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Analysis Sustainable Farming: Mitigating Climate Change Impacts on Vegetables in Aileu, Timor-Leste¹Cesaltino Guterres Lopes da Cruz²Xisto Martins, PhD.³Claudino Ninas Nabais, PhD.**ARTICLE INFO**

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This research explores the role of sustainable farming methods in minimizing climate change effects on vegetable production in Aileu Vila, Timor-Leste. Conducted between October and November 2024, it assesses approaches like crop diversification, organic farming, agroforestry, and water conservation to enhance resilience against shifting rainfall patterns, temperature changes, and extreme weather. Through field observations, farmer interviews, and data analysis, the study identifies major challenges, including limited resources, inadequate infrastructure, and a lack of technical knowledge. Results indicate that while sustainable practices boost productivity and resilience, their adoption remains constrained by high costs, restricted financial access, and insufficient support systems. Overcoming these obstacles through improved resource availability, capacity-building programs, and supportive policies is essential for broader implementation. This study offers valuable insights for policymakers, NGOs, and local stakeholders aiming to strengthen sustainable agriculture in Timor-Leste, ensuring food security and climate adaptation in the long term.

Key words: sustainable farming, climate change, crop diversification, organic agriculture, agroforestry, resilience

1. Introduction

The inevitability of climate change due to global warming has extensive repercussions on various sectors, particularly agriculture. Indonesia faces significant challenges from climate change, including alterations in rainfall patterns, heightened occurrence of extreme weather events, and escalating air and sea surface temperature (Akmalia, 2022).

Studying sustainable farming methods to mitigate the effects of climate change on vegetables crops is vital in tackling the challenges presented by increasingly severe environmental conditions. Sustainable agriculture involves utilizing compost, eco-friendly soil management practices, and crop rotation, all of which are known to improve plant resilience to environmental factors (Rai *et al.*, 2023).

Implementing sustainable land management practices is vital for maintaining soil fertility, improving groundwater absorption, and helping farmers mitigate the impact of climate change. These

practices play a crucial role in enhancing agricultural sustainability and productivity. Additionally, leveraging adaptive agricultural technologies such as weather sensors, drones, and real-time crop monitoring systems provides farmers with valuable data, facilitating informed decision-making in farming activities (Bwalya *et al.*, 2023).

The agriculture sector in Timor-Leste, particularly in the Aileu Municipality, indeed plays a crucial role in the country's economy and food security. Horticultural farming, which involves the vegetables and fruits crops are vital for sustaining the livelihoods of many rural communities. However, this sector faces increasing vulnerability due to the impacts of climate change, including shifts in rainfall patterns, rising temperatures, and more frequent extreme weather events. These changes pose significant threats to the productivity and long-term sustainability of horticultural farming (Erskine *et al.*, 2020).

The agriculture sector, particularly vegetable crops farming, is crucial for Timor-Leste's economy and food security, especially in

¹ Student of Graduate Program for master's degree in agricultural science (M.Agr.) UNPAZ² Lecturer Agriculture Faculty, UNPAZ, Timor Leste³ Lecturer Agriculture Faculty, UNPAZ, Timor Leste

the Aileu Municipality. However, this sector faces increasing vulnerability due to the impacts of climate change (Development Bank & Bank Group, 2021).

Number of farmers listed in Aileu post administrative during the Timor-Leste agriculture census 2019 were 20,240 of 25,527 population enumerated. Total households were 4325, where 3329 households involved in the farming activities (Timor-Leste Agriculture Census 2019).

Aileu is in a region prone to landslides and erosion hazards, which poses significant challenges for sustainable farming practices. The prevalence of these hazards necessitates the implementation of climate risk reduction measures such as soil bioengineering and complementary catchment management interventions (Paudel *et al.*, 2022). The area's environmental conditions also impact on the availability of resources, particularly water and agricultural land. For instance, the study on agricultural productivity in Aileu, Ainaro, and Covalima municipalities highlights the importance of water and agricultural land in the context of sustainable agriculture (Gomes *et al.*, 2023).

