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Review Article

Climate Smart-Agriculture practice in Ethiopia: A Flourishing Future

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Abstract

Ethiopia's agriculture-driven economy is highly vulnerable to climate change due to its dependence on rainfed farming and dominance of smallholder producers. Climate variability, rising temperatures, and frequent extreme weather events threaten crop yields, food security, and rural livelihoods. To address these challenges, climate-smart agriculture has emerged as a transformative approach integrating three core pillars: productivity enhancement, climate adaptation, and greenhouse gas mitigation: into sustainable, context-specific practices suited to Ethiopia's diverse agro-ecological zones. This review critically examines the current implementation, effectiveness, and challenges of climate-smart agriculture practices across Ethiopian regions. Climate-smart agriculture interventions vary: conservation agriculture and agroforestry in highlands, drought-tolerant crops and water harvesting in arid and semi-arid zones, and integrated nutrient and pest management in humid areas. Quantitative data show climate-smart agriculture increases crop yields by 25–40%, improves soil and water retention, enhances climate resilience, and sequesters substantial carbon. However, adoption remains uneven due to limited access to information, agricultural inputs, finance, rural infrastructure, secure land tenure, and gender-equitable opportunities. Climate-smart agriculture holds immense potential to ensure sustainable agricultural development and climate resilience in Ethiopia. Scaling up requires strengthened agricultural extension, broader market and financial access, investment in rural infrastructure, secure land rights, inclusive gender-sensitive approaches, integration of climate information services, and participatory planning. These systemic reforms and localized interventions are vital for mainstreaming climate-smart agriculture into agricultural and climate policy frameworks, contributing to food security, environmental sustainability, and Rural transformation under changing climatic conditions.

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INTRODUCTION

Ethiopia, a landlocked nation in the Horn of Africa, has an agrarian economy deeply intertwined with its population's livelihoods. Agriculture contributes 35–40% of the GDP **(**MoANR, 2022; CSA, 2022), generating foreign exchange through exports like coffee, oilseeds, pulses, flowers, and horticulture (NBE, 2022;EEA, 2021 Approximately 70% of Ethiopians depend on agriculture, primarily smallholder farmers relying on rainfed agriculture (CSA, 2022), making them highly vulnerable to weather patterns (Conway & Schipper, 2011; Barrett, 2010). The sector also supports pastoralists in arid and semi-arid lowlands, whose livelihoods are threatened by climate-induced changes in pasture and water (Catley *et al*., 2013).

Ethiopia's diverse agro-ecological zones, from arid lowlands to fertile highlands and humid lowlands (EARO, 2010; Friis *et al*., 2011), necessitate tailored agricultural practices. The highlands, suited for cereals like teff, wheat, and barley, face different challenges and require different adaptation approaches compared to the lowlands, which are better for livestock and drought-tolerant crops like sorghum and millet (Simane *et al*., 2012);Gebresamuel *et al*., 2020).

In Ethiopia, climate change has severely affected agriculture, threatening crop yields, livestock health, and rural livelihoods. Rising temperatures, erratic rainfall, recurrent droughts, and pest outbreaks have worsened food insecurity, particularly for smallholder farmers and pastoralists dependent on climate-sensitive systems (Feleke *et al*., 2025; Kassie *et al*., 2015).

Adaptation strategies are essential. Farmers respond by adjusting planting dates, diversifying crops, and adopting stress-tolerant and drought-resistant varieties (Tesfahunegn & Gebru, 2019; Daba *et al*., 2025). For instance, maize yields in the Central Rift Valley may decline by 20% by mid-century, requiring measures such as irrigation and nitrogen fertilization (Kassie *et al*., 2015). Yet, adaptation is constrained by limited finance, poor access to technology, and inadequate agricultural services (Gebrehiwot & Veen, 2013; Amare *et al.*, 2018). Policy support is therefore critical. Strengthening extension services, credit access, and climate information empowers farmers to adapt more effectively. Integrating resilience into agricultural policy and fostering interdisciplinary research are also key to sustaining agricultural productivity under climate stress (Amare *et al*., 2018; Yalew *et al*., 2018; Feleke *et al*., 2025). Therefore, this review aims to review the key CSA practices currently implemented in Ethiopia, the benefits and challenges associated with these practices, the effectiveness of CSA practices in enhancing resilience to climate change and evidence-based recommendations for promoting wider adoption and maximizing the impact of SCA in Ethiopia.

