

Review Article

THE SUSTAINABILITY OF CARBON MARKETS FOR CLIMATE-SMART AGRICULTURE(CSA) AMONG SMALLHOLDER FARMERS IN UGANDA

Abstract

This study evaluates the sustainability of Uganda's carbon markets within the context of climate-smart agricultural practices, aiming to align them with sustainable development goals. The research emphasizes the integration of sustainable development dimensions to address food security and climate issues proactively. Climate-smart agricultural practices, supporting smallholder agriculture efficiency, enable farmers to generate revenue by selling carbon-related environmental services, such as reduced greenhouse gas emissions and carbon sequestration. While these practices contribute to the resilience of smallholder livelihoods, challenges arise from large project volumes with low transaction costs, leading to insufficient carbon revenue for local communities. Additionally, limited methodologies and complex procedures hinder progress. The study recommends the involvement of national or international organizations to bridge the gap between farmer groups and the carbon market, emphasizing government policies and private sector collaboration to incentivize environmental services. In conclusion, establishing sustainable climate-smart agricultural linkages to the carbon market can yield co-benefits, including income diversification, poverty alleviation, and biodiversity conservation.

Keywords: Climate-smart agriculture, Carbon markets, Carbon prices, Smallholder farmers.

1.0. Introduction

As stated by the Food and Agriculture Organization (FAO) at the 2010 Hague Conference on Agriculture, Food Security, and Climate Change (FSCC), worldwide, climate-smart agriculture (CSA) is essential to achieving sustainable development objectives. Through addressing food security and climate-related difficulties at the same time, this method successfully integrates economic, social, and environmental elements (Näschen et al., 2019). Following a tripartite model, CSA prioritizes boosting agricultural incomes and productivity in a sustainable manner, encouraging climate change adaptation and resilience, and reducing or eliminating greenhouse gas emissions wherever possible.

CSA contributes to the goals of making sustainable development concrete. The three dimensions of sustainable development address food security and climate concerns in a forward-looking perspective (Migadde, 2020). CSA is guided by principles that aim for more resource efficiency and resilience in Agriculture. The significance of CSA in accomplishing sustainable development goals is well acknowledged; yet, there is a noticeable gap in knowledge regarding the real-world obstacles' smallholder farmers have while implementing CSA methods. Consequently, a thorough examination of the sustainability of carbon markets for CSA among smallholder farmers is needed (Chavula, 2021).

Many agricultural, land, and forestry management systems and practices for example sustainable land management, integrated food-energy systems, and Agroforestry are climate smart (Chavula et al., 2023). Some of the adopted CSA technologies or practices increase the

carbon content of the soils and aboveground biomass and enhance productivity and resilience (Karmaoui et al., 2020). Mitigation and adaptation co-benefits can be enhanced through integrated landscape management by seizing mitigation opportunities of any particular landscape through increased biomass production. CSA is not a new agricultural system, nor is it a set of practices. It is a new approach, a way to guide the needed changes in agricultural systems, given the necessity to jointly address food security and climate change. CSA shares sustainable development and green economy objectives and guiding principles. It aims at increasing food security and contributes to preserving natural resources (Ngoma et al., 2021). In addition, it has close links with the concept of sustainable intensification, which has been fully developed by FAO for crop production and is now being extended to other sectors and a food chain approach.

The four essential components of food security—availability, accessibility, use, and stability—are taken into consideration by CSA. But there is a clear knowledge gap about the complex interactions among the production-oriented CSA, farmer-focused strategies, and the highlighted aspects of food security. Although the major goals of CSA are to increase incomes, stabilize the economy, and boost productivity, the methods and tactics for accomplishing these goals are not as well understood (Makate et al., 2019). A deeper examination of the realistic routes and difficulties associated with incorporating CSA concepts into smallholder farming operations is necessary to close this gap. Furthermore, there may be synergies between CSA and sustainable intensification of crop production (SCPI), although further research is needed to determine the precise connections and complementary features of the two ideas.