The adoption of agricultural technologies and farming techniques plays a crucial role in enhancing the effectiveness of climate change mitigation efforts. The study on local agriculture products at high altitude such as in Aileu, Manufahi, and Ainaro municipalities reveals that horticulture farmers in these areas primarily use conventional agricultural practices (Gomes *et al.*, 2023). To improve agricultural productivity and sustainability, it is essential to introduce modern farming techniques and technologies, such as implementing drip irrigation, rain protection (tunnel), mulching and organic farming methods. These approaches can help reduce the environmental impact of farming practices and increase crop yields.

To address the challenges posed by climate change, it is essential to implement comprehensive climate change mitigation strategies. The National Communication processes in Timor-Leste, as outlined by the United Nations Framework Convention on Climate Change (UNFCCC), provide a framework for developing climate change adaptation and mitigation strategies. These strategies should focus on protecting and rehabilitating rainfall catchment areas, promoting sustainable agriculture practices, and enhancing the resilience of local communities (ADB, 2021).

The analysis of sustainable farming practices is crucial in devising impactful solutions to counter climate change effects in regions like Administrative Post of Aileu Vila. This involves embracing eco-friendly technologies, optimizing resource utilization, cultivating resilient crop varieties, and enhancing irrigation systems for improved water management.

Organic farming plays a key role in sustainable farming practices and is instrumental in reducing the effects of climate change. By emphasizing the use of natural inputs and maintaining ecological harmony, organic farming enhances environmental sustainability and helps farming systems adapt to climate variability. Organic farming contributes to climate change mitigation as part of broader sustainable agriculture to promote soil fertility through techniques such as composting, crop rotation, and the use of green

manures. These practices improve soil structure, enhance organic matter content, and enable soils to retain water more effectively, making crops more resilient to drought and extreme weather. Healthy soils have the capacity to sequester carbon by capturing CO₂ from the atmosphere and storing it in the soil, thus reducing greenhouse gas (GHG) emissions and helping to combat climate change. By promoting ecological balance, reducing reliance on synthetic inputs, and enhancing the resilience of farming systems, organic farming aligns well with sustainable agricultural practices. Key areas such as soil carbon sequestration, biodiversity, energy efficiency, and water conservation all play a role in reducing the impacts of climate change. Adopting these practices not only helps decrease global GHG emissions but also strengthens the capacity of farming systems to cope with climate-induced stresses (Rani *et al.*, 2023).

Efficient utilization of resources, particularly water and agricultural land, is essential for sustainable farming in the face of climate change. The study on agricultural productivity in Aileu, Ainaro, and Covalima municipalities highlights the importance of water and agricultural land in the context of sustainable agriculture (Malhi *et al.*, 2021). Implementing water conservation practices, such as drip irrigation and rainwater harvesting, can help optimize water usage and increase resilience to drought (Benitez-Alfonso *et al.*, 2023).

The selection and cultivation of crop varieties that are resilient to climate change impacts, such as heat stress, drought, and pests, can significantly improve the sustainability of farming systems. Researchers should work closely with farmers to identify and promote the adoption of locally adapted, climate-resilient crop varieties (Benitez-Alfonso *et al.*, 2023). This approach can help maintain crop yields and ensure food security in the face of changing climatic conditions.

The primary aim of this study is to assess farming methodologies that can mitigate the adverse effects of climate change on vegetable crops farming specifically in Post Administrative of Aileu vila, Aileu Municipality, Timor-Leste. Through this analysis, valuable insights will be gained to formulate robust and sustainable strategies for climate change mitigation.

By conducting a comprehensive analysis of sustainable farming practices in this locality, a more effective approach can be developed to confront the intricate challenges posed by global climate change.

2. Methodology

Post Administrative of Aileu is the capital of Aileu Municipality in Timor-Leste which is situated 47 km southwest of Dili. The town lies at an altitude of 927.37 meters above sea level and covers 251.48 km², with an approximate population density of 80 people per km². It shares borders with Dili Municipality to the north, Manatuto to the east, Manufahi to the south, and Ermera to the west. The administrative area includes 12 villages such as Aisirimou, Bandudato, Fahiria, Fatubosa, Hoholau, Lahae, Lausi, Lequitura, Liurai, Saboria, Selo Craic, and Selo Malere.

The climate in Aileu consists of a dry season from July to September, where temperatures range from 10.75°C to 30.36°C,

and a rainy season extending from November to June. Operating on the UTC+09:00 (TLT) time zone, the region, like the neighboring Ermera District. It does not have a coastline.

