Analysis of Climate Change Mitigation on Small Holder Farmers Adoption of Agroforestry and Biodiversity, Nakuru County, Kenya

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ABSTRACT

Climate change, which is taking place at a time of increasing demand for food and fuel, has the potential to irreversibly damage the natural resource base on which agriculture depends. The United Nations Economic Commission for Africa has revealed that Climate change impacts are already costing Africa 5 percent of its GDP. Smallholder farmers contribute significantly in agricultural production but their efforts to food and economic viability depend very much environmental factors mostly climate viability. Farming systems in Sub-Saharan Africa are characterized by low productivity, environmental degradation and unsustainability. The main challenge of land use and agriculture is to increase the productivity in a sustainable manner. Improving productivity and bio-diversity should be a crucial focus of good farming practices and climate change mitigation. There are many compelling reasons to focus on smallholder farmers when considering the climate challenge. This paper discusses the practices adopted by small scale farmers on adoption of agroforestry in mitigating climate change in Nakuru County. The County is an agricultural area with many smallholder farmers. Food insecurity and biodiversity loss are some of the challenges encountered in the area owing to climate change. The research sampled three Sub-counties Subukia, Lare and Kuresoi selected purposefully.138 household farms were randomly selected from a target population of 2768 smallholder farmers of which, 46 were from each sub-county. A mixed methods approach was used in this study. Data collected was coded and filtered then analysed using statistical methods (percentages, distributions) and descriptive analysis. The research was undertaken to deepen the understanding of the relationships between a changing climate and agroforestry to enable those dealing with smallholder farmers develop appropriate mitigation and adaptation responses in addressing the impacts of climate change.

Keywords: Agro-forestry**,** climate change**,** biodiversity**,** land use system, small-holder**,** sustainable development

INTRODUCTION

Sub-Saharan Africa (SSA) faces numerous challenges, including climate change, land degradation and high poverty levels, which necessitate innovative solution (Barraza Yvonne, 2023). According to Kuyah, Whitney, Jonsson, Sileshi, Öborn., Muthuri and Luedeling (2019), climate change and erratic weather condition are expected to contribute to further land degradation, expanding dryland ecosystems. Land degradation undermines the range of ecosystem services on which communities depend on for their livelihoods.

In East Africa, over the years, climate change has led to a drastic reduction in the quality and resilience of the land, increased greenhouse gas emissions, and food and nutrition insecurity for the growing urban and rural populations. In response, governments in Ethiopia, Kenya and Rwanda have included Climate-Smart Agriculture (CSA) in their national policies (World-Agroforestry Centre, 2023).

Climate action is gaining momentum in Africa. More than 40 African countries have revised their national climate plans (Nationally Determined Contributions – NDC) to make them more ambitious and add greater

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commitments to climate adaptation and mitigation (Agroforestry Network, 2018a). Although Africa contributes only 2-3% of global greenhouse gas emissions, more than 83% of national climate plans include greenhouse gas reduction targets, with focus areas including energy, agriculture, waste, land use and forestry

Agroforestry entails integrating trees and shrubs on the same land that is used for crop production and /or animal husbandry, promotes biodiversity and produces a multitude of ecosystem services (World Agroforestry Centre, 2023). It is not a new practice; rather, mixing trees and crops has been a common way to produce food, fodder, fibre, and fuels throughout human history.

Agroforestry bridges the gap that often separates agriculture and forestry by building integrated systems that address both environmental and socio-economic objectives. Agroforestry can improve the resiliency of agricultural systems and mitigate the impacts of climate change. Existing research suggests that integrating trees on farms can prevent environmental degradation, improve agricultural productivity, increase carbon sequestration, generate cleaner water, and support healthy soil and healthy ecosystems while providing stable incomes and other benefits to human welfare Kuyah et al (2023). Although these claims are becoming more widely accepted as the body of agroforestry research increases, systematic understanding of the evidence supporting them remains lacking for smallholder farmers. This systematic map will address this research need by providing a tool for identifying and visualizing the existing evidence demonstrating the impacts of agroforestry practices and interventions on agricultural productivity, ecosystem services, and human well-being