METHODOLOGY

This review employed a systematic literature search strategy to explore Climate Smart-Agriculture (CSA) practices in Ethiopia, with the aim of identifying relevant, recent, and peer-reviewed studies. The focus was on understanding the interplay between climate change and agriculture, particularly in a context characterized by reliance on rainfed farming and the predominance of smallholder producers.

Given the challenges posed by climate variability, rising temperatures, and the increasing frequency of extreme weather events, which collectively threaten crop productivity, food security, and rural livelihoods, a comprehensive search was conducted across four leading academic databases: Google Scholar, Scopus, Science Direct, and Web of Science. These platforms were selected for their broad interdisciplinary reach and their capacity to cover literature from crop science, food systems, and environmental health perspectives.

During the search process, a substantial number of records were retrieved from Google Scholar, Scopus, Science Direct, and Web of Science. From this pool, articles were screened and carefully reviewed to determine whether they met the inclusion criteria. These criteria required that selected studies explicitly address Climate Smart-Agriculture practices.

LITERATURE REVIEW

Definitions and Concepts of Climate Smart Agriculture

Climate Resilience: The capacity of agricultural systems and communities to absorb climate-related shocks and maintain or improve productivity.

Adaptation: The process of adjusting agricultural practices and systems to minimize the negative effects of climate change.

Mitigation: Actions taken to reduce greenhouse gas emissions or enhance carbon sinks in agriculture**.**

Agro-ecological Zones (AEZs): Geographically defined zones based on soil, landform, and climatic characteristics that influence agriculture.

Sustainable Land Management (SLM): Practices that integrate the management of land, water, and biodiversity to meet human needs while sustaining ecosystem services.

Integrated Soil Fertility Management (ISFM): Combining organic and inorganic inputs to enhance soil fertility and agricultural productivity.

Greenhouse Gas Emissions (GHGs): Gases such as CO_2, CH_4, and N_2O that contribute to global warming, often released through farming activities.

Climate Risk Management (CRM): A systematic approach to anticipating, assessing, and responding to climate risks in agriculture.

Climate-Smart Agriculture (CSA) is an integrated approach designed to enhance agricultural productivity while addressing the challenges posed by climate change. Climate-Smart Agriculture (CSA) is an approach designed to transform agricultural systems under the pressures of climate change, with the overarching aim of ensuring food security, enhancing resilience, and mitigating environmental impacts. Its primary objectives include sustainably increasing agricultural productivity and incomes through practices such as crop diversification, conservation agriculture, and agroforestry, which help maintain stable yields despite adverse climate conditions (Bhanuwanti *et al.,* 2024; Ghosh, 2019). CSA also emphasizes strengthening the adaptability of agricultural systems to climate variability by promoting climate-resilient crop varieties, improving soil health and water efficiency, and implementing land use management strategies, alongside practices like zero tillage and efficient irrigation to reduce vulnerability to droughts and floods (Safdar *et al*., 2024; Scherr *et al*., 2012; Bhanuwanti *et al*., 2024). In addition, CSA contributes to climate change mitigation by reducing greenhouse gas emissions through low-emission practices, precision farming, and resource-efficient technologies (Bhanuwanti *et al*., 2024; Safdar *et al*., 2024). The adoption of sustainable practices, including water management, biodiversity conservation, and reduced use of synthetic chemicals, further ensures long-term ecosystem health (Haldar & A, 2023; Ghosh, 2019). CSA also promotes integrated land-use management through a landscape approach that harmonizes multiple land uses for ecological, social, and economic benefits, requiring coordinated planning and governance at both field and landscape scales (Scherr et al., 2012). Finally, its successful implementation depends on institutional and policy integration, where climate and agricultural policies are aligned, local institutional capacity is strengthened, and funding strategies are coordinated to effectively support CSA initiatives (Adamides, 2020; Lipper et al., 2014)