2.1. Methodology Overview

1. Data Collection Approach

A combination of qualitative and quantitative methods is employed for comprehensive data gathering:

a. Primary Data Sources:

- Farmer Surveys: Data is gathered through structured interviews and questionnaires to understand farming practices, the perceived impacts of climate change, adoption of sustainable methods, and key challenges.
- Key Informant Interviews: Interviews with stakeholders such as agricultural officers and extension workers to provide insights into institutional frameworks and policy support.

b. Secondary Data Sources:

Document Review: Analyzing relevant research on sustainable farming, climate-related impacts, and vegetable activities in Timor-Leste.

2.2. Sampling Framework

- Target Population: Vegetable farmers operating in Post Administrative Aileu.
- Sampling Strategy: A simple random sampling method ensures equitable representation across the farming community.
- Sample Size: Determined using Slovin's formula with a 95% confidence interval and a 5% margin of error.

Table 1. Sampel size. Sources: Census population Timor-Leste 2022

No.	Village Name	Number of Population	Number of Sampel	% of number of samples
1.	Bandudato	632	27	27.96
2.	Lausi	717	30	31.73
3.	Saboria	911	39	40.31
Total		2260	96	100

2.3. Data Analysis Techniques

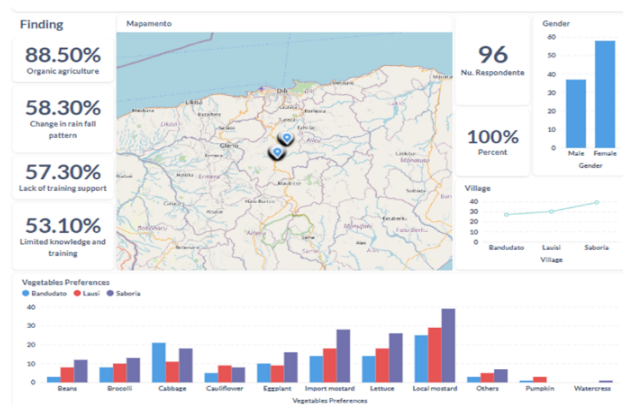
- Quantitative Analysis: Survey responses are processed using statistical tools such as SPSS or Excel.
- Qualitative Analysis: Data from interviews undergo thematic analysis to highlight recurring challenges and practices.

2.4. Assessment of Sustainable Farming Practices

Each sustainable practice is evaluated based on the following criteria:

- Effectiveness: The practice's role in addressing climate challenges, such as water scarcity or soil degradation.
- Adoption Levels: The proportion of farmers integrating the practice into their operations.
- Challenges to Adoption: Barriers related to finances, technical knowledge, or infrastructure availability.
- This methodology adopts an inclusive and robust approach to generate actionable insights, aiming to enhance the resilience of vegetable farming against climate variability in the Aileu region.

3. Result and discussion



Sustainable Agricultural Practices refer to various techniques employed by farmers to ensure environmental sustainability while boosting productivity. Among these, organic farming stands out as the most widely adopted practice, with an implementation rate of 88.5%. This high adoption reflects farmers' growing awareness of its advantages, including enhanced soil health, improved water quality, and reduced reliance on synthetic inputs that can harm ecosystems (Coulibaly *et al.*, 2021). Additionally, organic farming fosters biodiversity and helps mitigate the adverse impacts of climate change, making it a cornerstone of sustainable agriculture (Tilman *et al.*, 2011).

Agroforestry ranks as the second most utilized practice, with an adoption rate of 8.3%, significantly lower than organic farming. This method, which involves integrating trees with crops or livestock, provides several ecological benefits, such as reducing soil erosion, capturing carbon, and supporting biodiversity (FAO, 2014). However, its relatively low uptake may stem from limited technical expertise and inadequate resources needed for effective implementation ("Agroforestry for Sustainable Agriculture," 2019).

Crop rotation, adopted by only 1% of respondents, was the least utilized sustainable practice. This method offers numerous benefits, such as minimizing pest infestations, improving soil structure, and maintaining nutrient balance (K. K. Shah *et al.*, 2021). The low adoption rate, however, suggests a gap in farmers'

awareness of its importance and long-term advantages for agricultural sustainability.