Continuing population and economic growth are exerting greater demands on resources and the environment. Food production, non-renewable resource recovery, energy supply, atmospheric pollution, toxic wastes, and renewable resource management are all major issues requiring detailed analysis and policy solutions (HLPE, 2019). In addition, the nature of economic growth itself should adapt to environmental and resource constraints. The concept of Biodiversity and Agroforestry attempts to combine economic and environmental goals. Sustainable techniques for agricultural production, energy use, natural resource management, and industrial production have significant potential, but have yet to be widely adopted. A sustainable global economy also implies limits on population and material consumption. Climate-smart agroforestry is one of the solutions to sustainably improve agricultural yields, reverse ecosystems degradation, and improve resilience to climate change (World-Agroforestry Centre, 2023). In 2019, a Global Adaptation Commission of eminent experts outlined action areas for investment returns among them: climate-resilient infrastructure, improved agriculture and making water resources more resilient (Global Commission on Adaptation, 2019)

This paper presents a narrative for understanding the interwoven nature of the climate and economic development challenges, positioned in the evolving and diverse perspectives of smallholder farmers. It is a story of climate change's devastating consequences already hindering economic development among the smallholder farmers. It is a review that underscores the need for urgent actions in adaptation, resilience, and nature (ecosystems and biodiversity) to avoid development setbacks, while paying attention to mitigating climate change.

Statement of the Problem

Climate change is occurring more rapidly than anticipated and the increase in extreme weather events threatens more disruptive effects to agriculture. A large body of evidence around agroforestry has accumulated over the past three decades through research across Kenya. To date, however, there has not been a comprehensive synthesis of evidence of what agroforestry practices and interventions have been effective, under what circumstances, and by what measures among smallholder farmers' contexts. Recent literature reviews have given overviews of the evidence for the impacts of agroforestry on ecosystem services and environmental benefits, climate change adaptation and mitigation, carbon sequestration,

biomass production, soil health, and food production

Existing technologies and current institutional structures seem inadequate to achieve the mitigation needed to adequately slow climate change, while also meeting needed food security, livelihood, and sustainability goals. There is therefore need to identify actions that can utilize knowledge systems in new ways and provide resilience for food systems and ecosystem services in agricultural landscapes despite the future uncertainty of climate change and extreme events. It is imperative that new strategies that enhances the prospects of agroforestry and biodiversity adaptation by smallholder farmers as mitigating factors for climate change effects are reviewed and established.

Objectives of the Study

The primary aim of this research was to analyse the smallholder situation in relation to Agro Forestry and Biodiversity in mitigating Climate Change

The following are the specific objectives:

1. To Review the significance of agroforestry on agricultural productivity among smallholder farmers in selected locations of Nakuru County, Kenya
2. To establish the challenges faced by smallholder farmers in mitigating climate change in the study area.
3. To determine the prospects of agroforestry and biodiversity as mitigating factors for climate change effects among smallholder farmers

LITERATURE REVIEW

The current human activities are causing environmental destruction at a scale and pace unprecedented in human history (Miller 1989). Moreover, any specific natural resource is finite and therefore there are absolute limits on its use. In addition, biological and physical systems underlie all economic activity and form constraints to which the human economy must adapt. However, I argue, contrary to the limit's perspective, that biological or physical limits are seldom actually limiting to economic growth, such that reaching limits causes economic collapse or even stops growth. In most cases, the human economy is extremely adaptable and ways are found to adapt and continue to expand. Furthermore, in most cases, continued economic growth results not in ecological collapse but rather in continuous environmental degradation without clear limit points. In a *Webinar Paper Presentation, May 18, 2023. Food and Agriculture Pathway, World Business Council for Sustainable Development. Rome*, by Mporamazina, the presenter noted that climate solutions interventions are diverse and include; actions towards protection and conservation, sustainable management of nature and restoration of ecosystems. The author further notes that climate finance for small-scale agriculture is disproportionately low and covers only a small fraction of the total needs of small-scale farmers and agri-businesses for small business to succeed meaningful income benefits for farmers relative to current farm revenues, with a combination of short-term cash incentives and long-term in-kind benefits (income diversification, climate adaptation, etc.) are critical factors.