Agro-Ecological-Based Climate Smart Agriculture Practices in Ethiopia

Ethiopia's diverse agro-ecological zones, ranging from highland to lowland and semi-arid to humid, require tailored Climate-Smart Agriculture (CSA) practices to effectively address climate change challenges. Implementation of CSA in Ethiopia has been context-specific, shaped by variations in rainfall, topography, soil types, and farming systems.

Highland Areas

In the highlands, like **Amhara and Oromia Highlands,** which are prone to soil erosion and rainfall variability, CSA focuses on **soil and water conservation (SWC)** measures such as terracing, bunding, and agroforestry. These practices improve soil fertility and moisture retention. Agroforestry,agroforestry can reduce erosion rates by up to 30% while also increasing yields and supporting biodiversity (Amare et al., 2019; Hussein, 2024). Indigenous species like Faidherbia albida and Cordia africana not only curb erosion but provide vital resources like fodder and fuelwood, which strengthen local economies (Getachew and Mulatu, 2024).

Semi-Arid and Lowland Areas

Lowland areas such as Afar, Somali, and Borena Zone are more vulnerable to drought and desertification. The CSA practices include rainwater harvesting, drought-tolerant crop varieties, and rangeland management**.** Adoption of sorghum and cowpea varieties that mature early and tolerate moisture stress has expanded significantly (FAO, 2021). Additionally**,** silvopastoral systems have shown promise in improving livestock productivity and carbon sequestration in Borena and Somali regions (Shiferaw *et al*., 2023). *Example:* In Afar, the construction of water pans combined with early-maturing sorghum increased household food security by 25% (Gebreselassie & Mekuria, 2023).

Humid and Sub-Humid Areas

In humid regions where rainfall is sufficient but erratic, integrated nutrient and pest management, crop diversification**,** and climate**-**smart **horticulture** are commonly applied. These areas include SNNPR and parts of Benishangul-Gumuz**.** CSA here promotes diversification of enset, banana, and root crops with intercropping and mulching to reduce evapotranspiration and improve yield stability (Alemayehu & Degu, 2020). In SNNPR, the adoption of intercropping maize with legumes improved nitrogen use efficiency and increased yield by 28% (Wolde *et al*., 2021).

Table 1: CSA Practices and their effects Across Ethiopian Regions

Region	Common CSA Practices	Primary Effects	Key Reference
Amhara	Conservation Agriculture (e.g., row planting)	Significantly increases crop yields and per-capita income, which improves food security and enhances household resilience to climate change.	Asefa *et al*. (2024)
Oromia	Small-scale Irrigation	Boosts crop yields and farm income, directly improving livelihoods and resilience against climate stresses like erratic rainfall.	Tesfaye *et al*. (2023)
Tigray	Watershed Management, Water Harvesting, Drought-Tolerant Crops	Rehabilitates degraded lands, increases groundwater levels, and allows for crop diversification, which improves food security and income.	CIMMYT (2024)
Sidama	Agroforestry, Soil Conservation	Reduces soil erosion and enhances soil organic matter, improving soil fertility and carbon sequestration while securing harvests of both food and cash crops.	Fentie & Beyene (2025)
Somali	Improved Livestock Management, Water Harvesting	Secures livelihoods in pastoral and agro-pastoralist systems by providing access to water during droughts and regenerating rangelands.	World Bank (2023)
Gambela	Improved Crop Varieties, Water Management	Enhances food production and income, although challenges persist from large-scale land investments. The region has the potential to become a "bread basket" for the country.	Degife (2020), Fentaw *et al*. (2024)
Benishangul-Gumuz	Integrated Soil Fertility Management, Agroforestry	Increases soil fertility and crop productivity. The adoption of new cash crops like soybean helps to diversify income and improve food security.	Gebrekidan *et al*. (2024), Mosissa *et al*.(2019)

