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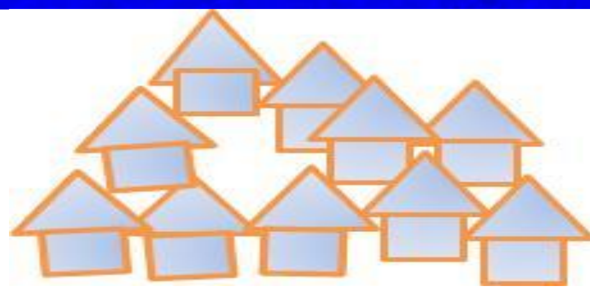

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Agroforestry Coffee Farming and Adaption to Climate Change: Qualitative Evidence from Arumeru District, Tanzania

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With food shortages and increased threats of climate change, there is a growing interest in agroforestry to address various on-farm adaptation needs. Even though, studies on-farm adaptation needs that integrate agroforestry, are rare. Being a tropical plant, coffees are adapted to higher rather than lower temperatures but still extreme high temperatures can hinder coffee health. One way to regulate temperature is to intercrop coffee with shade trees to prevent the plants from overheating. The study adopted qualitative research design to explore the role of agroforestry in increasing farmers` resilience to climate change. The study participants were purposively selected. The study employed “data saturation” and obtained the following study participants: 10 key informants, 25 focus group discussion (FGD) participants, and 35 in-depth interviewees (15 men and 20 women) different households. Overall, the study findings highlight that agroforestry is a sustainable practice helping poor smallholder farmers to adapt to climate change and sustain their livelihood. The main recommendations is that the farmers should adopt intercropping with shade trees, and use cover crops to cope with climate change.

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1.0 Introduction

Agroforestry is one of the most conspicuous land use systems across landscapes and agro-ecological zones in Africa. With food shortages and increased threats of climate change, interest in agroforestry is gathering for its potential to address various on-farm adaptation needs, and fulfil many roles. However, qualitative studies concurrently integrating several aspects of agroforestry are rare. Being a tropical plant, coffees are adapted to higher rather than lower temperatures. Nevertheless, extreme high temperatures can still hinder coffee health. One way to regulate temperature is to intercrop coffee with shade trees. Natural and autonomous air-conditioners, the trees can prevent coffee from overheating. Agroforestry provides assets and income from carbon, wood energy, improved soil fertility, and augmentation of local climate conditions; it provides ecosystem services and reduces human impacts on natural forests. Most of these benefits have direct benefits for local adaptation while contributing to global efforts to control atmospheric greenhouse gas concentrations. Agroforestry approach can help smallholder farmers adapt to climate change while improving their livelihoods. Agroforestry promotes the planting of different types of trees and crops, which can increase biodiversity and help maintain the health of natural ecosystems, which is critical for climate adaptation. This paper offers a qualitative finding on how agroforestry, as a sustainable practice, helps to achieve adaptation purposes while enduring relevancy to the livelihoods of the poor smallholder farmers in Arumeru District.

Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits (Nair, et al., 2021). It has been practiced in the United States and around the world for centuries. Moreover, agroforestry can contribute to climate change adaptation by increasing carbon storage, preventing deforestation, increasing biodiversity conservation, producing cleaner water, and controlling soil erosion, thus enabling agricultural lands to better cope with floods and drought events (Rijal, 2019). Agroforestry is a practical and low-cost means of implementing many forms of integrated land management (which seeks to reduce human impacts on land), and it contributes to a green economy by promoting long-term, sustainable, and renewable forest management, especially for small-scale producers (Nambiar, 2021). While the modern concept of agroforestry emerged in the early 20th century, the use of woody perennials in agricultural systems is ancient, with written descriptions of the practice dating back to Roman times (Schneider, et al., 2021). Undeniably, integrating trees with crops and animals, is a long-standing tradition throughout the world. According to Awazi, and Tchamba (2019), in 2004 the World Bank estimated that 1.2 billion people was using agroforestry practices.