Whether or not environmental destruction is conceived of in terms of biodiversity has important sustainability implications. The biodiversity perspective tends to focus on aggregate numbers of resources, consumption, and population and obscures the underlying causes of environmental destruction (Agroforestry Network, 2018b). I believe that examining the social structures of land use and production offers greater hope for understanding and changing climatic change effects.

My arguments against the concept of biodiversity build on and are in part similar to the arguments tends to direct to the existence of environmental destruction and its negative impact on human welfare and to believe

that agroforestry will allow the economy to expand without damaging the environment.

RESEARCH METHODOLOGY

This study was based on data collected from three Sub-counties of Nakuru County in Kenya. Purposive sampling was used to select the sub-counties for the study. The study focused on the three Sub-counties namely Kuresoi, Lare and Subukia that had many smallholder's agroforestry activities and were major areas of agricultural production in Nakuru County. The Sub-counties have robust ecological systems that the residents depend on for agriculture, environmental conservation, fuel-wood and other benefits. Small farm household both with and without agroforestry practices were engaged to provide empirical data. Agroforestry was analysed in a number of ways, including: if a farm had planted trees or not, systems used and diversity of tree species on the farm.

A mixed methods approach was used in this study. The methods included both field research and a literature review. Sample farms were identified by conducting visitations and interviews with farmers to determine their land use practices. Purposeful systematic field mapping of smallholder farms was also used to identify, collect, and describe available evidence on the effect of agroforestry on agricultural productivity and biodiversity relationship. A total of 138 household qualitative interviews were conducted. These interviews were in-depth, unstructured, and were tagged around agroforestry thematic areas. This study also reviewed types of research published in the field of agroforestry which were reviewed and analysed carefully. A comprehensive literature review was conducted via desk research to provide the preliminary contextual understanding of relationship between agroforestry practices and biodiversity. Content analysis was used to analyse qualitative information generated from respondents' discussions and semi-structured interviews. The data was then presented using frequency tables and percentages. Themes were derived from the research objectives while statistics were derived from the variables of the study.

RESULTS AND DISCUSSION

Agroforestry and its Significance

Agroforestry is essentially an integration of forestry and agriculture, and as such is a land use practice having a long history. The notion that forests have functions other than production is recognized in the concept of agroforestry. In particular, conservation and sustainability are considered important aspects of agroforestry land use. Also, it is recognized that agroforestry has the potential to be a particularly productive form of land use (Agroforestry Network, 2018a).

From experience, domesticated trees are frequently grown in monocultures, but they could play an important role in species-rich multi-strata agroforests (Castro et al., 2019). The development of multi-strata systems that include cultivars of domesticated trees could increase the profitability of these agroforests. Thus, this approach could, it seems, go a long way towards the establishment of land uses that will fulfil the needs of rural populations for food and income, while maintaining much of the biological diversity offorests or rehabilitating degraded ecosystems. However, the successful establishment of trees on cleared sites is known to suffer from changes in the populations and species diversity of symbiotic micro-flora associated with land clearance (FAO, 2017) and similar changes probably occur in the beneficial micro and meso-fauna above and below ground. Evidence exists for the negative effects of site clearance on soil fauna populations (Ghazoul, 2019), and the need to restore them to ensure soil fertility. A challenge for agroforestry research is to develop economically and socially acceptable land use systems that function likeundisturbed ecosystems and maintain biodiversity.

How agroforestry could improve smallholder livelihoods while mitigating climate change, restoring land and food security. As per FAO documentation. the transition to agroforestry holds various benefits

compared to monoculture (Rabobank, 2023); improving soil health, enhancing climate and weather resilient, enabling diverse high-quality nutrients, afforestation, and carbon sequestration as well as improved yield per land unit. This will ensure staying below 1.5 degrees of global warming, increasing crop production by over 56% and feeding 3.2 billion people by 2050.