General overview of CSA practice in Ethiopia

Conservation Agriculture (CA) (Assessment of Implemented Practices)

Conservation agriculture techniques, such as minimal tillage and mulching, have been adapted to Ethiopian conditions. These practices aim to conserve soil moisture and reduce erosion. In the Central Rift Valley, minimum tillage and zero tillage methods were compared with conventional tillage, with findings indicating varying degrees of yield and labor productivity. Although conventional tillage showed higher immediate productivity, techniques like mulching proved promising for moisture retention and yield improvement under high rainfall variability (Sime *et al*., 2014)

Improved Seed Varieties

Developing drought-resistant, heat-tolerant, and disease/pest-resistant varieties is crucial (Tesfaye *et al*., 2015; Joshi *et al*., 2011). Ethiopia has developed improved varieties of staple crops (MoARD, 2010; ATA, 2014). Improved sesame varieties have played a significant role in reducing food insecurity by increasing food consumption expenditures and enhancing nutritional intake (Eshetie *et al*., 2021). The direct contribution of quality seeds to total agricultural production can be as high as 45% when combined with effective management practices (Enhancing Access and Adoption of Improve., 2023). The adaptability of improved varieties has also been demonstrated in various contexts. For instance, studies on linseed varieties in the Kafa and Benchmaji zones revealed significant yield differences, with improved varieties such as Furtu and Kumo outperforming local varieties (Lea & Belay, 2021). Additionally, early-maturing sorghum varieties have been developed to address climate challenges, helping to ensure food security in drought-prone areas (Altaye *et al*., 2024).

Integrated Soil Fertility Management (ISFM

Integrated Soil Fertility Management (ISFM) is an essential approach to boosting agricultural productivity and mitigating the effects of climate change in Ethiopia. This strategy integrates the use of both organic and inorganic fertilizers with improved crop varieties, yielding notable benefits benefits across different agro-ecological zones. ISFM practices have been shown to significantly increase crop yields, especially for staples like teff, wheat, and maize. Research indicates that combining improved improved seeds with fertilizers substantially enhances productivity, such such as maize yields averaging 3.44 tons per hectare, with the greatest gains achieved through the combined application of inorganic fertilizers and organic amendments (Hörner & Wollni, 2020; Adem *et al*., 2023). Beyond yield improvements, ISFM also enhances soil quality by increasing soil organic carbon, nitrogen content, and water retention capacity, all of which are vital for sustainable farming. For example, the use of vermicompost alongside inorganic fertilizers has been found to improve soil health while reducing the dependence on chemical inputs by by half (Habtamu *et al*., 2024; Doldt *et al*., 2023). On the socioeconomic front, adopting ISFM is correlated with higher household incomes and better food security, though outcomes vary depending on local conditions

conditions and farmers' strategies for income diversification (Hörner & Wollni, 2020). Furthermore, ISFM practices often increase labor demand, demand, which can translate into greater labor productivity and improved improved financial returns, thereby supporting rural livelihoods (Hörner & & Wollni, 2020). Despite its many benefits, the adoption of ISFM faces challenges, primarily due to initial labor and capital requirements. Therefore, providing education and support to farmers is crucial for overcoming these barriers and fully realizing the potential of ISFM in Ethiopia's agriculture

Water Harvesting and Management

This technique involves the implementation of method (Grum *et al*., 2016) directly within the soil to capture and store rainwater. A study conducted in Northern Ethiopia evaluated the use of tied ridges and straw mulching, finding significant reductions in soil erosion and nutrient loss. Combined techniques of tied ridges and straw mulch decreased soil loss by 82 to 90%, and nutrient losses, such as nitrogen and phosphorus, by 82% and 83%, respectively (Grum *et al.,* 2016). These methods help maintain soil fertility and improve water retention, which is particularly important in regions with steep slopes and high erosion rates.