Similarly, natural fertilizers, used by 2.1% of farmers, remain underutilized. Limited access to organic materials, insufficient knowledge of composting techniques, and a lack of support for production processes may contribute to this low usage. Despite these challenges, natural fertilizers offer significant potential to enhance soil structure, retain moisture, and support sustainable agriculture in the long term (Cen *et al.*, 2020).

Overall, while organic farming has gained significant traction, practices like agroforestry, crop rotation, and the use of natural fertilizers require greater emphasis through targeted training, technical guidance, and supportive policies to encourage broader adoption.

The Impact of Climate Change on Agriculture is evident across various aspects of the horticultural sector, presenting challenges of differing magnitudes. Extreme climatic events, such as floods, storms, and droughts, were perceived as a relatively minor concern, affecting only 2.1% of respondents. However, such events can still disrupt farming systems, with floods damaging infrastructure and droughts creating severe water shortages, especially in regions with limited irrigation facilities (Lemi, 2019).

Temperature increases, reported by 39.6% of respondents as a significant concern, have a profound effect on horticultural crops, which are often sensitive to temperature fluctuations. Elevated temperatures can accelerate crop maturation but may lead to reduced yields due to shortened growing periods (I. H. Shah *et al.*, 2024). Additionally, higher temperatures can exacerbate pest and disease issues, posing further risks to crop productivity and quality (Lobell *et al.*, 2011).

The most significant impact of climate change, highlighted by 58.3% of respondents, is the alteration of rainfall patterns. Unpredictable rainfall creates challenges such as extended dry periods or excessive precipitation, which can lead to water stress or flooding. These irregular patterns also disrupt planting schedules, ultimately reducing yields and increasing financial uncertainty for farmers (Yila *et al.*, 2023).

In summary, climate change presents multifaceted challenges, with altered rainfall patterns being the most critical, followed by rising temperatures. Addressing these issues requires adaptive strategies such as improved water management systems, climate-resilient crop varieties, and enhanced technical assistance for farmers (El Fartassi *et al.*, 2023)

Training and Technical Support for Farmers play a pivotal role in enabling the adoption of sustainable practices (Li *et al.*, 2023). Unfortunately, the data indicates significant gaps in training and support availability. Only 6.3% of farmers reported receiving incidental training, suggesting that current programs lack regularity and structured planning, limiting their long-term effectiveness.

A substantial 57.3% of farmers indicated a lack of training opportunities, highlighting an urgent need to improve access to

educational resources. Factors such as limited government programs, insufficient funding, and a shortage of agricultural experts contribute to this gap. Moreover, 35.5% of farmers reported receiving no support at all, leaving them reliant on traditional methods that may not address contemporary challenges like climate change or resource scarcity.

To bridge this gap, there is a need for well-organized, continuous training programs supported by collaboration between government agencies, non-governmental organizations, and private sector stakeholders. Such initiatives can provide farmers with the knowledge, skills, and tools needed to adopt innovative and sustainable practices effectively.

Challenges in Implementing Sustainable Practices include various obstacles that hinder farmers' ability to transition to eco-friendly farming methods. Access to modern technology, cited by 10.4% of respondents, is one such challenge. Technological tools for irrigation, soil management, and weather forecasting are crucial for improving productivity, yet their high costs and uneven distribution limit their availability (Jastrzębska *et al.*, 2021).

Resource limitations, reported by 33.3% of respondents, are another major barrier. Financial constraints, lack of quality seeds and organic inputs, and inadequate infrastructure like roads and irrigation systems all contribute to this issue. Without sufficient resources, farmers struggle to adopt practices that require initial investment or specialized inputs.

The most significant challenge, cited by 53.1% of respondents, is a lack of knowledge and training. Many farmers lack awareness of sustainable farming techniques or their long-term benefits. Limited access to structured training programs further compounds this issue, leaving farmers ill-equipped to adopt new methods or adapt to changing environmental conditions.

To overcome these challenges, a multifaceted approach is required. This includes expanding training and education programs, improving access to financial and technological resources, and investing in infrastructure development to support sustainable agricultural transitions (FAO, 2017).

4. Discussion

4.1. Impact of Climate Change on Vegetable Production in Aileu

This research highlights the substantial effects of climate change on vegetable farming in Aileu, Timor-Leste. Key climate challenges faced by farmers include rising temperatures, unpredictable rainfall, and more frequent extreme weather events such as droughts and storms. These climatic shifts have contributed to lower crop yields, delayed planting seasons, increased pest and disease outbreaks, and a decrease in plant resilience.

