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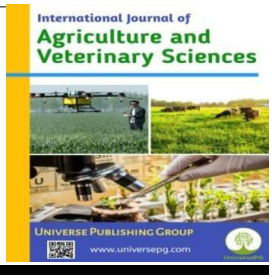

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Climate Change Adaptation and Mitigation Measures in the Agriculture Sector in Togo: A Review

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Abstract

Climate change is posing significant challenges in the world and is severely impacting economies, food security, and livelihoods of vulnerable countries, including Togo. Our work aimed to review climate change adaptation and mitigation measures in Togo's agricultural sector. Preferred Reporting Items for Systematic Reviews and Meta-Analyses approach was used to retain Twenty-seven articles in this review. Results showed that climate risks that are severely impacting negatively the agriculture sector in Togo are droughts, floods, coastal erosion, and strong winds. At the strategic level, the climate change adaptation and mitigation measures have been taken into consideration in the National Adaptation Plans, and Nationally Determined Contribution. At operational level, adaptation measures in farming systems include, crop diversification, changing planting dates, adopting short-cycle varieties, access to credit, extension services, education, and off-farm job opportunities; While mitigation measures were, soil fertility management techniques, organic fertilizer application, crop rotation, intercropping, and cover cropping which at the same time can optimize carbon sequestration efficiency and improve soil health. Fishermen adapt through economic diversification, changing fishing grounds, and adjusting fishing times. Even though little research is conducted on climate change mitigation technologies, some mitigation measures have been reported in the coastal region of Togo, including mangrove restoration, building green infrastructures using appropriate tree species planting along the coastal region. In the livestock sector, methane mitigation includes improved feed quality, dietary lipids, concentrate feeds for ruminants, and animal excrements management. However, few studies have been carried out on adaptation and mitigation technologies in livestock systems. The level of adoption of climate-smart agriculture is still low, given the low level of mobilization of climate-related financial resources at the national level. Togo still needs to make enormous efforts to provide better support to small-scale producers to ensure wider adoption of climate-smart technologies in the agricultural sector in Togo.

Keywords: Climate risks, Adaptation, Mitigation, Farming systems, Climate-smart agriculture, and Togo.

1. Introduction

Climate change poses significant challenges to agriculture, affecting crop yields, livestock productivity, and food security globally (Sudarkodi & Sathyabama, 2011; Verma *et al*., 2024). Rising temperatures, altered precipitation patterns, and

extreme weather events contribute to crop failures, reduced yields, and increased pest proliferation (Sudarkodi & Sathyabama, 2011; Mittal & Kumar, 2016). While some regions may experience short-term gains, the overall impact on agriculture is expected to be negative (Sudarkodi & Sathyabama, 2011; Uddin *et al*., 2022).

Climate change affects soil carbon, freshwater availability, and biodiversity, with consequences for major crops like rice, wheat, and maize (Bhattacharyya *et al*., 2020). Livestock production faces challenges due to heat stress, water scarcity, and disease outbreaks (Bhattacharyya *et al*., 2020). The complex interactions between climate change and agricultural systems necessitate appropriate strategies, policy interventions, and technological innovations to enhance resilience and mitigate adverse effects (Bhattacharyya *et al*., 2020; Verma *et al*., 2024).

In Togo, the impacts of climate change in the agriculture sector are becoming more and more a burning issue, which leads small scale farmers more vulnerable than ever before. Facing these multiple and overlapping challenges requires more attention from the State to improve the resilience of rural and farming communities.

This study explores the key climate-related risks that negatively impact the agricultural sector of Togo, and summarizes the adaptation and mitigation measures, both at strategic and operational levels in Togo.

2. Methodology

Presentation of the study area

This review is conducted on Togo. Togo is a small country of 56 600 km^2 (**Fig. 1**). Togo is a country in West Africa with an estimated population of 9.61 million in 2024 (INSEED, 2023) and a population density of 164 inhabitants/km2. The country's geographical profile resembles a rectangle 600 km long and 100 km wide on average. It has five administrative regions: the Maritime Region, the Plateaux Region, the Central Region, the Kara Region and the Savanes Region. Togo has four agro-ecological zones, namely: 1- the Littoral agro-ecological zone; 2- the Humid Savannah agro-ecological zone; 3- the Forest agro-ecological zone; and 4- the Dry Savannah agro-ecological zone. Togo is a predominantly agricultural country, contributing around 40% of Gross Domestic Product (GDP) and employing 70% of the working population.