Within the CSA paradigm, the Carbon Market (CM) intervention is an example of a proactive tactic meant to spur immediate action in support of a transformative process that will eventually take place. The CSA approach tackles the urgent question of "What steps can be taken now to progress toward a more sustainable future in agriculture under climate change?" as opposed to imagining an idealized future system of sustainability (Kurgat et al., 2020). The focus is on realistic actions that are adapted to the current agroecological, socioeconomic, and policy situations rather than only envisioning future aspects. This method entails developing transition plans that recognize significant chances to start the process while realistically considering current limitations (Bamanyaki, 2020). Still, there is a significant knowledge gap regarding the reproducibility and scalability of effective transition tactics in many settings. Filling this gap involves a comprehensive exploration of contextual factors that influence the effectiveness of CSA interventions, facilitating the development of adaptable and widely applicable strategies for sustainable agriculture under changing climate conditions (Fentie & Beyene, 2019).

The CM policy was initiated under the CDM schemes and was set up under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) to address climate change. Reduced Degradation and Desertification (REDD+) was a collaborative venture between three UN agencies, FAO, the United Nations Environmental Programme (UNEP), and the United Nations Development Programme (UNDP) meant to pay countries to keep rainforests untouched. UNFCCC which was initially not keen to accommodate REDD+, actually did under pressure from other UN agencies. However, Uganda has strategized to access carbon funds from different schemes. In 2006, the Uganda Carbon Bureau, the only full-service carbon firm, was registered. Among other things, it supplies carbon credits, provides information on climate change and carbon markets, and has a close relationship with Uganda's main donors, and international NGOs involved in climate change dynamics and carbon finance.

CSA programs serve two purposes: they mitigate the effects of climate change and offer crucial adaptation strategies. These methods are easily incorporated into the larger agenda for agricultural development (Zougmore et al., 2018), which is motivated by the fundamental

objective of improving smallholder agriculture's efficiency and sustainability in addition to financial incentives. Regardless of external incentives, implementing CSA practices has the potential to significantly increase smallholders' resilience and diversify their sources of income (Masikati et al., 2021). The growth of the carbon market and the dynamics of future demand and pricing for environmental credits will play a crucial role in achieving these benefits. It becomes essential to create Payment for Environmental Services (PES) programs that involve stakeholders at the national and regional levels and create strong connections between local actions within farmer and community organizations in order to guarantee the sustainability of such projects. The farmers combine their efforts on small farms to create amounts significant enough for market transactions, functioning as sellers who generate carbon (Heeb et al., 2019). Conversely, national and regional stakeholders—which comprise corporations, governments, and non-governmental organizations (NGOs)—play crucial roles in supporting the viability and scalability of climate-smart agricultural practices by either financing carbon credits or controlling the carbon trade. However, a research gap lies in understanding the long-term sustainability and equity implications of these market-driven mechanisms, warranting further exploration into their socio-economic and environmental impacts. Closing this gap will contribute to refining and optimizing the design of payment schemes, ensuring their effectiveness in supporting smallholder systems while aligning with broader climate and sustainability goals.

CSA aims at increasing soil organic carbon through improved Carbon market efficiency and resilience. The Carbon improves nutrient and water intake by plants, which increases yields and resource efficiency of land, nutrients, and water. It also reduces soil erosion and increases water retention in conservation agriculture (Pan & Dong, 2023). In allowing this combination the system will become more resilient to variability of precipitation and extreme events. Increasing carbon sinks in the soils also capture carbon, which contributes to climate change mitigation. For all these reasons, restoring degraded lands and increasing the level of organic carbon in soils is a priority action. All these will increase the carbon sink content hence increasing carbon markets.

