

Achieving Agricultural Sustainability in the Midst of Climate Change Through Agroforestry: Anecdotal Evidence From Smallholder Farmers and Key Agricultural Stakeholders in Rural Cameroon

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ABSTRACT

Climate change is having major adverse effects on the agricultural sector with smallholder farming systems and farmers being the most negatively impacted. To attain sustainability in the smallholder farming sector, there is an absolute need for more climate-smart and agroecological practices that can withstand climate change-induced stresses and shocks. This purely qualitative study was carried out to understand the role played by agroforestry—a climate-smart and agroecological practice, toward ensuring agricultural sustainability in smallholder farming systems in rural Cameroon, faced with climate change. Data were collected through focus group discussions ($n=5$) and key informant/expert interviews ($n=30$). The content-based approach was used for data analysis. Findings highlight the important role played by agroforestry in the provision of different environmental benefits including soil erosion control, soil fertility improvement, windbreaks, water retention in the soil, micro-climate buffering, and shade, as well as socio-economic benefits like fuelwood, building materials, food, local medicines, fodder, and income. These findings show that agroforestry provides social, economic, and environmental benefits to smallholder farmers which play a major role in enhancing agricultural sustainability in the midst of climate change. Thus, mainstreaming agroforestry into the national and international policy agenda could play a great role toward ensuring the sustainability of the agricultural sector in general and smallholder farming systems in particular, faced with the adversities of climate change.

Keywords: Agricultural sustainability, agroforestry, anecdotal evidence, climate change, rural Cameroon, smallholder farmers

Introduction

The increasing concentration of greenhouse gases in the atmosphere caused mainly by anthropogenic activities has led to global warming and climate change (IPCC, 2021). Evidence of climate change in the 21st century is multitudinous with the most common being recurrent floods, droughts, hurricanes, cyclones, bush fires, pests, and diseases (NAS and RS, 2014). The frequency of occurrence of extreme weather events has major repercussions on climate-dependent sectors like agriculture (IPCC, 2021; NAS and RS, 2014).

In developing countries like Cameroon, agriculture is the backbone of the economy employing over 70% of the active population (Molua, 2006). However, increasing climatic variations and changes have made it very difficult for farmers to practice agriculture normally (Awazi et al., 2020a; Molua, 2006). Most farmers are increasingly resorting to different adaptation choices among which are climate-smart and agroecological practices like agroforestry, all in a bid to counter the adverse effects of climate change (Awazi et al., 2019b, 2019c, 2020b, 2021a; Bate et al., 2019).

Agroforestry has been recognized as a climate-smart and agroecological practice with huge potential to enhance mitigation and adaptation efforts in the midst of climate change (Asaah et al., 2011; Awazi & Tchamba, 2019; Awazi et al., 2021a; Bishaw et al., 2013; Jose, 2009; Mbow et al., 2013a, 2013b; Quandt et al., 2017, 2018). This is largely due to the different ecosystem services provided by agroforestry systems. Studies have shown that agroforestry can provide diverse services including provisioning (food, timber, fuelwood, fodder, traditional medicines), supporting (soil fertility improvement, biodiversity conservation, pollination), regulatory (micro-climate modification, soil erosion control, carbon sequestration, pest, and disease control), and cultural (knowledge systems, cognitive development, social relations, reflection, spiritual enrichment, recreation, aesthetic experience, and aesthetic values) (Amare et al., 2018; Jose, 2009; Sileshi et al., 2007). Confronted with the

Cite this article as:

Awazi, N. P. (2023). Achieving agricultural sustainability in the midst of climate change through agroforestry: Anecdotal evidence from smallholder farmers and key agricultural stakeholders in rural Cameroon. *Forestist*, 73(3), 213-219.

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Received: July 13, 2022

Accepted: August 10, 2022

Publication Date: October 3, 2022



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adversities of climate change, smallholder farmers practicing agroforestry make use of these diverse ecosystem services to enhance their resilience and reduce vulnerability.