Farmers in Aileu have observed that extreme heat and extended dry periods particularly harm crops like cabbage, lettuce, and mustard, which are highly susceptible to water shortages and temperature variations. These crops require significant water and are sensitive to heat stress, resulting in reduced crop quality, lower yields, and even complete crop failure during severe conditions.

These observations align with broader climate change research. The Intergovernmental Panel on Climate Change (IPCC) reports that global temperature increases and altered rainfall patterns are likely to exacerbate food production challenges, especially in areas already vulnerable to drought and extreme weather events (Intergovernmental Panel on Climate Change, 2021). Additionally, (Fischer *et al.*, 2007) note that climate change is intensifying the frequency and severity of droughts, adversely affecting horticultural crops that depend on consistent water availability for productivity.

The climate-induced challenges faced by vegetable farmers in Aileu require targeted strategies for adaptation, particularly the integration of climate-resilient farming practices to maintain crop production and ensure food security. Implementing these practices is vital for dealing with the unpredictable nature of future climate patterns.

4.2. Sustainable Farming Practices in Aileu

Farmers in Aileu are adopting various sustainable farming methods to tackle the challenges posed by climate change, improving the ability of their crops to withstand unpredictable weather. These methods focus on organic fertilizers, agroforestry, crop diversification, and efficient irrigation systems.

Improving Soil Health with Organic Fertilizers: Farmers are using organic fertilizers and compost to enhance soil structure and its capacity to retain moisture, helping crops endure dry conditions (Lal, 2004). **Agroforestry and Crop Variety:** By planting trees around their fields, farmers help reduce soil erosion, improve water retention, and create beneficial microclimates. In addition, introducing drought-tolerant crops reduces the risks associated with erratic weather (Garrity *et al.*, 2010). **Efficient Irrigation Techniques:** Drip irrigation is becoming more common among farmers to optimize water use. This system delivers water directly to plant roots, ensuring consistent moisture and reducing wastage, which is especially critical during periods of irregular rainfall (Postel *et al.*, 2001).

These approaches have enabled farmers to adapt to climate challenges while promoting environmental health. Enhanced soil quality, better water management, and favorable microclimates illustrate the effectiveness of these strategies in reducing the adverse effects of climate change on vegetable farming.

4.3. Challenges in Implementing Sustainable Farming Practices in Aileu

While sustainable farming methods are vital for building resilience to climate change, farmers in Aileu face significant hurdles that limit their adoption. The primary barriers include:

Restricted Access to Resources and Technology. Many small-scale farmers in Aileu face financial difficulties that prevent them from acquiring technologies like drip irrigation systems or drought-tolerant seeds. High initial investment costs and limited availability of credit or financial assistance worsen these challenges (Lowder *et al.*, 2016).

Lack of Knowledge and Training. Limited awareness and insufficient training in climate-smart agriculture hinder farmers' ability to understand and implement sustainable practices effectively. This gap in knowledge slows progress in adopting environmentally friendly farming techniques (Altieri *et al.*, 2015).

Inadequate Government Support and Infrastructure. The absence of critical infrastructure, such as modern irrigation systems and storage facilities, creates obstacles for sustainable agriculture. Additionally, insufficient government programs, subsidies, or incentives for adopting climate-resilient technologies exacerbate these issues (Bowen *et al.*, 2013).

Overcoming these obstacles requires a comprehensive approach that provides farmers with better access to resources, education, and policy support. By addressing these challenges, sustainable farming can become more widespread, offering long-term solutions to the impact of climate change and improving agricultural resilience.

Conclusion

The study: *Analysis Sustainable Farming: Mitigating Climate Change Impacts on Vegetables in Aileu, Timor-Leste*, investigates the negative consequences of climate change on vegetable farming and evaluates how sustainable practices can help address these problems. Key challenges include rising temperatures, irregular rainfall, and extreme weather events like droughts and storms. These factors contribute to declining crop yields, soil degradation, and water scarcity, increasing the risk of agricultural losses (Manish Lad *et al.*, 2022; Molyneux *et al.*, 2012).