The fact that programs led by carbon buyers and brokers frequently produce large volumes with low transaction costs and less uncertainty presents one of the main challenges facing CSA. But the more farms that participate, the more complicated it is to aggregate the carbon sequestered, which drives up transaction costs and raises uncertainty. As a result, the amount of carbon revenue given to nearby towns or farmers is typically insufficient. Inadequate capacity also creates problems for project implementation, monitoring, and verification. The intricate processes associated with carbon sequestration require the advice of trained specialists, which raises overall expenses. The advancement of agricultural soil carbon sequestration programs is impeded by the limited number of approved methodologies and complex procedures (Foster & Neufeldt, 2014). Even though projects use both independent assessments and self-reporting, the organization verifies annual reports given to Plan Vivo through a review process and sporadic field visits, with independent third parties carrying out the verification exercise (Labzovskii et al., 2019). Carbon costs are still relatively low, which is the prevailing concern despite the acquisition of large co-benefits.

2.0. Contribution of Carbon Projects to Sustainable Development in Uganda

In Uganda, Blum (2020) notes that carbon initiatives are essential to sustainable development since they promote both economic empowerment and environmental preservation. Initiatives that emphasize reforestation, for example, improve biodiversity, safeguard

watersheds, and sequester carbon. Nevertheless, there is a considerable disparity in how fairly local communities share the gains. The economic and environmental benefits of carbon projects are often limited for marginalized communities, as larger landholders or certain groups tend to receive more of these benefits. In order to close this disparity, inclusive methods that guarantee fair benefit distribution must be put into practice. This will improve the overall impact on sustainable through the reassurance of climate-smart farming techniques among smallholder farmers, carbon programs in Uganda's agriculture sector support sustainable development. Initiatives that support agroforestry and sustainable land management techniques, for instance, improve soil fertility and water retention in addition to sequestering carbon. However, a significant deficiency is the scant incorporation of gender-responsive strategies in these programs. Since they are heavily involved in agriculture, women frequently encounter obstacles while trying to participate in and gain from carbon projects. Creating and executing programs that specifically address the special requirements and difficulties experienced by female farmers is necessary to close the gender gap while guaranteeing their equitable benefits and active involvement (Michaelowa et al., 2021).

The carbon projects in Uganda function as cooperative, community-driven carbon offsetting activities under the CSA paradigm. Smallholder farmers actively engage in business-oriented activities within the voluntary carbon market (Velonaki, 2021). Michaelowa et al., (2021) commends these initiatives for their skillful fusion of improving rural lives through carbon sequestration and small-scale, farmer-led forestry or agroforestry initiatives. This strategy promotes environmental and economic sustainability while also lessening the strain on natural resources. By engaging in a variety of land-use practices, project participants improve food security, conserve biodiversity, sequester carbon, and maintain watersheds. Planting fruit orchards and growing mixed woodlots with native or naturalized tree species are among the suggested techniques. Interestingly, individual farmers are the owners of the carbon credits, but they choose to sell them collectively through group marketing campaigns. The International Small Group and Tree Planting Program (TIST) and Trees for Global Benefits (TGB) have developed into self-financing mechanisms. These methods use the market to boost cash flow and increase the number of farmers participating in forestry initiatives by providing upfront funds to farmers to start such programs (Aganyira et al., 2020).

The Carbon programs seek to increase the earnings of rural agricultural communities while halting the unsustainable exploitation of forest resources and the degradation of ecosystem quality. This serves as a creative financial tool that motivates farmers to engage in ventures that produce long-term revenue. Thus, improved ecosystem health is promoted and the destruction of the ecosystem is partially reversed. Concurrently, it produces funds for recouping investments, increasing involvement, and promoting diversity. Farmers that participate usually get paid for raising the carbon stocks on their property. Because of the payment structure, farmers are able to devote a portion of their property for asset development and consider in terms of long-term investment (Tumushabe, 2018; Tumushabe et al., 2023). These assets provide long-term advantages from trees in addition to immediate cash from annual crops.

The carbon programs work in tandem with pre-existing community organizations to galvanize farmers and enable ongoing land management plan observation (Newell et al., 2020). Farmers in the communities that are being targeted participate in workshops and training to determine what agricultural forestry operations best suit their needs (Mawa et al., 2021). Smallholder farmers register and then sign sales agreements that outline the terms and amounts. New regions that need funding, technical specifications, and market prospects are found through farmer groups. Carbon projects and companies pool the credit from different farmer groups and

negotiate pricing directly or through brokers on behalf of the farmers (Zakaria et al., 2020). This guarantees smallholders who might not normally have such possibilities access to the market. By helping local institutions become more capable, these businesses also help farmers diversify their sources of income and increase their ability to withstand the effects of climate change and advance sustainable development through institutional funding and capacity, sector cooperation, management techniques, policy execution, and legal compliance as in line with (Turyasingura et al., 2023 p. 553).