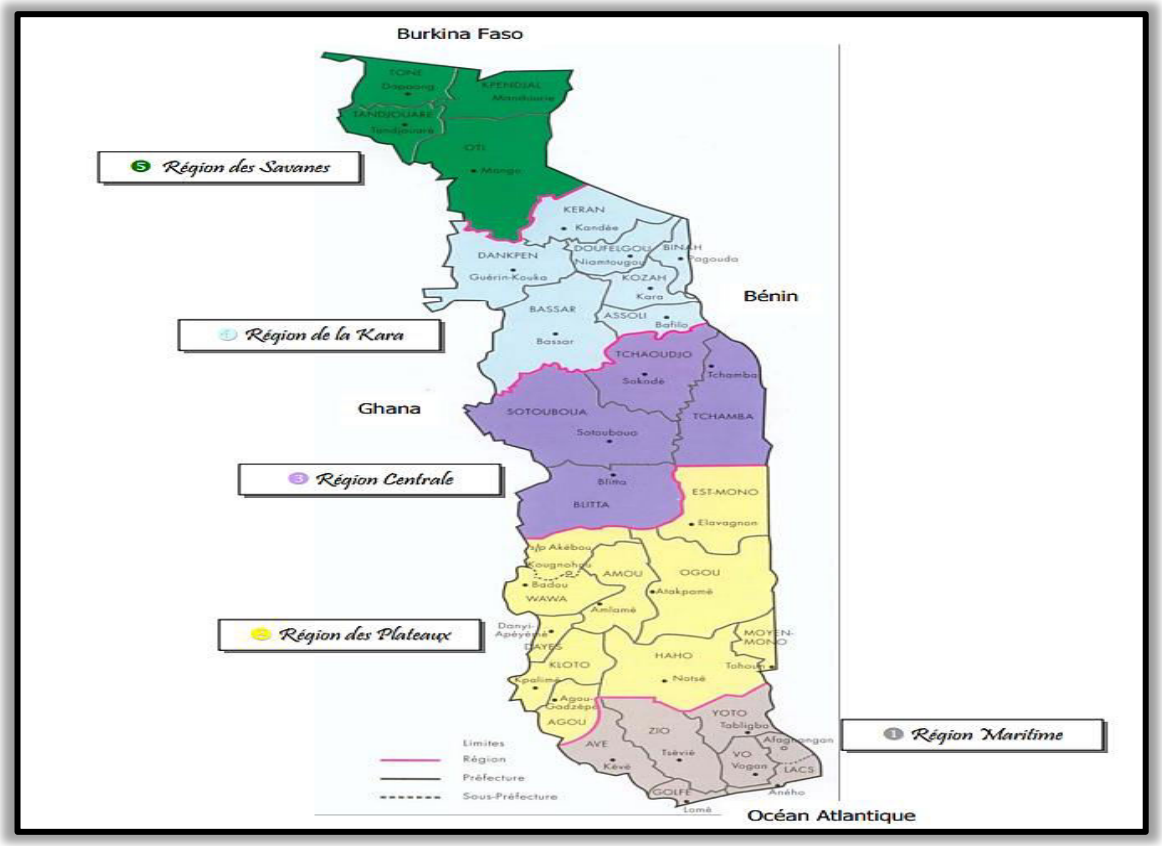

Fig. 1 : Mapping of administrative regions of Togo (Source: INSEED, 2023).

Search methods

We conducted our literature review from 1st May to 25 July 2025 using the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) approach (Moher *et al.* 2009). The databases mobilized to this end are Directory of Open Access Journals (DOAJ), Web of Science (WoS), Google Scholar, and the United Nations Framework Convention on Climate Change (UNFCCC) where are documented all the country climate-related strategies, like National Adaptation Plans (NAPs), Nationally Determined Contributions (NDCs).

Search keys related to our specific research questions, used to retrieve relevant articles are: *"Climate risks" AND "Togo", "Climate change adaptation measures" AND "Togo", "Climate change mitigation measures" AND "Togo".* From these search keys, 1242 articles related to climate change adaptation and mitigation across all sectors, and which include Togo were found.

In the second step, we used the following search keys as including and rejection criteria to retain only articles related to the agriculture sector or farming systems in Togo: *"Climate change adaptation measures" AND "Agriculture" OR "Farming systems" AND "Climate change adaptation measures", "Climate change adaptation measures" AND "livestock", "Climate change adaptation measures" AND "Fisheries"; "Climate change mitigation measures" AND "Agriculture" OR "Farming systems" AND "Climate change mitigation measures", "Climate change mitigation measures" AND "livestock", "Climate change mitigation measures" AND "Fisheries".* From there, 27 relevant and recent articles and documents were retained and fully read to make this review.