Farmers in Aileu have adopted measures such as using organic fertilizers, incorporating agroforestry practices, and cultivating drought-resistant crops. These approaches improve soil health, conserve moisture, and reduce vulnerability to adverse climatic conditions (Assefa, 2019; Lasco *et al.*, 2014). Despite these benefits, several challenges hinder the widespread implementation of sustainable farming methods. Farmers face limited access to advanced irrigation technologies, inadequate training on climate-resilient agriculture, and insufficient government support in the form of infrastructure and financial incentives (Dhillon & Moncur, 2023; Izuchukwu *et al.*, 2023).

Overcoming these obstacles requires addressing technical, social, and policy-related gaps. By enhancing government programs, offering targeted agricultural training, and increasing financial assistance, farmers in Aileu can adopt sustainable practices more effectively, bolstering the resilience of the local agricultural sector against climate change.

Recommendations

This study provides several key recommendations to address challenges in the agricultural sector:

1. Enhancing Technical Assistance and Farmer Training:

- Train farmers in sustainable practices, including crop rotation, organic farming, agroforestry, and soil and water conservation.
- Introducing climate-smart agriculture (CSA) strategies, such as adopting climate-resilient crop varieties, efficient irrigation methods, and integrated pest management (IPM).
- Maintain ongoing support through extension services and digital tools to facilitate the application of innovative techniques.

2. Expanding Access to Essential Resources:

- Ensure farmers can access affordable organic fertilizers, climate-resilient seeds, modern irrigation equipment, and other critical inputs.
- Provide financial support mechanisms like microloans and subsidies to encourage the transition to sustainable farming methods.

3. Improving Government Policy Frameworks:

- Incorporate climate adaptation measures into agricultural policies to bolster food security.
- Strengthen collaboration between government entities, extension officers, non-governmental organizations, and private-sector stakeholders for technology and resource sharing.

4. Fostering Community Participation:

- Engage farmers in initiatives to raise awareness about the advantages of sustainable agricultural practices.
- Empower local leaders and farming cooperatives to disseminate resources and knowledge within their communities.

5. Building Crucial Infrastructure:

- Develop facilities for water management (e.g., drip irrigation systems), storage (e.g., cold storage units), and market connectivity (e.g., transportation and price information networks).
- Upgrade irrigation infrastructure to boost water-use efficiency and crop yield.

6. Creating Monitoring and Early Warning Systems:

- Establish systems to monitor environmental changes and provide early warnings, enabling farmers to adapt to climate-related risks effectively.

These strategies aim to enhance agricultural resilience, productivity, and sustainability in the context of a changing climate.