Although some studies have been carried out on different ecosystem services of agroforestry and their potential role in enhancing the resilience of smallholder farmers faced with climate change (Bishaw et al., 2013; Jose, 2009; Sileshi et al., 2007), few studies have examined the role played by agroforestry toward ensuring agricultural sustainability (especially in smallholder farming systems) amid climate change (Awazi & Tchamba, 2019). The findings of Awazi and Tchamba (2019) which were uncovered from an in-depth review of literature on agroforestry and its role in enhancing agricultural productivity and sustainability in the face of climate change revealed that agroforestry contributes positively toward enhancing agricultural productivity and sustainability mainly through the provision of ecosystem services like carbon sequestration, soil fertility improvement, and biodiversity conservation. This study was therefore initiated to add more empirical literature to the limited body of literature on the contribution of agroforestry to agricultural sustainability in the face of climate change. Adopting the qualitative approach, the study sought to (1) examine anecdotal experiences of climate variability and change in the northwest region of Cameroon; (2) assess the different environmental benefits of agroforestry and its contribution to sustainability in smallholder farming systems faced with climate change; and (3) evaluate the socio-economic benefits of agroforestry and its role toward ensuring the sustainability of smallholder farming systems in the face of climate change.

Methods

Study Area

The study was carried out in the northwest region of Cameroon, specifically in five sub-divisions namely Bamenda I, Bamenda II, Bamenda III, Santa, and Tubah sub-divisions (Figure 1). With over a million inhabitants, these five sub-divisions found in the Mezam division are among the most densely populated areas in Cameroon. The northwest region is found in the western highlands of Cameroon—one of the five major agroecological and relief regions of Cameroon. The northwest region of Cameroon is characterized by two seasons namely a short dry season (from mid-October to mid-March) of about 5 months and a long rainy season of about 7 months (mid-March to mid-October). The average temperature is 22°C and the average rainfall is 2500 mm. However, the seasonal pattern has been fluctuating tremendously in recent years with the dry months increasing (Awazi et al., 2020a; Gur et al., 2015). The vegetation type is mainly grassland while soils are dominated by ferralsols and andosols. The grassland vegetation which dominates the study sites makes it highly prone to landscape degradation notably from agents of erosion. Agriculture is the principal economic activity of rural dwellers—employing over 90% of the active population.

Crops cultivated include cash crops, food crops, and market gardening crops. The main cash crops cultivated include banana, coffee, and oil palm. The major food crops cultivated include potato, cassava, sweet potato, cocoyam, yam, maize, beans, and plantain. Market gardening crops include tomato, cabbage, carrot, leek, celery, and different types of condiments. Fruits like avocado, mango, orange, and guava are equally common. Food crops are both for subsistence and sale while market gardening and cash crops are mainly grown for the market.

Data Collection

Data were collected through focus group discussions and key informant/expert interviews. Five focus group discussions were conducted

in December 2018 across five selected sub-divisions namely Bamenda I, Bamenda II, Bamenda III, Santa, and Tubah sub-divisions in the Mezam division—one focus group discussion per sub-division (Table 1). The focus groups were composed of men, women, and youths. Each focus group discussion had between 10 and 15 participants made up of smallholder farmers, local authorities (chiefs and council authorities), heads of farming groups, and agricultural extension officials. Questions were posed to the participants geared toward eliciting information on climate variability and change, the different agroforestry practices, the role played by agroforestry practices in the face of climate change adversities, as well as the environmental and socio-economic benefits of agroforestry. Each focus group discussion lasted between 45 minutes and 1 hour. Key informant interviews were conducted in January 2019 with resource persons in the different sub-divisions to elicit information on climate variability and change, the different agroforestry practices of smallholder farmers, contributions of agroforestry to agricultural sustainability amid climate change, as well as the different environmental and socio-economic benefits of agroforestry. A total of 30 key informant interviews were conducted across the 5 sub-divisions (Table 2). Key/expert informant interviews lasted between 20 and 30 minutes.