According to Jeanneret (2012), agroforestry can occur at a variety of spatial scales (e.g., field or woodlot, farm, watershed) in different ecosystems and cultures. Ada et al. (2022), contend that when properly applied, agroforestry can improve livelihoods through enhanced health and nutrition, increased economic growth, and strengthened environmental resilience and ecosystem sustainability. In turn, such improvements can contribute to increased social sustainability in which human needs are satisfied in a way that fosters environmental health. Farm diversification is a growing strategy for economic competitiveness, especially throughout the industrialized temperate zone, and agroforestry offers great promise for the sustainable production of specialty nut and fruit crops, high-value medicinal, dairy and beef cattle, sheep, goats, and biomass for biofuel (Jose et al., 2021). Agroforestry systems also produce proven strategies for long-term carbon sequestration, soil enrichment, biodiversity conservation, and air- and water-quality improvements, benefiting both the landowners and society (Jose, 2019). Despite the many potential successes, the adoption of agroforestry in Tanzania is generally uneven, the majority of farmers are unaware of the potential benefits of the practice (Jha et al, 2021; Charles et al, 2013; Kajembe et al, 2016; Jawo et al, 2022).c

1.1 Agroforestry in coffee system for climate change adaptation

Coffee is an important crop in many countries in Africa and contributes significantly to their economies. According to data from the International Coffee Organization, the total export value of coffee from Africa in the 2019/20 coffee year was USD 2.6 billion, which represents an increase of 7.3% compared to the previous year (Lima et al., 2023). In terms of GDP contribution, the exact figure varies by country. However, coffee is a significant contributor to the GDP of many African countries. For example: Ethiopia: Coffee accounts for approximately 28% of Ethiopia's annual exports and contributes to about 10% of the country's GDP. Uganda: The coffee industry accounts for over 20% of Uganda's total export earnings and contributes approximately 6% to the country's GDP. Rwanda: Coffee is the country's top export and accounts for about 25% of Rwanda's export earnings. Kenya Coffee is the third-largest export earner for Kenya, contributing over 3% to the country's GDP (Kadigi, et al., 2022). Overall, coffee farming plays a vital role in supporting the livelihoods of millions of people in Africa and contributes significantly to the economies of many countries.

Climate change is anticipated to impose severe challenges to farmers to maintain agricultural production levels in the future (IPCC, 2019) This is predominantly the case for producers of coffee, which is an important cash crop for approximately 25 million smallholder farmers and 100 million livelihoods in many countries in Africa. *Coffea arabica* is extremely sensitive to changes in climate and global projections indicate a reduction in the area that is suitable for coffee production due to changing temperature and precipitation regimes (Ovalle-Rivera et al., 2015). According to Rao (2007), Climate change is expected to impose severe difficulties to coffee farmers attempting to maintain agricultural production levels, which provides an income for approximately 25 million smallholder farmers throughout Africa. According to Alemu and Dufera (2017), from water scarcity to soil degradation, *Coffee Arabica* is highly affected by a many of environmental changes which may force the production to relocate to other regions with more suitable climates. However, introducing agroforestry systems into these plantations offer an alternative solution.

According to Chirwa and Adeyemi (2020), Tanzania foresees that four million households would have adopted and benefit from agroforestry by 2025, and has committed to restore 5.2million hectares of degraded land by 2030. This goal complements the national development strategy “MKUKUTA”, which aims to increase household income while conserving the environment. Agroforestry is one of the landscape restoration technologies projected in the country's programs and projects to meet this target.