Agroforestry

In 2022, the Ethiopian government launched a program to support smallholder farmers in adopting climate-smart agricultural practices. The program focuses on promoting drought-resistant crop varieties, agroforestry systems, and precision irrigation technologies. In the Tigray region, local farmers have been implementing drought-resistant crop varieties, water harvesting, and integrated soil fertility management, which have helped to increase food production, conserve natural resources, and reduce the vulnerability of farming communities to climate variability and extreme weather events (Mekonnen *et al.* 2021).Agroforestry, which integrates trees and shrubs into crop systems, is a significant climate-smart practice in Ethiopia. It helps in stabilizing soil, conserving water, and contributing to biodiversity. Studies in regions like Humbo Woreda demonstrate the effectiveness of such integrated practices in enhancing agricultural productivity and resilience (Erekalo & Yadda, 2023; Tessema *et al.,* 2025). Agroforestry, along with soil and water conservation measures, has improved food security indicators and income levels among adopters.

Livestock Diversification and Improved Management

Livestock diversification and improved management are key strategies for adapting to climate variability in Ethiopia, where pastoralism is central to livelihoods. Promoting drought-tolerant breeds such as camels, goats, and sheep enhances resilience under arid conditions (Megersa *et al.,* 2014). Feed and health management strategies, including the use of crop residues, purchased supplements, and expanded veterinary services, support livestock during scarcity (Benin *et al*., 2003; Teku & Derbib, 2025). Sustainable grazing practices such as herd size reduction, efficient water use, communal grazing, herd splitting, and strategic destocking help balance productivity with environmental conservation and reduce climate-related risks (Abdela, 2024).

Climate Information Services

According to Zougmoré *et al.* (2021), Climate Information Services (CIS) including forecasts, projections, and early warning systems are vital for managing climate variability and guiding decisions on planting, irrigation, and crop management in Ethiopia. Access to such information also shapes the adoption of Climate-Smart Agriculture (CSA), as farmers can choose resilient crop varieties and apply effective water management strategies (Erekalo & Yadda, 2023). Strengthening extension services and farmer training remains critical for disseminating climate information and promoting practices such as soil fertility management, conservation agriculture, and crop diversification (Gudina & Alemu, 2024).

Index-Based Insurance:

This provides a weather-indexed mechanism for agricultural risk management that offers payouts based on objectively measured weather weather parameters-such as rainfall or temperature thresholds-rather than individual loss assessments. This approach significantly reduces transaction costs and mitigates problems like moral hazard and adverse adverse selection, which often hinder traditional insurance schemes (Carter et al., 2014; Barnett et al., 2008). By linking compensation directly to weather indices, index-based insurance improves access to risk protection for smallholder farmers and pastoralists who are usually excluded from conventional insurance markets due to high costs and verification difficulties (Greatrex et al., 2015). Furthermore, with the security provided by such insurance, farmers are incentivized to adopt climate-smart and productivity-enhancing investments, including improved seeds, fertilizers, and irrigation systems. However, the success success of index-based insurance depends heavily on the availability and accuracy of weather data. In many developing regions, sparse weather stations and data quality issues create basis risk-where payouts payouts do not perfectly match actual losses, which can reduce farmer trust and uptake (World Bank, 2019). Recent technological advances in satellite remote sensing and digital financial services have helped address some of these challenges by improving data coverage and facilitating efficient premium payments and claims processing. Successful implementations of index-based insurance in countries such as Kenya, Ethiopia, and Mexico have demonstrated their potential to enhance resilience and stabilize rural incomes in the face of climate shocks. Nonetheless, scaling these programs requires strong policy support, public-private collaboration, and farmer education to overcome challenges related to affordability, basis risk, and awareness (Barnett *et al*., 2008).