Because of the crisis that was prevailing in the northwest region at the time of the study, the offices of most of the key informants had been relocated to Bamenda I which accounts for the large number of key informants interviewed in Bamenda I. Key informants included agricultural extension officials, delegates of decentralized services of different ministries including agriculture and rural development; livestock fisheries and animal husbandry; environment, protection of nature and sustainable development; and forestry and wildlife. The snowball approach was used to select key/expert informants while focus group discussants were selected with the help of agricultural extension officials who had a better mastery of the environment and the agricultural stakeholders living therein.

Data Analysis

Data were analyzed using the content-based approach. Although there are different software used to analyze qualitative data including NUDIST or QSR NVivo, this study adopted an in-depth content analysis of the interview transcripts in which key themes were identified (Bryman, 2008). This approach was adopted because the number of key/expert informant interviews ($n=30$) and focus group discussions ($n=5$) was relatively small, allowing for manual analysis. Thus, the use of a complex computerized software program for analysis was judged to be unnecessary as manual analysis was good enough to do a robust analysis.

Results and Discussion

Anecdotes on Climate Variability and Change

Focus group discussants and key informants discussed a plethora of manifestations/evidence that made them believe that climate variability and change are a reality. In discussing some of the manifestations or evidence of climate change, focus group discussants in Santa (SFGD4_2018) noted that, "The onset and cessation of rains has been fluctuating tremendously. We as farmers don't know when to plant our crops again. We use to plant our crops at the beginning of the rainy season which was usually by March 15 of each year. But these days, we can't predict when the rainy season will start as sometimes it starts at the end of March or even in April and sometimes, the rainy season starts earlier than expected. The cessation of rains has also become difficult to predict as rains usually stopped by October 15. But these days, the rainy season will either stop before October 15 or extend into November and even December. This has made it very difficult for us the farmers to plan