2.1. Causes of Low Carbon Payments among Farmers Using CSA in Uganda

The restricted availability of carbon markets is a major factor contributing to Ugandan farmers who practice CSA low carbon payments (Schilling et al., 2023). Many farmers have difficulty negotiating the complex carbon trading markets, especially smallholder farms. Their inability to take advantage of carbon sequestration projects is hampered by their lack of knowledge and resources to engage in these marketplaces. Farmers lose out on possible revenue streams when there isn't a clear way to link their environmentally friendly operations to carbon credits, which lowers carbon payments (Carton, 2014). The lack of reliable procedures for CSA initiative monitoring and verification is another important factor (Gabiri et al., 2022). Carbon sequestration or quantifiable and verifiable emission reductions are frequently linked to carbon credits. Uncertainty arises in Uganda due to a lack of trustworthy instruments and methods for precisely tracking and validating these results. Buyers of carbon credits and investors alike need to be certain about the projects they fund's environmental impact. Lower carbon payments occur from farmers finding it difficult to demonstrate the value of their climate-smart actions in the absence of such mechanisms.

Another challenge to getting enough carbon payments in Uganda is the financial capability of Ugandan farmers (Migadde, 2020). It is frequently necessary to make upfront investments in sustainable technologies, crop diversification, and better land management in order to implement CSA methods. Making these first investments is difficult for many farmers, especially those with minimal resources. The adoption of climate-smart practices slows down in the absence of appropriate financial assistance or incentives, which lowers the overall impact on carbon sequestration and, ultimately, lowers farmer carbon payments (Ruge, 2023).

The idea of pricing greenhouse gas emissions and establishing a market-based price-setting mechanism through certificate trading offers a potent tool for climate finance, notwithstanding all the challenges associated with its implementation (Pan & Dong, 2023). A significant amount of foreign finance for CSA initiatives may come from the carbon markets. But for at least 20 years, there has been ongoing debate about whether or not agricultural GHG reductions' carbon credits should be included in compliance with carbon markets. The challenges of maintaining environmental integrity with regard to potential leaks, unclear permanence, and the additionality of GHG reductions are a few of the worries. Another contributing factor to Ugandan farmers participating in CSA's low carbon payments is the lack of regulatory frameworks and supportive policies. The creation of an environment that is favorable to carbon trading may be hampered by a lack of government actions and incentives. Policies that honor and incentivize farmers' sustainable efforts are necessary. In the absence of such frameworks, the carbon market is unpredictable, which makes it challenging for farmers to draw in capital and bargain for advantageous terms for the carbon credits they produce.

Low carbon payments are a result of a lack of knowledge and instruction regarding the advantages of CSA and involvement in carbon markets. It's possible that many farmers are unaware of the possible financial benefits of implementing climate-smart techniques and taking

part in carbon trading (Standal & Westskog, 2022). Missed opportunities might arise from ignorance of the value of carbon credits and the workings of the market. Improving carbon payments among Ugandan farmers requires teaching them about the financial and environmental advantages of their practices as well as giving them the know-how to participate in carbon markets.

2.2. Strategies for Sustainable Carbon Markets for Small Scale Farmers Practicing CSA

The agricultural and food systems' institutional and enterprise reforms must be supported for the carbon markets to remain stable. For smallholders, fishermen, and pastoralists to increase productivity, these changes need strong support from the public and commercial sectors. The importance of these changes is highlighted by the ensuing economic growth and employment creation, especially in rural areas and nations with a strong agricultural sector. The need for innovative methods, tools, and services that smallholders, pastoralists, fishers, and foresters may access both financially and physically (Degefu et al., 2021). This accessibility creates chances for neighborhood businesses to meet farmers' requirements when CSA techniques are put into effect. Information on weather, temperature, and agricultural possibilities is quickly relayed by local organizations and institutions, which are essential in the dissemination of technical knowledge.

