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Climate Smart Agriculture (CSA) for Sustainable Agriculture Nexus: A Tool for Transforming Food Systems

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A B S T R A C T

Climate Smart Agriculture (CSA) is a global strategy for enhancing food productivity amidst climate change uncertainties in the 21st century. CSA improves farmers' incomes, reduces greenhouse emissions, and farming systems become resilient to climate change. Despite the vital role that CSA plays in the development of the agricultural industry and the economy, the extent to which CSA is related to sustainable agriculture (SA) is not well documented. Is CSA the same as SA? If they are the same, do CSA practices impose mitigation requirements for developing countries like Uganda? Studies or research on CSA and SA unfortunately have certain shortcomings. Lack of this knowledge makes it difficult to plan investments and develop policies that will increase farmers' resilience to climate change and variability to improve SA. This study is aimed at assessing how CSA links to SA and whether the two contribute to climate change mitigation requirements. It was found that CSA and SA are also related in a way that the latter leads to lowering greenhouse gas emissions hence mitigating climate change. CSA and SA share a common principal goal of achieving food security. It was concluded that developing countries are the worst affected by the negative impacts of climate change and don't have the adaptive capacity to respond to climate change effects.

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Introduction

CSA is an approach to help guide actions to transform and reorient agricultural systems to effectively and sustainably support the development and food security under a changing climate (Shirley, 2018; Everest, 2021; Kombat et al., 2021). The new realities of climate change being experienced across the continent include rising temperatures (Raimi et al., 2021), rising sea levels (Kontgis et al., 2019), alteration of precipitation patterns (Griggs and Reguero, 2021), droughts, and floods (Raimi et al., 2021; Hamza et al., 2020). These have effects on crop and food production (Everest, 2021), more especially in developing countries where agriculture is the mainstay of their economies and a means of livelihood for the majority of the population (Mersha and Leta, 2019; Mbuli et al., 2021; Lamichhane et al., 2022). According Njeru et al. (2022), the negative effects of climate change are more common than the positive ones, and developing countries are highly vulnerable to the negative impacts from climate change on agriculture. CSA thus allows agricultural enterprises to respond to climate change in order to increase productivity and income while building resilience (Nyamadi et al., 2018; Sekaran et al., 2021), adapting to, and mitigating climate change (Azadi et al., 2021).

Contrarily, SA involves growing a lot of food without harming the planet's resources or ecosystem (Ulian et al., 2020). Sustainable production practices interact with and improve natural resources through an ecosystem approach that makes the most of harnessing natural biological inputs and processes (Kleijn et al., 2019), protects the environment, biodiversity, and crop quality (Oberč and Arroyo Schnell, 2020). As a result, it emphasizes techniques and procedures that increase soil production while reducing negative effects on the environment, including the climate, soil, water (Turyasingura and

Mohammed, 2022), air, biodiversity (Pulleman et al., 2022), and human health (Sarkar and Rakshit, 2020).

Despite the vital role that CSA has been shown to play in the development of the agricultural industry and the extent to which CSA is related to SA, and if they are the same, does CSA impose mitigation requirements on developing countries like Uganda? The understanding from this study helped to achieve sustainable agricultural productivity in the face of climate change. Studies or research on CSA and SA unfortunately have certain shortcomings. Lack of this knowledge makes it difficult to plan investments and develop policies that will increase farmers' resilience to climate change and variability to improve SA.

The Origin of Climate Smart Agriculture

An approach to managing agriculture in the face of climate change is called CSA (Venkatramanan et al., 2020). Since the concept's first debut in 2009, it has undergone changes as a result of input and dialogue from numerous parties involved in its creation and implementation (Notteboom et al., 2021). The goal of CSA is to offer universally applicable guidelines for managing agriculture for food security under climate change that might serve as a foundation for suggestions and support for public policy by international agencies like Food and Agriculture Organization (FAO). The main components of the CSA approach were established in response to gaps in the understanding of agriculture's contribution to food security and its ability to capture synergies between adaptation and mitigation in the context of international climate policy (Azadi et al., 2021).