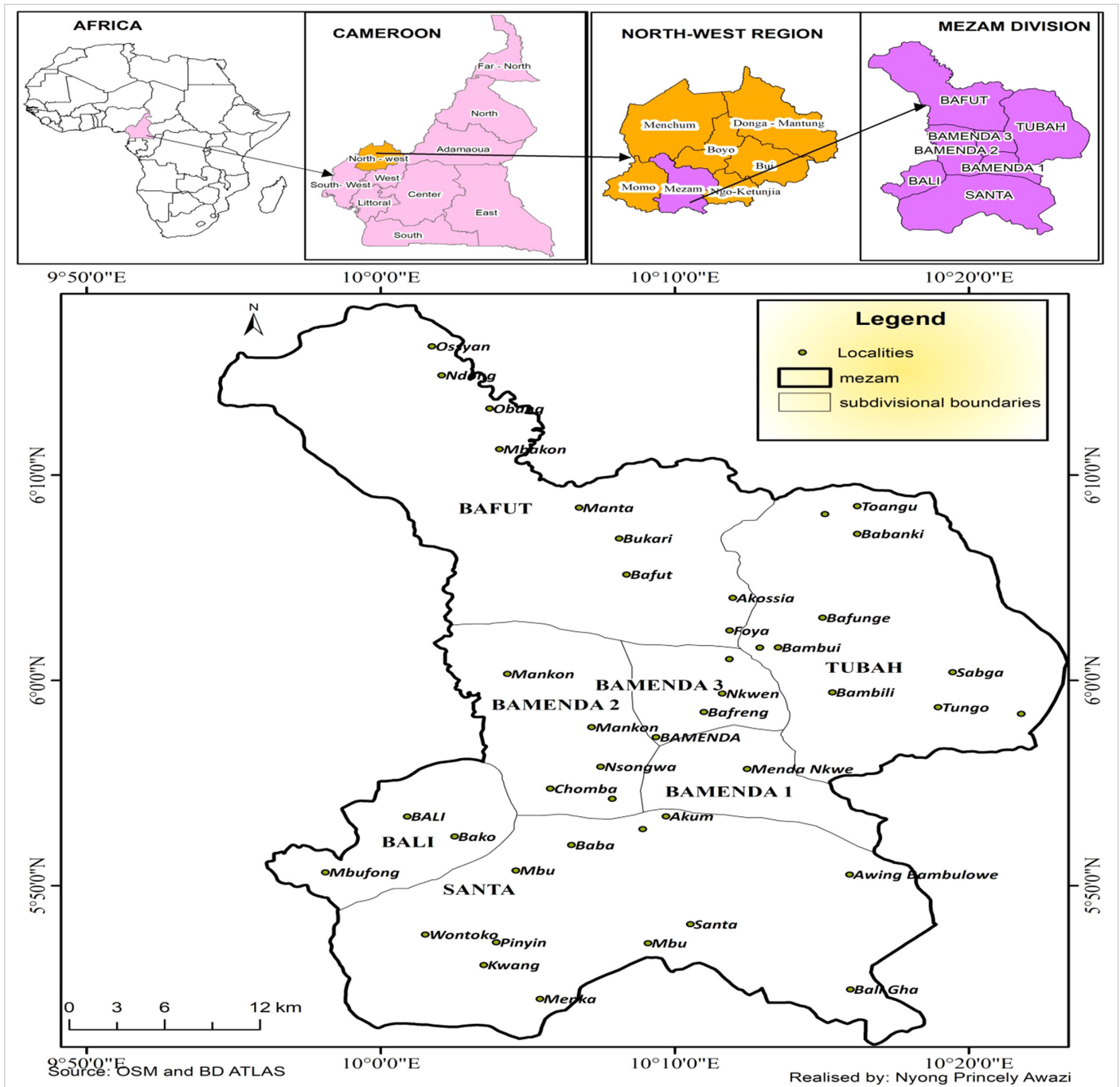


Figure 1.
Map of the Study Area.

our farming season." Scanty and erratic rainfall, increasing temperatures, frequent storms, and extreme sunshine were equally identified by farmers as major indicators of climate variability and change. For example, focus group discussants in the Tubah sub-division (TFGD5_2018) noted that, "Rainfall has become very scanty and erratic making it difficult for farmers to cultivate market gardening crops and some food crops like maize, beans, groundnuts, and soya beans which are unable to withstand prolong dry spells. Temperatures have increased and this is noticed by an increase in mosquitoes and malaria which was not prevalent in the northwest region due to the cool nature of the environment moderated by the high altitude (over 1000m in most places). Increasing

temperatures has made it difficult to cultivate some crops which are intolerant to high temperatures like potato and several market gardening crops. We are equally experiencing extreme sunshine and frequent storms which destroy our crops, making it difficult for us to have a fruitful harvest during the harvesting season."

From the anecdotes of key informants, several indicators of climate variability and change were uncovered. A key informant in Bamenda I sub-division (BIKI1_2019) stated that, “The increasing incidence of pests and diseases is a clear manifestation of climate variability and change. Some decades back, farmers could cultivate their crops without using

Table 1.
Number of Focus Group Discussions and Participants in the Five Sub-Divisions

SN	Sub-division	Number of Focus Group Discussions	Number of Participants
1	Bamenda I	1	12
2	Bamenda II	1	15
3	Bamenda III	1	13
4	Santa	1	15
5	Tubah	1	10
Total		5	65

pesticides but today, it is almost impossible as pests and diseases are so rampant." Another key informant in the same vicinity (BIKII2_2019) affirmed noting that, "Without the application of pesticides especially on market gardening crops and some food crops like potato, maize and cocoyams, there is little hope of harvesting anything." Meanwhile, a key informant in the Regional Delegation of Environment, Protection of Nature and Sustainable Development for the northwest region listed a number of indicators of climate variability and change in the northwest region. According to him (BIKII21_2019), "The clearest indicators of climate variability and change in Bamenda I sub-division in particular and the northwest region in general are frequent floods, prolong dry spells, frequent bushfires, drying off of streams and rivers that were once perennial, disappearance of some animal and bird species, and increasing growth of weeds."