Financial services and market access need to be considered for carbon markets to prosper. By providing loans, insurance, safety nets, and incentives for environmental services, efficient microfinance channels are crucial for encouraging farmers to adopt new technologies, practices, and attitudes. Important elements include boosting market knowledge among smallholder farmers, linking with national and international markets, and energizing local markets. The dynamics of international climate finance are favorable to CSA, providing chances to transform investments in agriculture, both public and private, into CSA investments. Integrating strategies and obtaining international funding for projects are necessary to overcome the obstacle of dispersed climate finance sources, particularly in the context of clean energy (CSA) (Parag & Eyre, 2017). The global climate problem is highlighted by agriculture's crucial role in adapting to climate change and its contribution to greenhouse gas emissions.

Underdeveloped finance channels might only offer limited assistance, although progress is being made as evidenced by the continued emphasis on CSA operations in public financing, such as the GEF-6 replenishment. This dynamic may have an impact on the Green Climate Fund's design process in the middle term, opening the door for more CSA finance. Developing nations must take care of prerequisites such data quality, monitoring mechanisms, institutional capacity, and policy frameworks in order to effectively harness increased international CSA support (Dube & Chatterjee, 2022). A strong foundation can be established by bridging gaps in the agriculture sector, leveraging current knowledge and experiences, and utilizing priority setting and climate change assessments. Developing nations should take the initiative to create the framework necessary to take advantage of new opportunities in the carbon markets in order to get a head start on clean energy.

3.0. Conclusion and Recommendations

In conclusion, there is a great deal of promise for both environmental and financial gains from the sustainability of carbon markets for CSA among Ugandan smallholder farmers. It is essential that Ugandan government, foreign organizations, and local players work together to provide complete assistance in order to ensure its longevity and beneficial impact. It is imperative to fortify institutional frameworks, augment accessibility to financial services, and

foster knowledge sharing. Furthermore, specific capacity-building initiatives must be put in place to enable smallholders to take an active role in the carbon markets. It will be essential to have systems for ongoing observation and assessment in order to modify plans as necessary.

The integration of carbon projects within Uganda's sustainable development framework represents a viable approach to mitigating environmental issues and promoting economic expansion. Coordinated efforts are required to match carbon projects with more general sustainable development objectives in order to optimize these advantages. To guarantee successful project implementation, cooperation between governmental organizations, non-profits, and commercial businesses is essential. In addition, it is imperative to have a transparent and inclusive strategy for allocating revenue from carbon payments, with a focus on fairly allocating benefits to nearby communities. In addition to increasing the overall impact of carbon programs, this will support Uganda's long-term sustainable development.

The identification of low carbon payments among Ugandan farmers using CSA highlight important issues that need to be resolved for these programs to be successful. It is advised that stakeholders thoroughly examine the current payment schemes to make sure they fairly compensate farmers for their actual environmental contributions in order to address this problem. Improving the procedures for gathering and verifying data, along with open and equitable pricing structures, can assist in removing the existing obstacles. Increased focus on capacity-building initiatives is necessary to help farmers understand the importance of their input and get the tools they need to interact with carbon markets more successfully.

Establishing sustainable carbon markets for small-scale farmers engaged in CSA requires a multifaceted approach. It is imperative to develop and implement policies that recognize the unique challenges faced by smallholders and create an enabling environment for their participation. Governments, along with international organizations, should invest in building robust monitoring and verification systems to ensure the credibility of carbon credits. Furthermore, incentivizing the adoption of CSA practices through targeted financial support and capacity-building initiatives will contribute to the resilience and long-term success of carbon markets. Emphasizing community engagement and stakeholder collaboration will be instrumental in creating a sustainable ecosystem that benefits both farmers and the environment.