Agroforestry coffee systems consist of coffee plants intercropped with shade trees and banana which can increase nutrient cycling, biodiversity, carbon storage, and provide a moderate microclimate (Fahad et al., 2022). The microclimate produced by the trees results in lower mean air temperatures and higher soil moisture in coffee agroforestry systems than in unshaded coffee systems. Nevertheless, increasing shade can also affect the physiology of coffee plants, stimulating the vegetative growth instead of flower buds, reducing the number of nodes per branch and coffee yield. In unshaded systems, the coffee flowering shows strong yearly fluctuations, causing in a regular production pattern with alternating years with high and low productivity. These fluctuations can compromise income security for farmers and decrease the lifespan of coffee plants due to fatigue during heavy production years. In disparity, the productivity of coffee under shade tends to be more stable across years than in unshaded coffee systems (Bhattarai, et al., 2017). Therefore, agroforestry coffee systems, when appropriately managed, may lighten the effects of projected climate change by adjusting the microclimate without decreasing coffee productivity. Nevertheless, while several studies have shown the quantitative benefits of agroforestry systems on microclimate at specific locations, the efficacy of agroforestry systems to mitigate the effects of climate change is still little. (Gomes et al., 2021). Therefore, this paper qualitatively assess co-benefits and trade-offs of shaded agroforestry for climate change adaptation.

2.0 Methodology

The study was conducted at Akheri and Poli villages. The primary rationale behind the selection of this study is proximity with the forest that make easier to get genuine information about coffee farming, climate change adaptation and agroforestry. The secondary rationale is the areas were characterized with the deforestation due to increased use of both firewood and charcoal.

2.1 Research design

The study adopted qualitative research design; where by farmers were purposively selected. The study employed “data saturation” to decide the number of study participants (Banester, 2012). The purposive sampling procedure does not aim to provide the final and conclusive answers to the research questions but merely explores the research topic with varying levels of depth (Scholz, 2002). Data saturation is reached when there is sufficient information to reproduce the answers investigated in a study, that is, a point when the researcher does not get different (new) information from the study participants and/or their context (Morse, 2015). Data saturation is not about the numbers per se, but rather the depth of the data accrued (Burmeister and Aitken, 2012).

2.2 Data Collection Methods

Data were collected by the use household in-depth interviews, focus group discussions, and key informant interviews. Focus groups are convenient to obtain detailed information about personal and group feelings, perceptions, and opinions (Bennett *et al*., 2017) they can provide a broader range of information and offer the opportunity to seek clarification (Morgan 2017). The key informant interviews can be conducted either by face to face or telephone conversation (Jäckle *et al.*, 2006). Key informant interviews are qualitative in-depth interviews with people who know what is going on in the community (McAlearney, 2016). The purpose of key informant interviews is to collect information from a wide range of people including community leaders, professionals, or residents who have first-hand knowledge about the community (McAlearney, 2016). Key informant interviews helped to get information from people with diverse backgrounds and opinions and be able to ask in-depth and probing questions (Carter, 2002).

A total of 10 key informants were purposively selected based on their knowledge on the topic of investigation. Focus group discussion (FGDs) involved 25 participants. The participants of In-depth interviews were obtained through data saturation. The data saturation point was reached after interviewing 35 men and women from different households. Despite some key informants being leaders, they concurrently happened to be farmers and had experience in coffee farming. Key informants included District Executive Directors, Ward Executive Officer, village executive officers, Representative from disaster committee, Village chairpersons, Tanzania coffee farmers, Agriculture officers, and Extension officers.

2.3 Data analysis

Data analysis was carried out using content analysis. This is a research technique used to make replicable and valid inferences by interpreting and coding textual material (Bazeley, 2007). This can also be done by systematically evaluating texts and presenting them in the form of quotations. Content analysis is useful for the analysis of a case study predominantly of heterogeneous types of data (Stemler *et al.,* 2015). In the analysis, words, phrases, sentences, and paragraphs are considered as meaningful units that are condensed according to their context and content. The analysis involved the following five steps.

Data transcriptions process by which audio and/or video recording is interpreted or translated into words that can then be studied and coded (Davidson, 2009).

i. The data were changed from audio format to textual format verbatim.
ii. Data translation data was converted from Kiswahili language to the English language
iii. Data familiarization. The researcher ensured to be familiar with the data through reading and re-reading interview transcripts
iv. Codes were developed through condensing raw textual data into a brief, summary format
v. Categorizing the codes into group patterns thus creating meaningful units or categories.