From the foregoing, farmers and major stakeholders in the agricultural sector have identified a good number of tell-tale signs of climate variability and change in the northwest region of Cameroon. Most studies assessing climate change indicators and the degree of variability and change in climate elements in the northwest region have been purely quantitative (Awazi et al., 2019a, 2020c, 2021b; Awazi & Tchamba, 2018; Azibo et al., 2016; Gur et al., 2015; Innocent et al., 2016; Kimengsi & Azibo, 2015; Kimengsi & Botanga, 2017; Tume et al., 2019). This study however adopts a qualitative approach and focuses essentially on anecdotal evidence which is more exploratory.

Environmental Benefits of Agroforestry and Contribution to Sustainability of Smallholder Farming Systems in the Midst of Climate Change

Agroforestry practices provided farmers with several environmental benefits including soil erosion control, soil fertility improvement, water retention in the soil, windbreaks, micro-climate buffering, and shade. These environmental benefits contributed enormously toward improving the sustainability of smallholder farming systems faced with the

adversities of climate change. During focus group discussions, focus group discussants in Bamenda I (BIFGD1_2018) noted that, "With the frequency in extreme weather even especially sudden heavy downpours which has the tendency to wash away the topsoil through the process of erosion, agroforestry practices help to limit the degree of soil erosion via its tree/shrub components which trap raindrops and prevent them from reaching the bare soil and causing erosion. The practice of agroforestry has therefore spared us from the menace of erosion." Focus group discussants in Santa (SFGD4_2018) also confirmed what their counterparts in Bamenda I said, noting that, "The practice of agroforestry has helped us to control soil erosion during sudden storms. Our area is very hilly and without the practice of agroforestry, we will lose all our soils to erosion. Controlling soil erosion through the practice of agroforestry has enabled us to improve soil fertility and increase crop yields."

Extreme weather events like floods, droughts, and storms have led to soil erosion and leaching which drive soil infertility. However, the practice of agroforestry contributes toward reducing soil erosion and leaching, thereby improving soil fertility and enhancing agricultural sustainability faced with climate change. For example, smallholder farmers during focus group discussions in Bamenda II sub-division (BIIFGD2_2018) affirmed that, "The practice of agroforestry has helped us to improve the level of soil fertility on our farms. We are making use of improved fallows through the planting of nitrogen fixing shrubs like Calliandra calothyrsus, Tephrosia vogelii on our farms. These improve fallows have contributed enormously towards increasing soil fertility on our farms, reducing our demand for chemical fertilizers, improving our crop yields and increasing our income from the sale of these crops." Farmers in Tubah sub-division during focus group discussions (TFGD5_2018) also affirmed that, "The practice of agroforestry, especially improve fallows has contributed towards improving soil fertility and reducing our demand for chemical fertilizers."

With increasing sunshine, prolonged dry spells, and scanty and erratic rainfall caused by climate change, water retention in the soil is minimal. This makes it difficult for crops that are intolerant to water scarcity to survive. The practice of agroforestry however contributes toward water retention in the soil. This is because the tree component of an agroforestry system is able to penetrate deep into the soil and draw up water to the surface which allows associated crops to have sufficient water for survival during prolonged dry spells. A key informant in Bamenda I sub-division (BIKII30_2019) noted that, "Farmers practicing agroforestry do not panic during prolong dry spells because the presence of the tree component in the system helps to limit water loss, thereby enabling associated crops to survive." This is confirmed by another key informant in the Bamenda II sub-division (BIKII20_2019) who states that, "Trees in agroforestry systems are able to draw up water from deeper horizons and bring to the surface which enables associated crops to withstand stresses and shocks resulting from prolong dry spells."