Importance of Agroforestry Systems Implementation

The importance of agroforestry as a land use lies in its potential to enhance eco-systems, economic benefits and maintaince of biodiversity. In the study a four-point scale was used in measurement of the importance of agroforestry interventions as: Very important – referring to having a major effect; important – refers to a good effect; Somehow important – refers to an average importance; Not important – is not important. This is summarized in *Table 2*.

Table 1: Distribution of respondents by importance

Importance of agroforestry interventions	Frequency	Percent
Not important	2	1.5
Somewhat important	10	7.4
Important	62	44.9
Very important	64	46.3
Total	138	100.0

Source: own data of research

The study established that most respondents agreed that agroforestry systems were important to addressing their farming and climate actions. A high number of respondents 64 (46.3 %) felt that the interventions were very important, 62 (44.9 %) important, 10 (7.4 %) stated that the mitigation were somewhat important and only a small number 2 (1.5 %) indicated that they were not important to them. In view of the above, it is clear that agroforestry has an importance among smallholder farmers to climate mitigation solutions.

The Influence of Land Use on Diversity

The study found that agroforestry sites may be comparable to forested environments across a variety of ecosystem. The results suggest that well-established agroforests composed of perennial tree and shrub crops intermixed with non-crop trees have the potential to be comparable in both species richness and diversity to uncultivated forests. Managed agroforests indicated more species as per reviewed literature at farm system than natural forests, but these species largely differed among land use types. Allowing agroforestry systems to develop alongside farmlands areas may be a viable strategy to promote biodiversity conservation and socio-ecological stability in smallholder land use systems.

Kind of Projects Implemented by the Smallholder Farmers

This section describes types of projects and activities that were found being undertaken by the smallholder farmers in the studied areas. The types of projects enumerated by the respondents are given in *Table 1*;

Table 2: Frequency of projects smallholder farmers were involved in for self-reliance

Projects	Frequency	percentage
Tree planting	9	5.9
Crop farming/ Fruit growing	69	51.1
Bee-keeping	5	3.0

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Milk collection and distribution	6	3.7
Rural transport	7	5.2
Cooperative scheme activities	19	14.1
Others informal projects	23	17.0
Total	138	100.0

A majority of respondents assessed showed that 51% were involved in crop farming and fruit farming. Equally 3.7 % were engaged in other agri-system ventures along the food value chain such as milk collection and distribution of farm produce. 5.9% of the respondents were engaged in farm tree planting. In essence these can be taken as agroforestry systems as indicated in the background and literature review.

Evidently, the integration of agroforestry and agriculture is more than a question prospects. The potential of agroforestry to mitigate climate change and provide a sustainable land use is to be realized, engagement must be given to the socioeconomic and cultural context of smallholder farmers.

Challenges Faced by Smallholder Farmers in Mitigating Climate Change

The study findings indicated that smallholder farmers faced a number of challenges that worked against them in climate change mitigation. It clearly emerged from the study that they were concerned about financial support for adopting agroforestry actions as reported in *Table 3*.

Table 3: Challenges affecting climate mitigation in agroforestry systems

Challenges	**Frequency**	**Percent**
Lack of resources/capital	83	62.5
Inadequate knowledge / skills	18	12.5
Unintended side effects	7	3.9
Others cited constraints	30	21.1
Total	138	100.0

Source: own research data

The first major challenge affecting the mitigation was majorly lack of resources and capital (62.5 %). This included availability of funds. Another challenge recoded from the study is the inadequate knowledge and skills (12.5 %). Other important challenges identified were land-based issues by 21.1 % of respondents. Responses in this category included unclear land tenure and small fragmented holdings among the respondents.

