World Bank 2018). Addressing CSA financial needs can be an opportunity to increase private and public sector funds, strengthen the links between financial institutions, smallholder farmers and SMEs, and build the capacity of both lenders and borrowers.

> Access to finance for the implementation of CSA projects is a challenge. There are many CSA projects the Ministry of Food and Agriculture wants to implement targeting smallholder farmers in rural areas but the funding is inadequate. Proposals have been submitted to raise

funds for these projects but at the international level, it seems difficult with funding for CSA projects (P22, Ghana).

4 Which Lessons for Sustainability?

Our review shows that CSA can help achieve sustainability in developing countries. Studies (Clay and Zimmerer 2020; Etwire et al. 2020; Partey et al. 2018; Thiele 2016) show that CSA incorporates the dominant pillars of sustainability (social, economic, and environmental) in supporting agricultural systems transformation. As revealed in our review, different CSA options promoted environmental sustainability (Garrity et al. 2010; Kibru et al. 2020), reduced household poverty and improved rural livelihoods (Branca et al. 2020; Clay and Zimmerer 2020), enhanced resilience towards adapting to climate change (Adolph et al. 2020; Aggarwal et al. 2018), and generated capital (including knowledge) to raise future well-being (Andrieu et al. 2020; Wattel and Asseldonk 2018). Thus, environmental concerns can augment welfare in the context of inter-generational and intra-generational equity. Practically, CSA provides a manual for measuring sustainability, preventing sustainability from being a slogan, an empty phrase, or just conveying an expression of emotions.

5 How Can CSA Reduce Women's Vulnerabilities and Improve Priorities and Needs?

Consideration of gender differentiation in implementing CSA options is relevant to achieving equality and equity (Branca et al. 2020; Aggarwal et al. 2018). Understanding the different challenges of women and men in agriculture is essential to build effective household climate-resilience and food systems (Wattel and Asseldonk 2018). The literature suggests that intra-household power inequalities and social norms in SSA underscore why women are disproportionately affected by climate change (Jansson and Hofmockel 2020; Zakaria et al. 2020; Konapala et al. 2020). Moreover, access to resources and ownership of properties are male-dominated which further worsens the climate vulnerabilities of women (Wattel and Asseldonk 2018). Concerning these circumstances, CSA contributes to achieving the environmental, social, and economic priorities of women. Further, the CSA contributes to women's agricultural productivity, lower labour requirements, plus building resilience through additional income, knowledge, and skills towards market value and access. More importantly, strengthening the capacity of women can improve access to productive resources, and the information capital requirement for the optimization of CSA adoption.

6 Conclusion

The study reveals that CSA continues to thrive as a feasible approach in agricultural systems transformation. In SSA especially, CSA is marked as an opportunity to reduce rural poverty, enhance livelihoods while providing knowledge to improve environmental protection. The study found that various practices (derived from indigenous knowledge and new technologies) considered as CSA options are implemented in different SSA countries. Common practices established in the literature and at the farm-level include agroforestry, integrated nutrient management, crop association, soil fertility, and tillage management. Also, residue management, improved varieties, organic fertilization, and drip irrigation were prominent. Even though CSA implementation has made significant progress in SSA, there's a steady growth in up-scaling and out-scaling due to inadequate understanding of the CSA concept and framework, the marginality of agro-ecological regions in SSA, difficulty in mainstreaming CSA into existing policies as well as an inadequate financial investment towards broadening CSA packages. The study recommends that countries strengthen national level institutions and carefully identify opportunities within already existing national policies to support the mainstreaming of CSA. Also, integrated efforts from various economic sectors are needed to evaluate, test and implement practical CSA options with greater potential of achieving sustainable development.

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