3. Results and Discussion

Major climate related risks in Togo

In Togo, climate risks such as droughts, floods, coastal erosion, and strong winds have been identified as major concerns (Assiah *et al*., 2024; N'Souvi *et al*., 2024). These phenomena impact agriculture, livelihoods, and overall living standards, especially rural communities (Sodokin & Nyatefe, 2021; Kissi *et al*., 2023). Regional variations in climate risk perception exist, with the Kara region showing higher awareness (Assiah *et al*., 2024). Farmers in the Savanna region face increased dry spells and erratic rainfall, affecting crop production (Kissi *et al*., 2023). Adaptation strategies include early warning systems, improved water management techniques, and sustainable agriculture (Assiah *et al*., 2024). Income from activities and remittances plays a crucial role in building household resilience to climate shocks (Sodokin & Nyatefe, 2021). To address these challenges, multi-sector collaboration and climate-responsive policies are recommended (Assiah *et al*., 2024).

Strategic Measures in the Agriculture Sector in Togo

Climate change poses significant challenges to Togo's agricultural sector, necessitating strategic mitigation and adaptation measures. Studies indicate that climate change could reduce agricultural added value by 7.11% to 15.24% by 2050, potentially costing Togo 2.84% to 6% of its GDP (Mikémina, 2013). To address this, Togo has committed to climate change mitigation through its Nationally Determined Contributions, which could reduce greenhouse gas emissions by 20% by 2030 while simultaneously improving adaptation measures (NAP, 2009; NDC, 2021; Agbossou *et al*., 2022).

Operational Measures in the Agriculture Sector in Togo

Farmers are adopting various climate-smart agricultural practices, influenced by factors such as farm size, and access to resources (Affoh *et al*., 2024). These practices, including crop rotation, improved seed varieties, and irrigation, have shown positive impacts on food security and agricultural productivity (NDC, 2021; Affoh *et al*., 2024). Additionally, soil fertility management, short-cycle crop varieties, and adjusting planting dates have been identified as effective adaptation strategies (Hoque *et al*., 2022, Yovo & Lantomey, 2023).

Adaptation and mitigation measures in cropping production systems

Adaptation measures: Climate change significantly impacts agriculture in Togo, necessitating adaptation strategies. Farmers perceive increased temperatures and decreased, irregular rainfall (Gadedjisso-Tossou, 2015; Sanou *et al*., 2018). Common adaptation measures include crop diversification, the changing planting dates, and adopting short-cycle varieties

(Gadedjisso-Tossou, 2015; Yovo & Lantomey, 2023). Climate-smart agricultural practices, such as crop rotation and improved seed varieties, positively impact food security (Affoh *et al*., 2024). Factors influencing the adoption of climate change adaptation measures in Togo include age, education, farm size, access to credit, extension services, and climate information (Gadedjisso-Tossou, 2015; Affoh *et al*., 2024). Soil fertility management techniques and organic fertilizer use are also employed (Sanou *et al*., 2018; Yovo & Lantomey, 2023). These adaptations can increase crop yields, particularly for maize (Yovo & Lantomey, 2023). To enhance farmers' adaptive capacity, policies should focus on improving access to credit, extension services, education, and off-farm job opportunities (Gadedjisso-Tossou, 2015). Economic modelling suggests that soil and water conservation techniques and irrigation can provide higher incomes under climate change conditions in Togo's Savanna region (Gadedjisso-Tossou, 2015; Pilo *et al*., 2021).

Mitigation measures: Cropping systems play a crucial role in climate change mitigation and in improving soil health in Togo and other tropical regions through carbon sequestration and reducing greenhouse gas emissions. Practices such as crop rotation, intercropping, and cover cropping can optimize carbon sequestration efficiency and improve soil health (Adden *et al*., 2016, Kintche *et al*., 2018, Mazinagou *et al*., 2022; Gmakouba *et al*., 2024). Incorporating cover crops like Mucuna and pigeon pea into maize-based systems can significantly increase grain yields and reduce nutrient losses compared to continuous maize cultivation (Adden *et al.,* 2016). These systems enhance carbon sequestration, restore degraded soils, and improve land productivity (Adden *et al*., 2016, Kintche *et al*., 2018). Adopting alternative cropping systems can address second-generation agricultural problems, such as declining factor productivity and pest buildup, while improving resource use efficiency. Implementing climate-resilient practices, including changes in cropping patterns and new technologies, can help farmers to adapt to, and mitigate climate change (Adden *et al.*, 2016). Maintaining soil organic carbon levels through appropriate cropping systems and management practices is essential for sustaining soil health in the Plateaux region of Togo (Adden *et al*., 2016). Overall, well-designed cropping systems offer multiple benefits for agricultural sustainability and climate change mitigation.