3.0 Results

3.1. Benefits and Trade-offs Agroforestry

Results from in-depth interviews revealed that agroforestry has environmental and economic benefits. One of the key informants said:

"Agroforestry practices in coffee farming provide numerous benefits for climate change adaptation such as increased sustainability. I think agroforestry practices are more sustainable than conventional coffee farming methods. For example, shade trees in agroforestry systems can help to reduce the need for chemical inputs, increase soil health, conserve water, and provide habitat for pollinators. At the time when coffee trees do flower, they attract a lot of bees. Subsequently, coffee plants become healthy. At the same time, beehives around are filled with honey".

Another key informant said that *"…the integration of trees in agroforestry systems has been shown to improve the resilience of coffee farms to climactic stressors such as drought or excessive precipitation. Shade trees help to regulate temperature and moisture levels, which can reduce heat stress and prevent soil erosion. Agroforestry practices provide additional sources of income for coffee farmers, such as honey, banana, and fruit. This diversification of income is an important factor in building resilience to climate change and can provide a buffer against the potential loss of income from coffee due to adverse weather conditions*"

Overall, the benefits include improved soil quality; increased biodiversity, increased carbon storage, improved water quality and availability, increased crop and livestock productivity, diversified sources of income, improved resilience to climate change and extreme weather events, and reduced erosion risk.

Concerning Trade-offs of agroforestry, results indicate that there are sincere costs associated with adopting agroforestry practices, opportunity costs of land use change, reductions in short-term crop yield compared to monoculture systems, time required for trees to grow to maturity, potential for competition between trees and crops for nutrients and water, changes to labour requirements and workload associated with managing an agroforestry system. Similar findings were shared through FGDs. Reflecting the findings captured from in-depth interviews and FGDs, one of the key informants believed:

"*There is a need to understand agroforestry systems and their potential benefits as well as the skills to implement and maintain them. Capacity building activities such as training programs, farmer field schools, and extension services should be provided to farmers to foster adoption of agroforestry practices. The environmental context of the area in which agroforestry practices are being implemented is a crucial factor in determining their effectiveness. The soil, topography, and rainfall patterns in the area should be carefully assessed to determine which tree and crop species are most appropriate for the system. The needs of wildlife such as pollinators and other fauna should also be taken into consideration. The social and economic context of the area should also be considered when implementing agroforestry practices. There is a need of ensuring that agroforestry systems do not cause conflicts over land use, negatively impact local livelihoods, or perpetuate gender".*

Overall, agroforestry has significant potential to mitigate and adapt to climate change while providing multiple benefits to farmers and society. The FGD results is supported by key informant interview

I agreed that agroforestry systems have high potential for carbon sequestration, particularly in developing countries that have extensive areas of degraded or underutilized land. Agroforestry systems can sequester carbon in both aboveground and belowground biomass, and that the amount of carbon sequestered depends on the type of agroforestry system, the tree and crop species involved, and the management practices. These systems can also help to reduce greenhouse gas emissions through the avoidance of deforestation and the reduction of chemical inputs, and can also provide other ecosystem services such as soil conservation, water management, and the maintenance of biodiversity. However, several challenges and barriers that can hinder the potential of agroforestry systems for carbon sequestration. These include inadequate financial support for farmers to implement agroforestry systems, the lack of secure land tenure"

3.2. Role of agroforestry in increasing farmers` resilience to climate change

Overall, the findings of the study indicate that agroforestry products and production practices play an important role in increasing farmers' resilience to climate change. The integration of trees, crops, and livestock in a single agricultural system help smallholder farmers adapt to changing climatic conditions. FGD results indicate that diversification of income was one of the key benefits of agroforestry. It was found that by having multiple sources of income, farmers could better withstand climate shocks such as disease outbreaks, droughts, and floods. There were challenges that those who relied solely on a single crop or activity experienced difficulties adopting to climate change. Specifically, agroforestry provides multiple goods such as timber, fruit, shade, forage, and grazing, along with various ecosystem services that can bring economic benefits to smallholder farmers. Agroforestry systems help preserve the soil by reducing soil erosion, improving soil quality, and managing water resources.