References

- Aganyira, K., Kabumbuli, R., Muwanika, V. B., Tabuti, J. R. S., & Sheil, D. (2020). Determinants of participation in state and private PES projects in Uganda. *Scientific African*, 8, e00370.
- Bamanyaki, P. A. (2020). *Barriers and opportunities for gender-responsive climate-smart agriculture adoption in Northern. Fao 2014.*
- Blum, M. (2020). Whose climate? Whose forest? Power struggles in a contested carbon forestry project in Uganda. *Forest Policy and Economics*, 115, 102137.
- Carton, W. (2014). Environmental protection as market pathology?: carbon trading and the dialectics of the 'double movement.' *Environment and Planning D: Society and Space*, 32(6), 1002–1018.
- Chavula, P. (2021). A Review between Climate Smart Agriculture Technology Objectives' Synergies and Tradeoffs. *International Journal of Food Science and Agriculture*, 5(4), 748–753. <https://doi.org/10.26855/ijfsa.2021.12.023>
- Chavula, P., Mambwe, H., Mume, A. A., & Umer, Y. (2023). *East African Journal of Forestry*

& Agroforestry Impact of Agroforestry Adoption among Smallholder Households in Zambia : An Expenditure Approach Farmers '. 6(1), 309–328.
<https://doi.org/10.37284/eajfa.6.1.1474>

- Degefu, M. A., Argaw, M., Feyisa, G. L., & Degefa, S. (2021). Effects of urbanization on the relationship between greenspace patterns and evolution of regional heat island in cities of Ethiopia. *Chinese Journal of Population, Resources and Environment*, 19(4), 330–343.
- Dube, L. C., & Chatterjee, S. (2022). Assessing livelihood impact of forest carbon projects using sustainable livelihood framework. *Mitigation and Adaptation Strategies for Global Change*, 27(8), 49.
- Fentie, A., & Beyene, A. D. (2019). Climate-smart agricultural practices and welfare of rural smallholders in Ethiopia: Does planting method matter? *Land Use Policy*, 85, 387–396.
- Foster, K., & Neufeldt, H. (2014). Biocarbon projects in agroforestry: Lessons from the past for future development. *Current Opinion in Environmental Sustainability*, 6(1), 148–154.
<https://doi.org/10.1016/j.cosust.2013.12.002>
- Gabiri, G., Luswata, K. C., Sebuliba, E., & Nampijja, J. (2022). *Climate Smart Agriculture in Uganda*.
- Heeb, L., Jenner, E., & Cock, M. J. W. (2019). Climate-smart pest management: building resilience of farms and landscapes to changing pest threats. *Journal of Pest Science*, 92(3), 951–969.
- Karmaoui, A., Barrick, K., Reed, M., & Baig, M. B. (2020). Impacts of climate change on agriculture and aquaculture. *Impacts of Climate Change on Agriculture and Aquaculture*, August, 1–333. <https://doi.org/10.4018/978-1-7998-3343-7>
- Kurgat, B. K., Lamanna, C., Kimaro, A., Namoi, N., Manda, L., & Rosenstock, T. S. (2020). Adoption of Climate-Smart Agriculture Technologies in Tanzania. *Frontiers in Sustainable Food Systems*, 4(May). <https://doi.org/10.3389/fsufs.2020.00055>
- Labzovskii, L. D., Wai, H., Mak, L., Takele, S., Rhee, J., Lashkari, A., Li, S., Goo, T., Oh, Y., Byun, Y., & Asia, E. (2019). What can we learn about effectiveness of carbon reduction policies from interannual variability of fossil fuel CO₂ emissions in East Asia? *Environmental Science and Policy*, 96(March), 132–140.
<https://doi.org/10.1016/j.envsci.2019.03.011>
- Makate, C., Makate, M., Mango, N., & Siziba, S. (2019). Increasing resilience of smallholder farmers to climate change through multiple adoption of proven climate-smart agriculture innovations. Lessons from Southern Africa. *Journal of Environmental Management*, 231, 858–868.
- Masikati, P., Sisito, G., Chipatela, F., Tembo, H., & Winowiecki, L. A. (2021). Agriculture extensification and associated socio-ecological trade-offs in smallholder farming systems of Zambia. *International Journal of Agricultural Sustainability*, 19(5–6), 497–508.
<https://doi.org/10.1080/14735903.2021.1907108>
- Mawa, C., Tumusiime, D. M., & Babweteera, F. (2021). Are community forests delivering livelihood benefits? Insights from Uganda. *Forests, Trees and Livelihoods*, 30(2), 133–150.
- Michaelowa, A., Hoch, S., Weber, A.-K., Kassaye, R., & Hailu, T. (2021). Mobilising private climate finance for sustainable energy access and climate change mitigation in Sub-Saharan Africa. *Climate Policy*, 21(1), 47–62.
- Migadde, A. (2020). *Carbon farming opportunities for crop cooperatives in Uganda*. Van Hall Larenstein.
- Näschen, K., Dieckrüger, B., Evers, M., Höllermann, B., Steinbach, S., & Thonfeld, F. (2019). The Impact of Land Use/Land Cover Change (LULCC) on Water Resources in a Tropical