Frequent occurrences of violent winds are also attributed to climate change. These violent winds usually destroy crops especially tree crops like bananas, plantains, oil palms, fruit trees, cocoa, and coffee. The destruction of these crops adversely affects farmers who depend on these crops for subsistence and livelihood. Agroforestry systems play the role of windbreaks which could go a long way to limit the destruction caused by recurrent violent winds. A key informant in the Santa sub-division (SKII12_2019) noted that, "In farms cultivating banana, plantains, fruit trees, oil palms, cocoa and coffee, the practice of agroforestry plays a major role in limiting destruction caused by violent winds as agroforestry trees on these farms serve as windbreaks. The role of windbreaks played by agroforestry systems, helps to improve

Table 2.
Number of Key Informant Interviews in the Five Sub-Divisions

SN	Sub-division	Number of Key Informant Interviews
1	Bamenda I	16
2	Bamenda II	4
3	Bamenda III	2
4	Santa	4
5	Tubah	4
Total		30

crop yields and enhance farmers' livelihoods." Another key informant in the Tubah sub-division (TKII15_2019) stated that, "The windbreaks role played by agroforestry systems contributes enormously towards reducing crop failure in many smallholder farms in Tubah sub-division."

Agroforestry systems through the presence of the tree component help to moderate the micro-climate as well as provide shade. The moderation of the micro-climate and the provision of shade allows some crops to thrive which would not have been possible without the moderating effect put in place by the tree component in agroforestry systems. During focus group discussions in the Santa sub-division (SFGD4_2018), farmers noted that, "The micro-climate moderation and shade provided by agroforestry systems have enabled us to cultivate Arabica coffee and improve our yields despite the increasing regularity of extreme weather events like prolong dry spells, extreme sunshine and increasing temperatures." This is affirmed by another key informant in the same vicinity (SKII14_2019) who stated that, "Despite an increase in the intensity of sunshine and increasing temperatures, agroforestry systems enable a moderation of the micro-climate and provides shade which allows crops like Arabica coffee and banana to thrive."

Studies such as those of Awazi and Avana (2020), Awazi and Tchamba (2019), Bugayong (2003), Coulibaly et al. (2017), Jose (2009), Leakey (2018, 2022), Lin (2007), Neupane and Thapa (2001), Shidiki et al. (2020), Sileshi et al. (2007), and Tsufac et al. (2019, 2021a, 2021b) have indicated that agroforestry provides a plethora of environmental benefits including soil erosion control, soil fertility improvement, water retention in the soil, windbreaks, micro-climate buffering, and shade. However, limited research has been done showing how the environmental benefits of

agroforestry systems contribute toward improving the sustainability of smallholder farming systems faced with the adversities of climate change. This study based essentially on anecdotal evidence has filled this research gap.

Socio-Economic Benefits of Agroforestry and Contribution to Sustainability of Smallholder Farming Systems Confronted with Climate Change

Socio-economic benefits of agroforestry abound as identified by farmers and different agricultural stakeholders during focus group discussions and key informant interviews. The most cited socio-economic benefits of agroforestry were fuelwood, building materials, food, local medicines, fodder, and income. These benefits contribute immensely toward ensuring the sustainability of smallholder farming systems in the face of climate change. For example, during focus group discussions, farmers in the Bamenda I sub-division (BIFGD1_2018) confirmed that, "Besides providing us with food, agroforestry systems provide us with other benefits like fuelwood, local medicines, building materials, income from sale of agroforestry products as well as fodder for animals. This helps us a lot to withstand the adverse effects of climate change." In the Santa sub-division, focus group discussants (SFGD4_2018) affirmed that, "We the farmers of Santa practice agroforestry especially live fences wherein we plant trees like Eucalyptus which we use for fuelwood, building material as well as for income generation through sales of Eucalyptus poles—used as electricity transportation poles by the electricity supply company known as ENEO."