Practices like agroforestry, alley cropping enhance soil fertility and carbon sequestration in southern Togo (Adden *et al*., 2016; Mawussi *et al*., 2020). In northern Togo, farmers use organic manure, crop rotations, and soil conservation techniques to combat soil degradation and climate change effects (Abalo-Esso *et al*., 2021). Implementing these priority measures could help Togo's commitment of greenhouse gas emissions reduction by 20% and black carbon emissions by over 75% by 2030 (Agbossou *et al*., 2022).

Adaptation and mitigation measures in livestock systems in Togo

Various strategies can mitigate non-CO2 emissions, especially methane emissions, including improved feed quality, dietary lipids, concentrate feeds for ruminants, and animal excreta management to avoid methane emission (Hristov *et al*., 2013). However, smallholder crop-livestock systems in sub-Saharan Africa, including Togo, face constraints such as small farm sizes, limited market access, and land tenure insecurity, which hinder the adoption of adaptation and mitigation measures (Descheemaeker *et al*., 2016; Islam *et al*., 2019).

To effectively address these challenges, integrated impact assessments and system-oriented approaches are necessary to inform decision-making and implement sustainable solutions in Togo's agricultural sector. However, very few studies have been carried out on climate change adaptation and mitigation technologies and practices in livestock production systems in Togo.

Adaptation and mitigation measures in fisheries systems in Togo

Climate change is significantly impacting fisheries in Togo, necessitating adaptation measures. Fishermen in coastal Togo perceive changes in temperature, sea level, wind patterns, and rainfall, which affect their catches (N'Souvi *et al*., 2024). They adapt through economic diversification, changing fishing grounds, and adjusting fishing times. The Government of Togo supports small-scale fisheries through subsidies. This improves their technical efficiency and lead to better adaptation and resilience (N'Souvi *et al*., 2023).

However, concerns persist about over-exploitation and illegal fishing, which threaten food security and poverty alleviation efforts (Belhabiba *et al*., 2015). Togo has committed to climate change mitigation through its Nationally Determined Contributions, aiming to reduce greenhouse gas emissions (Agbossou *et al*., 2022). Even though very few studies are conducted among fisheries, some mitigation measures have been reported in the coastal region of Togo, including mangrove restoration, building green infrastructure such as specific and appropriate tree species planting along the coastal region (Agbossou *et al*., 2022).

All these efforts underscore the need for integrated approaches to address environmental challenges and support sustainable fisheries in Togo. N'Souvi *et al.* (2023) suggested that, to enhance adaptation, policies should focus on improving extension services, providing affordable credit, investing in education, and promoting cooperative membership among fishermen.

4. Conclusion

Our work aimed to review the climate change adaptation and mitigation measures in Togo's agricultural sector. The results showed that several measures have been implemented. Policies, strategies, plans, and projects have been developed, such as the National Adaptation Plan and Nationally Determined Contributions. However, their implementation on the ground with producers is still limited. The level of adoption of climate-smart agricultural technologies is still low, given the low level of mobilization of climate-related financial resources at the national, regional, and international levels. The country still needs to make enormous efforts to provide better support to small-scale producers to ensure wider adoption of climate smart agriculture technologies, innovations, and practices.

5. Author Contributions

A.O.: Designed the study, performed the methodology, Conducted the review, wrote, reviewed and finalized the manuscript. C.M.T.: Performed the methodology, Conducted the review, and reviewed the manuscript. A.H.C.: Performed the methodology, Conducted the review, and reviewed the manuscript. H.B.D.: Performed the methodology, conducted the review, and reviewed the manuscript. H.H.S.: Reviewed the manuscript. K.A.: Performed the methodology reviewed the manuscript and finalized the manuscript. All the authors checked the manuscript for the final publication.

6. Acknowledgment

The present was conducted in compliance with ethical standards and guidelines.

7. Conflicts of interest

Authors confirm that they have no conflicts of interest related to this work.

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