Agroforestry also enhances biodiversity, which is crucial for maintaining ecosystem balance and resilience. By incorporating a variety of species, agroforestry systems create habitats which control pests and pollinate crops. This biodiversity not only supports the health of the agricultural system but also contributes to the overall stability of the environment, making it more resilient to climate change impacts.

Moreover, agroforestry practices can contribute to carbon sequestration, helping to mitigate climate change. Trees and other perennial plants in agroforestry systems capture and store carbon dioxide from the atmosphere, reducing greenhouse gas concentrations. This process not only benefits the global climate but also improves local air quality and provides additional income opportunities for farmers through carbon credits and other environmental services markets.

Socially, agroforestry strengthens community ties and improve livelihoods. Here, communities can share knowledge and resources, fostering collaboration and mutual support. This collective approach can lead to more sustainable and resilient farming practices, as well as improved food security and nutrition. Additionally, the aesthetic and recreational value of agroforestry landscapes can enhance the quality of life for rural communities.

The consensus of FGDs is that agroforestry government and other stakeholders should provide technical assistance, financial support, and education to farmers. The proposed measures have a potential to incentivize the adoption of agroforestry practices, leading to broader environmental and socio-economic benefits including addressing climate change.

The present study further revealed that by promoting soil conservation, farmers maintain soil fertility and productivity, even in periods of drought or flood, thus ensuring that yields remain stable even under adverse climatic conditions. A consensus from FGDs aligned with the result from the key informant interview: agroforestry helps farmers manage climate variability and mitigate the risks associated with crop failure or loss of income from traditional cash crops. Agroforestry systems promote sustainable land use practices by integrating the cultivation of trees, crops, and livestock in a single agricultural system. This promotes long-term soil health and local biodiversity, while also helping to mitigate the impacts of climate change.

Agroforestry systems also enhance water management, which is crucial for maintaining agricultural productivity in the face of climate change. Trees in these systems help to regulate water cycles by improving water infiltration and reducing surface runoff. This not only conserves water but also reduces the risk of soil erosion and nutrient loss. By maintaining a more stable water supply, agroforestry can help farmers sustain their crops and livestock during periods of drought or irregular rainfall.

Furthermore, agroforestry improves the microclimate within agricultural landscapes. The presence of trees and other vegetation can moderate temperatures, reduce wind speeds, and provide shade for crops and livestock. These microclimatic benefits can protect crops from extreme weather conditions, such as heatwaves and storms, thereby enhancing their resilience and productivity. Additionally, shaded areas can reduce water evaporation from the soil, further conserving this vital resource.

Economic diversification is another significant advantage of agroforestry. By producing a variety of products such as timber, fruits, nuts, and medicinal plants, farmers can generate multiple streams of income. This diversification reduces their dependence on a single crop and spreads the risk of economic loss. In times of market fluctuations or crop failures, having alternative sources of income can provide a financial buffer, ensuring that farmers can continue to support their families and invest in their farms.

4.0. Discussion

Overall, the findings of this study imply that agroforestry provide significant benefits in terms of climate change adaptation, biodiversity conservation, and livelihood improvement for smallholder farmers. The finding is in line with past research (Ntawuruhunga *et al.,* 2023; Kaler *et al*., 2022). The findings further imply that the potential for carbon sequestration through agroforestry varies depending on the region and the specific agroforestry practices being used. Muthee *et al.* (2022) indicate that some regions with high potential for carbon sequestration in Sub-Saharan Africa this region has large areas of degraded land and could benefit greatly from the implementation of agroforestry practices. It has the potential to mitigate climate change by sequestering carbon dioxide in trees, shrubs, and soils while also providing various benefits such as improving soil health, conserving biodiversity, and providing food and fuel resources. Trees play a crucial role in carbon sequestration as they absorb carbon dioxide during photosynthesis and store it in their biomass and soils. Agroforestry practices such as alley cropping, silvopasture, and forest farming can enhance carbon sequestration and provide multiple benefits to farmers. In addition to carbon sequestration, agroforestry can also contribute to climate change adaptation by increasing the resilience of agro -ecosystems to extreme weather events such as droughts and floods. Trees help to regulate water cycles by capturing and storing water in the soil, reducing runoff and erosion, and increasing water infiltration. Furthermore, agroforestry practices can enhance biodiversity and provide habitats for wildlife, which can help to maintain ecological balance and support ecosystem services such as pollination and pest control.