The findings indicated some challenges but, equally, opportunities and strategies that will go a long way towards mitigating against climate change. It was noted from the study area that the barriers that hinder smaller holder farmers to adopt agroforestry as a strategy for mitigating climate change are; high cost of farming due to small fragmented holdings and inputs requirement, unclear land tenure that increases risks for farmers, unintended side effects when agroforestry systems are wrongly implemented on farm productivity among others. This study lifted barriers to climate change mitigation through agroforestry adoption. Thus, creating a conducive institutional and policy environment is crucial to promoting increased agroforestry technology adoption. Additionally, enhancing smallholders support services, can incentivize

adoption. Addressing these barriers and promoting adoption will achieve the ecosystems-livelihood balance.

CONCLUSION

This study has given an account of the interrelationship between agroforestry and biodiversity in mitigating climate change. Over the coming years, smallholder farmers will play a greater role in experiencing and mitigating climate change effects. The farmers share many of the greatest interests in limiting the effects of climate change, and face many of the most critical factors needed to address the needs of their climate actionable endeavours. But challenging financing conditions impede progress in adapting to climate change, in promoting resilience, protecting natural resources and in advancing new technologies to underpin sustainability. Smallholders require greater policy support to address proactive-enhancing sustainable development strategies.

Notwithstanding the challenges which agroforestry may face in gaining widespread adoption among smallholder farmers, it has at least some possible prospects. The information search of agroforestry presented in this paper indicate an integrated land use that, through the capture of intraspecific diversity and the diversification on farm, combined increases productivity and income generation with environmental rehabilitation and the creation of biodiverse agroecosystems. In most places this is just an idea, but there are increasing numbers of examples where this is already a reality in the study areas. The body of ecological data from agroforestry research is growing and the research agenda is changing towards systems mitigating climate change effects.

In Kenya, and especially among smallholder farmers, agroforestry can help to halt biodiversity loss. By providing forest products, agroforestry can reduce pressure on forest ecosystems. By reducing erosion and flood events, agroforestry prevents habitat destruction. Fruit tree planting is similarly an important ecosystem venture that enhances the small holder farmers' livelihoods and fight against climate change. There has been a number of other researchers investigating the role of agroforestry in supporting biodiversity. These studies demonstrate that agroforestry systems support communities of plants and animals that can be as species-rich, abundant, and diverse as forests. While agroforestry systems are unlikely to provide habitat for specialist forest species that require large tracts of undisturbed forest or woodland, they can support biodiversity in otherwise open landscapes and allow movement of species between habitat remnants, as well as buffer protected areas from the impacts of more intensive systems.

By supporting higher levels of biodiversity, agroforestry systems benefit from the ecosystem biodiversity for example, pest control, which can lead to the use of fewer pesticides. Reduced pest problems in agroforestry systems can be attributed to a number of mechanisms including scattered distribution of host plants makes it more difficult for pests to find the plants; one plant species acting as a trap-crop or as a repellent which protects the other crop from herbivore attack; one plant species acting as a repellent to the herbivore; higher predator and parasitic densities due to higher plant diversity and increased interspecific competition between pest and non-pest species. Trees, hedgerows, and other permanent non-cropped areas of agro-ecosystems provide shelter for natural enemies such as beetles, spiders, and wasps, as well as alternative food sources when crop pest populations are reduced following harvest. However, some pests such as slugs have been observed in higher numbers in agroforestry systems because of the permanent vegetation under the trees and shifts in relative importance of pest groups may present novel management problems and influence crop choice. Farmers can increase the value of agroforestry systems for biodiversity through careful design and management, for example by planting trees adjacent to protected areas to increase landscape connectivity and buffer from agricultural impacts, planting a diverse mixture of trees and shrubs, and sowing a flower-rich mixture underneath the trees. Thus, by effectively implementing agroforestry technologies, it is possible to enhance biodiversity conservation and ensure food security and diversity in livelihoods. Thus, Agroforestry adoption presents a promising strategy for regenerating

ecosystems for mitigating climate change and improving smallholder farmers' livelihoods in Kenya and other Sub-Sahara Africa regions

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