- Catchment in Tanzania under Different Climate Change Scenarios. *Sustainability (Switzerland)*, 11(24). <https://doi.org/10.3390/su11247083>
- Newell, P., Srivastava, S., Naess, L. O., Torres Contreras, G. A., & Price, R. (2020). *Towards transformative climate justice: key challenges and future directions for research*. Institute of Development Studies.
- Ngoma, H., Finn, A., & Kabisa, M. (2021). *Climate Shocks, Vulnerability, Resilience and Livelihoods in Rural Zambia*.
- Pan, Y., & Dong, F. (2023). Green finance policy coupling effect of fossil energy use rights trading and renewable energy certificates trading on low carbon economy: Taking China as an example. *Economic Analysis and Policy*, 77, 658–679.
- Parag, Y., & Eyre, N. (2017). Barriers to personal carbon trading in the policy arena. In *Personal Carbon Trading* (pp. 353–368). Routledge.
- Ruge, T. (2023). Toward a New Model for African Agriculture: The Subscription Model of Farming in Uganda. *The Fletcher Forum of World Affairs*, 47(2), 5–14.
- Schilling, F., Baumüller, H., Ecuru, J., & von Braun, J. (2023). *Carbon farming in Africa: Opportunities and challenges for engaging smallholder farmers*.
- Standal, K., & Westskog, H. (2022). *Understanding low-carbon food consumption transformation through social practice theory: The case of community supported agriculture in Norway*.
- Tumushabe, J. T. (2018). Climate change, food security and sustainable development in Africa. In *The Palgrave handbook of African politics, governance and development* (pp. 853–868). Springer.
- Tumushabe, J. T., Rogers, B., Bwanika, B., & Twongyirwe, R. (2023). *The Trends and Magnitude of Tree Plantation Growing in Rural Communities of Kigezi Sub-region, South Western Uganda*.
- Turyasingura, B., Akatwijuka, R., Tumwesigye, W., Ayiga, N., Ruhiiga, T. M., Banerjee, A., Benzougagh, B., & Frolov, D. (2023). Progressive Efforts in the Implementation of Integrated Water Resources Management (IWRM) in Uganda. In *Disaster Risk Reduction in Agriculture* (pp. 543–558). Springer.
- Velonaki, A. (2021). *From Climate Change Knowledge to Climate Change Passivity: Airline Policies on Voluntary Carbon Offsets and the Carbon Literate Citizen*. Manchester Metropolitan University.
- Zakaria, A., Azumah, S. B., Appiah-Twumasi, M., & Dagunga, G. (2020). Adoption of climate-smart agricultural practices among farm households in Ghana: The role of farmer participation in training programmes. *Technology in Society*, 63, 101338.
- Zougmore, R. B., Partey, S. T., Ouédraogo, M., Torquebiau, E., & Campbell, B. M. (2018). *Facing climate variability in sub-Saharan Africa : analysis of climate-smart agriculture opportunities to manage climate-related risks*.