However, there is trade-offs of agroforestry for climate change adaptation, reduced income in the short-term, as some tree crops take years to reach maturity and yield, increased labour requirements and labour costs, particularly during the establishment phase, opportunity costs associated with land use change, where land that could have been used for other purposes, such as crop cultivation (Staton *et al.,* 2022).

The findings further align with past research highlighting that agroforestry practices have emerged as a promising strategy for climate change adaptation in the coffee industry (Quandt *et al*., 2923). According to Fatima (2023) coffee plantations are highly vulnerable to the impacts of climate change, including increased temperatures, changes in precipitation patterns, and extreme weather events. Studies by Koutouleas et al *(*2023) indicate that shade trees play a critical role in coffee agroforestry systems as they mitigate extreme temperatures and provide a shield against direct sun rays, helping to avoid overheating the coffee plants. They also help to preserve moisture in the soil, which is important in periods of drought, providing an ideal microclimate for coffee cultivation. According to Fahad *et al.* (2022) coffee agroforestry systems can help to maintain soil health in several ways, such as preventing soil erosion, maintaining soil moisture, and promoting soil biodiversity. A healthy soil profile can withstand climate-related stress, and improved ground cover management can help retain soil nutrients that are essential for coffee growth. Coffee farmers who practice agroforestry can diversify their income streams by selling not only coffee but also the co-products of agroforestry, such as shade trees banana and fire wood.

5.0. Conclusion

In conclusion, agroforestry holds significant potential for enhancing the resilience of coffee farming and smallholder farmers against climate change. The integration of trees, crops, and livestock within agricultural systems offers diverse benefits, including improved farm production, enhanced ecosystem services, and increased household income. Agroforestry practitioners demonstrate greater economic resilience, enabling them to withstand various stresses and shocks more effectively than those relying solely on conventional agriculture.

To fully realize the benefits of agroforestry, it is essential to provide effective extension services, training, and supportive policies. Outreach programs should emphasize the multifunctional values of agroforestry, preserving traditional systems while strategically introducing new practices such as beekeeping and aquaculture. Additionally, promoting new cash crops like sunflower, carrots, Irish potatoes, cardamom, and sweet potatoes can further improve household income and contribute to the overall sustainability and resilience of farming communities.

7.0. Reference

Alemu, A., & Dufera, E. (2017). Climate smart coffee (Coffea arabica) production. *American Journal of Data Mining and Knowledge Discovery*, *2*(2), 62-68

Awazi, N. P., & Tchamba, N. M. (2019). Enhancing agricultural sustainability and productivity under changing climate conditions through improved agroforestry practices in smallholder farming systems in sub-Saharan Africa. *African Journal of Agricultural Research*, *14*(7), 379-388.

Bhattarai, S., Alvarez, S., Gary, C., Rossing, W., Tittonell, P., & Rapidel, B. (2017). Combining farm typology and yield gap analysis to identify major variables limiting yields in the highland coffee systems of Llano Bonito, Costa Rica. *Agriculture, Ecosystems & Environment*, *243*, 132- 142.

Charles, R. L., Munishi, P. K. T., & Nzunda, E. F. (2013). Agroforestry as adaptation strategy under climate change in Mwanga District, Kilimanjaro, Tanzania. International Journal of Environmental Protection, 3(11), 29-38

Chirwa, P. W., & Adeyemi, O. (2020). Deforestation in Africa: implications on food and nutritional security. *Zero hunger*, 197-211.