Recent CSA controversies have their origins in lengthy debates about climate change and the cultivation of SA. These include the role of emerging countries, particularly their agricultural sectors, in reducing global greenhouse gas emissions, as well as the determination of which technologies will best promote sustainable farming methods. Since the term "CSA" was widely used before a formal conceptual framework and the tools required to implement the method were developed, it has been given a broad variety of meanings, which has also resulted in conflicts (Van Oosterzee et al., 2013), as local communities over use the available land in implementing CSA practices. The advantages of the CSA approach are starting to become clearer as more research is done on its concepts, methodology, tools, and applications. The usefulness of CSA will ultimately depend on how effectively it integrates climate change adaptation into regional SA development projects.

The Concept of Climate Smart Agriculture

According to Bernier et al. (2015) in a meeting at the Hague Conference on Food Security and Climate Change in 2010, the FAO developed the idea of CSA and presented it (Nyasimi et al., 2017). CSA is defined as agricultural activity that effectively and sustainably raises output and income, mitigates or eliminates greenhouse gas emissions, and advances the achievement of national food security and development goals (Field et al., 2014; Officer, 2016). In general, this idea aims to combine environmental stability and food production without compromising either of them.

According to Onyeneke et al. (2018), there is a direct and perhaps fatal connection between agriculture and climate change. On the one hand, changes in the agricultural system and land use, such as deforestation, account for nearly 30% of all global GHG emissions, while the effects of climate change are causing land degradation, low agricultural productivity, and food insecurity on the other. Because smallholder farmers are more susceptible to the effects of climate change, they need more robust production systems. Natural resource management is also necessary for an agricultural system to be more productive and robust (Turyasingura et al., 2022). As a result, the benefits of mitigation have been observed to greatly increase with the changeover of this system (Mwungu et al., 2018).

According to Teklewold et al. (2019), CSA aims to boost agricultural productivity in a way that is both environmentally and socially responsible, to increase farmers' adaptability to climate change, and to lessen the impact of agriculture on global warming by lowering greenhouse gas emissions and increasing carbon sequestration on farmland. It aids smallholder farmers in bolstering their standard of living in the face of climate change while also minimizing its effects.

Pillars of Sustainable Agriculture

According to Lipper et al. (2014), three key goals are incorporated into the work of SA practitioners: a healthy environment, economic viability, and social and economic equality. A sustainable agricultural system may be ensured by everyone participating in the food system, including growers, food processors, distributors, retailers, consumers, and waste managers (Heller and Keoleian, 2003).

SA is, in general, essential to CSA. SA, in contrast to CSA, does not specifically address additional problems brought on by climate change. The connection can be stated simply as: CSA = SA + Resilience + Emissions (Lipper et al., 2014). The CSA method is founded on SA ideas, practices, and technologies, but it expressly emphasizes considering the impacts of unprecedented climate change. In order to implement CSA, new policy and funding mechanisms must be developed as well as proposals and potential alternatives for reorienting current SA initiatives to address changing conditions.

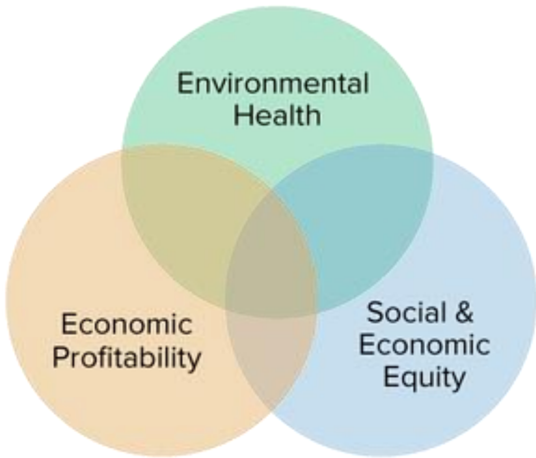

Figure 1. Pillars of Sustainable Agriculture

How is CSA related to Sustainable Agriculture? Are they the same thing?

Despite the explicit emphasis on tackling climate change, CSA is widely related to SA in a way that the CSA approach is almost an integral part of SA, such that SA is fundamental to CSA (Lipper and Zilberman, 2018; Birtalan et al., 2020). In addition, SA practices might not be climate smart in principle, most CSA practices are sustainable since the approach capitalizes on the existing SA practices, concepts, and skills and utilizes them by transforming and reorienting them to respond to the new realities of climate change (Mishra et al., 2021).