References

- ADB. (2021). Climate Risk Country Profile: Timor-Leste. *Asian Development Bank*. www.worldbank.org
- Agroforestry for sustainable agriculture. (2019). In *Agroforestry for sustainable agriculture*. <https://doi.org/10.1201/9780429275500>
- Akmalia, H. A. (2022). The Impact Of Climate Change On Agriculture In Indonesia And Its Strategies: A Systematic Review. *AGRITEPA: Jurnal Ilmu Dan Teknologi Pertanian*, 9(1). <https://doi.org/10.37676/agritepa.v9i1.1691>
- Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. In *Agronomy for Sustainable Development* (Vol. 35, Issue 3). <https://doi.org/10.1007/s13593-015-0285-2>
- Assefa, S. (2019). The Principal Role of Organic Fertilizer on Soil Properties and Agricultural Productivity -A Review. *Agricultural Research & Technology: Open Access Journal*, 22(2). <https://doi.org/10.19080/artoaj.2019.22.556192>
- Benitez-Alfonso, Y., Soanes, B. K., Zimba, S., Sinanaj, B., German, L., Sharma, V., Bohra, A., Kolesnikova, A., Dunn, J. A., Martin, A. C., Khushi u Rahman, M., Saati-Santamaria, Z., Garcia-Fraile, P., Ferreira, E. A., Frazão, L. A., Cowling, W. A., Siddique, K. H. M., Pandey, M. K., Farooq, M., ... Foyer, C. H. (2023). Enhancing climate change resilience in agricultural crops. In *Current Biology* (Vol. 33, Issue 23). <https://doi.org/10.1016/j.cub.2023.10.028>
- Bowen, K. J., Ebi, K., Friel, S., & McMichael, A. J. (2013). A multi-layered governance framework for incorporating social science insights into adapting to the health impacts of climate change. *Global Health Action*, 6(1). <https://doi.org/10.3402/gha.v6i0.21820>
- Bwalya, B., Mutandwa, E., & Chiluba, B. C. (2023). Awareness and Use of Sustainable Land Management Practices in Smallholder Farming Systems. *Sustainability*, 15(20), 14660. <https://doi.org/10.3390/su152014660>
- Cen, Y., Guo, L., Liu, M., Gu, X., Li, C., & Jiang, G. (2020). Using organic fertilizers to increase crop yield, economic growth, and soil quality in a temperate farmland. *PeerJ*, 8. <https://doi.org/10.7717/peerj.9668>
- Coulibaly, T. P., Du, J., & Diakitè, D. (2021). Sustainable agricultural practices adoption. In *Agriculture (Pol'nohospodarstvo)* (Vol. 67, Issue 4). <https://doi.org/10.2478/agri-2021-0015>
- Development Bank, A., & Bank Group, W. (2021). *Climate Risk Country Profile: Timor-Leste*. www.worldbank.org
- Dhillon, R., & Moncur, Q. (2023). Small-Scale Farming: A Review of Challenges and Potential Opportunities Offered by Technological Advancements. In *Sustainability (Switzerland)* (Vol. 15, Issue 21). <https://doi.org/10.3390/su152115478>
- El Fartassi, I., Milne, A. E., El Alami, R., Rafiqi, M., Hassall, K. L., Waive, T. W., Zawadzka, J., Diarra, A., & Corstanje, R. (2023). Evidence of collaborative opportunities to ensure long-term sustainability in African farming. *Journal of Cleaner Production*, 392. <https://doi.org/10.1016/j.jclepro.2023.136170>
- Erskine, W., Ximenes, A., Glazebrook, D., da Costa, M., Lopes, M., Spyckerelle, L., Williams, R., & Nesbitt, H. (2020). Wild Foods and Food Security: The Case of Timor-Leste. In *Food Security in Small Island States*. https://doi.org/10.1007/978-981-13-8256-7_15
- FAO. (2014). Enhancing the socioeconomic benefits from forests. In *State of the world's forests*.
- FAO. (2017). The future of food and agriculture: Trends and challenges. <https://www.fao.org/3/i6583e/i6583e.pdf>. In *Food and Agriculture Organization of the United Nations*.
- Fischer, G., Tubiello, F. N., van Velthuisen, H., & Wiberg, D. A. (2007). Climate change impacts on irrigation water requirements: Effects of mitigation, 1990-2080. *Technological Forecasting and Social Change*, 74(7). <https://doi.org/10.1016/j.techfore.2006.05.021>
- Garrity, D. P., Akinnifesi, F. K., Ajayi, O. C., Weldesemayat, S. G., Mowo, J. G., Kalinganire, A., Larwanou, M., & Bayala, J. (2010). Evergreen Agriculture: A robust approach to sustainable food security in Africa. *Food Security*, 2(3). <https://doi.org/10.1007/s12571-010-0070-7>
- Gomes, G. S., Code, C. de A. M., Moniz, A. da C., & Silva, O. da. (2023). Production Systems and Agricultural Productivity Factors