Impacts of CSA practice in Ethiopia

Increased Agricultural Productivity

CSA practices such as conservation agriculture, integrated soil fertility management, and agroforestry have significantly enhanced crop yields and resource use efficiency. For instance, Muluneh *et al*. (2022) found that smallholder farmers practicing minimum tillage and crop rotation in the central highlands of Ethiopia achieved a 25–30% yield increase in maize compared to conventional practices. Similarly, the adoption of drought-tolerant crop varieties in the Oromia and SNNPR regions led to yield improvements of up to 40% during erratic rainfall years (Abera *et al*., 2021).

Improved Climate Resilience and Adaptation

CSA has contributed to strengthening the adaptive capacity of Ethiopian farmers. Integrated Watershed management and soil and water conservation interventions have reduced land degradation, improved water retention, and stabilized yields (Taffese *et al*., 2023). In drought-prone areas like Tigray, CSA-based community water harvesting, and agroforestry systems have improved resilience to dry spells and enhanced food security (Yimer & Belay, 2021).

Greenhouse Gas Emissions Reduction

Some CSA strategies, particularly agroforestry, improved livestock feeding, and biochar application have shown promising results in reducing greenhouse gas (GHG) emissions. According to Kassie *et al*. (2023), incorporating leguminous trees and shrubs into farming systems systems in western Ethiopia sequestered up to 3.5 tons of CO_2 equivalent per hectare annually. Improved manure management and fodder systems have also been reported to reduce enteric methane emissions by up to 18% (MoA & FAO, 2022).

Socio-Economic and Livelihood Impacts

Beyond ecological and technical outcomes, CSA adoption has shown positive impacts on household income, food security, and employment. Participatory research by Gebremariam *et al*. (2023) across four Ethiopian regions revealed that households implementing CSA practices had 1.7 times higher food self-sufficiency and 28% higher annual income than non-adopters. Gender-Inclusive CSA interventions also improved access to resources for female-headed households, contributing to equity and livelihood diversification (UNDP Ethiopia, 2021).

Challenges and Constraints

Widespread SCA adoption faces several interconnected challenges:

Limited Access to Information and Technology

Many smallholder farmers lack access to information, training, and appropriate technologies related to SCA (Deressa *et al*., 2011; Giller *et al*., 2009). Extension services often lack the capacity and resources to effectively disseminate SCA knowledge. This is compounded by low literacy rates and limited access to communication technologies in some rural areas.

Limited Access to Inputs and Markets

Access to quality seeds, fertilizers, credit, and markets for agricultural products can be limited, hindering SCA adoption (Desta & Tezera, 2013; Jayne *et al*., 2003). Market infrastructure and Value chains need improvement to support the sustainable production and marketing of SCA products. This includes improving road networks, storage facilities, and market information systems.

Inadequate Infrastructure

Poor rural infrastructure, including roads, irrigation systems, storage facilities, and market infrastructure, limits the effectiveness of SCA interventions (FAO, 2010; Fan *et al*., 2004). This can increase transportation costs, reduce market access, and limit the adoption of certain SCA technologies.

Limited Financial Resources

Many smallholder farmers lack the financial capacity to invest in SCA practices, especially in the initial stages (Tesfaye *et al*., 2015; Barrett *et al*., 2006). Access to affordable credit and financial services are crucial for enabling farmers to adopt SCA practices. This includes providing access to microfinance, agricultural loans, and other financial instruments.

Policy and Institutional Constraints

Weak policy frameworks, inadequate institutional support, and limited coordination among stakeholders can hinder CSA adoption (Wiebe *et al*., 2015; McCarthy *et al*., 2011). Clearer policies and stronger institutional support are needed to create an enabling environment for CSA. This includes developing clear policy guidelines, strengthening extension services, and promoting coordination among government agencies, research institutions, and other stakeholders.

Land Tenure Insecurity

Secure land tenure is crucial for long-term investments in SCA practices (Place & Otsuka, 2002). Farmers are less likely to invest in long-term sustainable practices if they do not have secure rights to their land. This requires clarifying land ownership rights, strengthening land administration systems, and resolving land disputes.