Fahad, S., Chavan, S. B., Chichaghare, A. R., Uthappa, A. R., Kumar, M., Kakade, V., ... & Poczai, P. (2022). Agroforestry Systems for Soil Health Improvement and Maintenance. *Sustainability*, *14*(22), 14877

Fatima, Z., Naz, S., Iqbal, P., Khan, A., Ullah, H., Abbas, G., ... & Ahmad, S. (2022). Field crops and climate change. *Building Climate Resilience in Agriculture: Theory, Practice and Future Perspective*, 83- 94
Gomes, L. C., Bianchi, F. J. J. A., Cardoso, I. M., Fernandes, R. B. A., Fernandes Filho, E. I., & Schulte, R. P. O. (2020). Agroforestry systems can mitigate the impacts of climate change on coffee production: a spatially explicit assessment in Brazil. *Agriculture, Ecosystems & Environment*, *294*, 106858
Igbatayo, S. A. (2023). Climate Change and Agroforestry Resilience Strategy in West Africa's Cocoa Supply Chain Dynamics. In *Disaster Risk Reduction for Resilience* (pp. 361-385). Springer, Cham
Jawo, T. O., Kyereh, D., & Lojka, B. (2022). The impact of climate change on coffee production of small farmers and their adaptation strategies: a review. Climate and Development, 15(2), 93–109. https://doi.org/10.1080/17565529.2022.2057906
Jeanneret, P., Aviron, S., Alignier, A., Lavigne, C., Helfenstein, J., Herzog, F. & Petit, S. (2021). Agroecology landscapes. *Landscape Ecology*, *36*(8), 2235-2257
Jha, S., Kaechele, H., & Sieber, S. (2021). Factors influencing the adoption of agroforestry by smallholder farmer households in Tanzania: Case studies from Morogoro and Dodoma. Land use policy, 103, 105308
Jose, S. (2019). Environmental impacts and benefits of agroforestry. In *Oxford research encyclopedia of environmental science*
Jose, S., Garrett, H. E. G., Gold, M. A., Lassoie, J. P., Buck, L. E., & Current, D. (2021). Agroforestry as an integrated, multifunctional land use management strategy. *North American Agroforestry*, 1- 25
Kajembe, J., Lupala, I., Kajembe, G., Mugasha, W., & Nuru, F. (2016). The role of selected agroforestry trees in temperature adaptation on Coffea arabica: a case study of the Moshi district, Tanzania. Climate Change and Multi-Dimensional Sustainability in African Agriculture: Climate Change and Sustainability in Agriculture, 553-566
Kaler, N. S., Attri, V., & Kumari, P. (2022). Agroforestry: The Adaptive Solution for Global Climate Change. *Advances in Agricultural and Horticultural Sciences*, 596
Koutouleas, A., Sarzynski, T., Bordeaux, M., Bosselmann, A. S., Campa, C., Etienne, H., ... & Ræbild, A. (2022). Shaded-coffee: A nature-based strategy for coffee production under climate change? A review. *Frontiers in Sustainable Food Systems*, *6*, 158.
Muthee, K., Duguma, L., Majale, C., Mucheru-Muna, M., Wainaina, P., & Minang, P. (2022). A quantitative appraisal of selected agroforestry studies in the Sub-Saharan Africa. *Heliyon*, e10670
Nair, P. R., Kumar, B. M., Nair, V. D., Nair, P. R., Kumar, B. M., & Nair, V. D. (2021). Definition and concepts of agroforestry. *An Introduction to Agroforestry: Four Decades of Scientific Developments*, 21-28.
Nambiar, E. S. (2021). Small forest growers in tropical landscapes should be embraced as partners for Green-growth: Increase wood supply, restore land, reduce poverty, and mitigate climate change. *Trees, Forests and People*, *6*, 100154
Ntawuruhunga, D., Ngowi, E. E., Mangi, H. O., Salanga, R. J., & Shikuku, K. M. (2023). Climate-smart agroforestry systems and practices: A systematic review of what works, what does not work, and why. *Forest Policy and Economics*, *150*, 102937.
Quandt, A., Neufeldt, H., & Gorman, K. (2023). Climate change adaptation through agroforestry: opportunities and gaps. *Current Opinion in Environmental Sustainability*, *60*, 101244.
Rao, K. P. C., Verchot, L. V., & Laarman, J. (2007). Adaptation to climate change through sustainable management and development of agroforestrysystems. *Journal of SAT agricultural research*, *4*(1), 1-30
Rijal, S. (2019). Agroforestry System: approaches for climate change mitigation and adaptation. *Big Data in Agriculture (BDA)*, *1*(2), 23-25.