- in the Municipalities of Aileu, Ainaro and Covalima, Timor-Leste. In *METHODOLOGY FOCUSED ON THE AREA OF INTERDISCIPLINARITY- VI*.
<https://doi.org/10.56238/methofocusinterv1-062>
- Intergovernmental Panel on Climate Change. (2021). Climate Change 2021 The Physical Science Basis Summary for Policymakers Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. *Climate Change 2021: The Physical Science Basis*.
- Izuchukwu, A., Erezi, E., & David Emeka, E. (2023). Assessing the Impact of Farmer-to-Farmer Communication Networks on Knowledge Sharing and Adoption of Sustainable Agricultural Practices in Africa. *International Journal of Agriculture and Earth Science*, 9(4). <https://doi.org/10.56201/ijaes.v9.no4.2023.pg58.76>
- Jastrzębska, M., Kostrzewska, M., & Saeid, A. (2021). Sustainable agriculture: A challenge for the future. In *Smart Agrochemicals for Sustainable Agriculture*. <https://doi.org/10.1016/B978-0-12-817036-6.00002-9>
- Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. In *Science* (Vol. 304, Issue 5677). <https://doi.org/10.1126/science.1097396>
- Lasco, R. D., Delfino, R. J. P., Catacutan, D. C., Simelton, E. S., & Wilson, D. M. (2014). Climate risk adaptation by smallholder farmers: The roles of trees and agroforestry. In *Current Opinion in Environmental Sustainability* (Vol. 6, Issue 1). <https://doi.org/10.1016/j.cosust.2013.11.013>
- Lemi, T. (2019). Effects of Climate Change Variability on Agricultural Productivity. *International Journal of Environmental Sciences & Natural Resources*, 17(1). <https://doi.org/10.19080/ijesnr.2019.17.555953>
- Li, B., Guo, B., Zhu, Q., & Zhuo, N. (2023). Impact of Technical Training and Personalized Information Support on Farmers' Fertilization Behavior: Evidence from China. *Sustainability (Switzerland)*, 15(11). <https://doi.org/10.3390/su15118925>
- Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science*, 333(6042). <https://doi.org/10.1126/science.1204531>
- Lowder, S. K., Skoet, J., & Raney, T. (2016). The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide. *World Development*, 87. <https://doi.org/10.1016/j.worlddev.2015.10.041>
- Malhi, G. S., Kaur, M., & Kaushik, P. (2021). Impact of climate change on agriculture and its mitigation strategies: A review. In *Sustainability (Switzerland)* (Vol. 13, Issue 3). <https://doi.org/10.3390/su13031318>
- Manish Lad, A., Mani Bharathi, K., Akash Saravanan, B., & Karthik, R. (2022). Factors affecting agriculture and estimation of crop yield using supervised learning algorithms. *Materials Today: Proceedings*, 62. <https://doi.org/10.1016/j.matpr.2022.03.080>
- Molyneux, N., Da Cruz, G. R., Williams, R. L., Andersen, R., & Turner, N. C. (2012). Climate change and population growth in timor leste: Implications for food security. In *Ambio* (Vol. 41, Issue 8). <https://doi.org/10.1007/s13280-012-0287-0>
- Paudel, S., Baral, H., Rojario, A., Bhatta, K. P., & Artati, Y. (2022). Agroforestry: Opportunities and Challenges in Timor-Leste. *Forests*, 13(1). <https://doi.org/10.3390/f13010041>
- Postel, S., Polak, P., Gonzales, F., & Keller, J. (2001). Drip irrigation for small farmers: A new initiative to alleviate hunger and poverty. *Water International*, 26(1). <https://doi.org/10.1080/02508060108686882>
- Rai, A. K., Sengupta, S., & Sahay, S. (2023). *Climate-Resilient and Sustainable Development in Horticulture: Cultivating a Greener Future*. <https://www.researchgate.net/publication/373213791>
- Rani, M., Kaushik, P., Bhayana, S., & Kapoor, S. (2023). Impact of organic farming on soil health and nutritional quality of crops. In *Journal of the Saudi Society of Agricultural Sciences* (Vol. 22, Issue 8). <https://doi.org/10.1016/j.jssas.2023.07.002>
- Republic of Timor-Leste Timor-Leste Agriculture Census 2019 National Report on Final Census Results General Directorate of Statistics, Ministry of Finance and the Ministry of Agriculture and Fisheries. (2020).
- Shah, I. H., Manzoor, M. A., Jinhui, W., Li, X., Hameed, M. K., Rehaman, A., Li, P., Zhang, Y., Niu, Q., & Chang, L. (2024). Comprehensive review: Effects of climate change and greenhouse gases emission relevance to environmental stress on horticultural crops and management. *Journal of Environmental Management*, 351. <https://doi.org/10.1016/j.jenvman.2023.119978>
- Shah, K. K., Modi, B., Pandey, H. P., Subedi, A., Aryal, G., Pandey, M., & Shrestha, J. (2021). Diversified Crop Rotation: An Approach for Sustainable Agriculture Production. In *Advances in Agriculture* (Vol. 2021). <https://doi.org/10.1155/2021/8924087>
- Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, 108(50). <https://doi.org/10.1073/pnas.1116437108>
- Yila, K. M., Gboku, M. L. S., Lebbie, M. S., & Kamara, L. I. (2023). Changes in Rainfall and Temperature and Its Impact on Crop Production in Moyamba District, Southern Sierra Leone. *Atmospheric and Climate Sciences*, 13(01). <https://doi.org/10.4236/acs.2023.131003>