Gender Inequality

Women farmers often face specific constraints in accessing resources, information, and decision-making related to SCA (Kristjanson *et al*., 2010; Quisumbing *et al*., 2013). Addressing gender inequalities is crucial for ensuring equitable and effective SCA implementation. This includes providing women farmers with equal access to land, credit, inputs, training, and extension services.

Socio-cultural factors

Existing farming practices, traditional beliefs and knowledge, and social norms can influence the acceptance and adoption of new agricultural technologies, including SCA (Adesina & Baah, 1995). Understanding local knowledge systems and engaging with communities is crucial for promoting the adoption of SCA practices

CONCLUSION

Climate-Smart Agriculture (CSA) represents a transformative, integrated approach that addresses the interlinked challenges of agricultural productivity, climate change adaptation, and mitigation. The Ethiopian context, marked by highly diverse agro-ecological zones, demonstrates the importance of tailoring CSA practices to local conditions. Evidence from across the country shows significant improvements in agricultural productivity (as example, 25–40% yield increases), climate resilience (e.g., improved water retention, soil health), greenhouse gas emission reductions, and socio-economic outcomes such as increased income and food security. Despite these positive impacts, widespread CSA implementation in Ethiopia faces notable constraints. These include limited access to information, technology, and inputs; poor infrastructure; inadequate financial services; weak institutional coordination; insecure land tenure; gender inequality; and socio-cultural barriers. While national policies like the CRGE Strategy and support from international partners provide a supportive framework: the actual scaling up of CSA requires stronger grassroots-level interventions, infrastructure, and inclusive institutional frameworks

RECOMMENDATION

Based on the review's findings, the following recommendations are proposed to promote wider adoption and maximize the impact of SCA in Ethiopia:

Strengthen and Reform Agricultural Extension Services: Invest in training extension workers on SCA principles and practices, and equip them with the necessary resources to effectively disseminate information to farmers and promoting participatory approaches to extension that involves farmers in the design and implementation of SCA programs.

Improve Access to Inputs, Markets, and Financial Services: Strengthen input supply chains to ensure access to quality seeds, fertilizers, and other inputs at affordable prices and developing market infrastructure and value chains to support the sustainable production and marketing of SCA products. Expand access to affordable credit and financial services for smallholder farmers

Invest in Rural Infrastructure Development: Prioritize investments in rural roads, irrigation systems, storage facilities, and market infrastructure to improve market access, reduce post-harvest losses, and facilitate the adoption of SCA technologies

Strengthen Policy and Institutional Frameworks: Develop clear and supportive policies that promote SCA adoption and address the specific needs of smallholder farmers. Strengthen institutional coordination among government agencies, research institutions, and other stakeholders.

Promote Research and Development and Knowledge Sharing: Invest in research to generate context-specific knowledge on effective SCA practices and technologies. Establish knowledge-sharing platforms and networks to facilitate the exchange of information and best practices among farmers, researchers, and other stakeholders

Address Land Tenure Insecurity and Promote Secure Land Rights: Implement policies and programs that strengthen land tenure security and provide farmers with clear and secure land rights.

Empower Women Farmers and Address Gender Inequalities: Implement targeted interventions to address the specific constraints faced by women farmers in accessing resources, information, and decision-making related to SCA and Promoting women's participation in agricultural organizations and decision-making processes.

Integrate Climate Information Services into Agricultural Planning: Develop and disseminate tailored climate information services that meet the specific needs of farmers in different agro-ecological zones. Integrate climate information into agricultural planning and extension programs.

Scale up Index-Based Insurance and other Risk Management Tools: Expand the availability and accessibility of index-based insurance schemes and other risk management tools to help farmers manage climate-related risks and incentivize the adoption of SCA practices.

Promote participatory approaches: Involve farmers in the design, implementation, and monitoring of SCA interventions to ensure that they are relevant and effective.

Conflicts of Interest

The author declares that there is no conflicts of interest

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