Schneider, P., Rochell, V., Plat, K., & Jaworski, A. (2021). Circular Approaches in Small-Scale Food Production. *Circular Economy and Sustainability*, 1-25
Staton, T., Breeze, T. D., Walters, R. J., Smith, J., & Girling, R. D. (2022). Productivity, biodiversity trade-offs, and farm income in an agroforestry versus an arable system. *Ecological Economics*, *191*, 107214
URT (2006). MKUKUTA Status Report 2006: Progress towards goals for growth, social well-being, and governance in Tanzania. Research and Analysis Working Group, Ministry of Planning, Economy, and Empowerment
Zada, M., Zada, S., Ali, M., Zhang, Y., Begum, A., Han, H., ... & Araya-Castillo, L. (2022). Contribution of small-scale agroforestry to local economic development and livelihood resilience: evidence from Khyber Pakhtunkhwa Province (KPK), Pakistan. *Land*, *11*(1), 71

Policy Brief
Enhancing Climate Resilience through Agroforestry in Tanzania

Introduction

With the increasing threats of climate change and food shortages, there is a growing interest in agroforestry as a viable solution to address various on-farm adaptation needs. Despite its potential, studies integrating agroforestry into on-farm adaptation strategies remain rare. This policy brief highlights the findings of a recent study on the role of agroforestry in increasing farmers' resilience to climate change, with a focus on coffee farming.

Key Findings

1. **Temperature Regulation**: Coffee, being a tropical plant, thrives in higher temperatures but is vulnerable to extreme heat. Intercropping coffee with shade trees can regulate temperatures and prevent overheating, thus protecting coffee health.
2. **Sustainable Practices**: Agroforestry systems, which integrate trees, crops, and livestock, promote sustainable land use. These systems enhance farm production (food, fodder, timber, fuel wood, and manure) and provide essential ecosystem services (soil improvement, climate amelioration, windbreaks, erosion control, and pest and disease management).
3. **Economic Resilience**: Farmers practicing agroforestry demonstrate greater economic resilience, enabling them to withstand stresses, disturbances, and shocks more effectively than those relying solely on conventional agriculture.

Recommendations

1. **Adoption of Intercropping and Cover Crops**: Encourage farmers to adopt intercropping with shade trees and use cover crops to cope with climate change. These practices help regulate temperatures, improve soil health, and enhance water management.
2. **Extension Services and Training**: Provide effective extension services and training programs to equip farmers with the necessary skills and knowledge to implement agroforestry practices. Emphasize the multifunctional values of agroforestry in these programs.
3. **Supportive Policies**: Develop and implement policies that support agroforestry practices. These policies should promote sustainable land use, provide financial incentives, and facilitate access to markets for agroforestry products.
4. **Outreach Programs**: Launch outreach programs to raise awareness about the benefits of agroforestry. These programs should focus on preserving traditional agroforestry systems while introducing new practices such as beekeeping and aquaculture.
5. **Promotion of New Cash Crops**: Promote the cultivation of new cash crops like sunflower, carrots, Irish potatoes, cardamom, and sweet potatoes. These crops can improve household income and contribute to the overall sustainability and resilience of farming communities.

Conclusion

Agroforestry holds significant potential for enhancing the resilience of coffee farming and smallholder farmers against climate change. By integrating trees, crops, and livestock within agricultural systems, agroforestry offers diverse benefits, including improved farm production, enhanced ecosystem services, and increased household income. To fully realize these benefits, it is essential to provide effective extension services, training, supportive policies, and outreach programs. Promoting new cash crops can further improve household income and contribute to the overall sustainability and resilience of farming communities in Tanzania.