CSA and SA are also related in a way that the latter leads to lowering greenhouse gas emissions across the world, complementing the former in tackling climate change (Mishra et al., 2021). Sustainable crop production practices, such as improved soil cover, the use of low inorganic fertilizers, and the use of low pesticides, all aim to create a pollution-free environment, which reduces greenhouse gas emissions in agriculture (Niggli et al., 2009; Adomako and Ampadu, 2015; Shah and Wu, 2019). As a result, sustainable crop production intensification, crop production practices, and approaches are inherently climate smart, because crop production system sustainability requires addressing the risks and vulnerabilities posed by climate change (Pereira, 2017).

Another similarity between CSA and SA is that CSA aims at achieving the same food security objectives as SA, but through the lens of climate change (Ingutia, 2021). Therefore, through their various respective crop production practices, CSA and SA share a common principal goal of achieving food security (Beddington et al., 2012).

Does Climate Smart Agriculture impose mitigation requirements on Developing Countries?

"CSA" does not, under any circumstances, place mitigation obligations on developing nations (McCarthy et al., 2011). Several developing nations are already experiencing the negative effects of climate change on agricultural and food production, making them extremely susceptible to additional negative effects on agriculture (Nelson et al., 2009; Benson and Ayiga, 2022).

Climate change mitigation would be nearly impossible in developing countries due to their limited resource availability and increased vulnerability to the impacts of climate change on agriculture as agriculture is the backbone of their economies and the primary source of income for the majority of their populations (Thornton and Herrero, 2010;; Jarvis et al., 2011; Thornton & Herrero, 2015).

Therefore, the CSA approach strongly supports food security as a priority and places emphasis on the need to identify plausible synergies between the food security (Scherr et al., 2012), adaptation (Steenwerth et al., 2014).

In addition, the mitigation tenets of CSA (Azadi et al., 2021), (Turyasingura and Chavula, 2022), as well as on the need to analyse costs that may be incurred and deal with trade-offs between mitigation and other CSAe objectives in order to enlighten countries by highlighting potential scenarios in an effort to mitigate (Williams et al., 2015).

Conclusion

Climate change is a major threat to food security as its unprecedented effects on agriculture are devastating to the much-needed increase in crop production to feed the growing population.

Developing countries are the worst affected by the negative impacts of climate change as they are already poor and hence do not have the adaptive capacity to respond to climate change effects. Furthermore, the majority of the population in developing countries relies on agriculture to make a living, which suffers the most as the climate keeps changing, making the people more vulnerable.

Agriculture itself, however, presents an opportunity to achieve food security and development under the new realities of climate change through an approach which aims to transform and reorient farming systems to effectively and sustainably respond to climate change, referred to as CSA. The CSA approach relates to SA as the latter is fundamental to the former, which builds on the concepts, technologies, and experiences from it.

Furthermore, the two approaches both aim at attaining the principal goal of food security, though CSA utilizes the lens of climate change.

Finally, the CSA approach does not impose mitigation requirements on developing countries, which are resource constrained and most vulnerable to the effects of climate change, and thus would be unable to achieve the mitigation options. The approach rather strongly upholds food security as the main goal and focuses on discovering synergies between the food security, adaptation, and mitigation objectives as well as dealing with trade-offs between the objectives and highlighting costs that might be incurred, thereby well informing the countries on the potential options, their benefits, and related financing.

Recommendations

Policies aimed at CSA and SA at grassroots level need to emphasize the key role of providing access to training on adaptation strategies to climate change. Thus, there is a need to help farmers improve their citizen science, which will facilitate the use of CSA.

The adoption of appropriate policies by district and national governments to address barriers to the implementation of CSA practices, such as the distribution of certified seed to stallholder farmers during planting season and crop insurance schemes to protect farmers in the event of a drought or disease outbreak, in order to improve SA. This will enhance the implementation of variation approaches by farmers.

Since most farmers depend on rain-fed agriculture, there is a need to encourage smallholder farmers to diversify their sources of income. Additionally, the population is increasing and farmers have a small area of land to produce enough produce for their consumption. They face challenges of diseases and drought, leaving them food insecure for most parts of the year. Therefore, encouraging farmers to try other sources of income will help them get an extra source of income to meet their food demand. This can be enhanced by the creation of a conducive environment for business and the creation of employment opportunities by the governments in developing countries.

Competing Interests

The authors declare that they have no competing interests.

Authors' contributions

Benson Turyasingura (MSc), mainly did the preliminary analysis and extensive review. Prof. Natal Ayiga mainly designed this work and revised the paper totally. The authors read and approved the final manuscript. Wycliffe Tumwesigye (PhD), proofread the manuscript and provided technical advice.

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