Key informants and experts equally opined that socio-economic benefits of agroforestry including food, local medicines, fodder, building

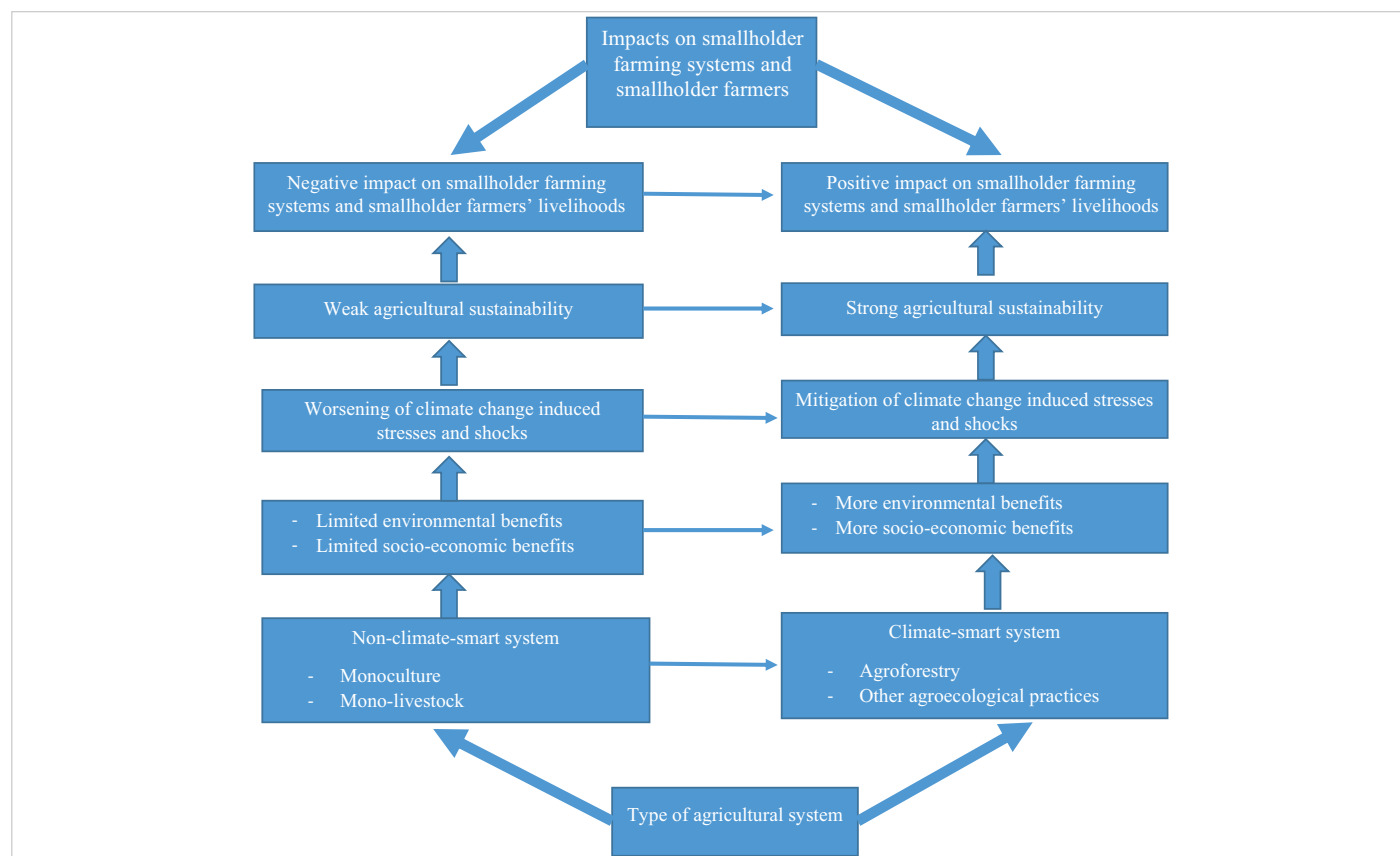


Figure 2.
Agricultural Sustainability Framework for a Climate-Smart and Non-Climate-Smart Agricultural System.

materials, fuelwood, and income contribute toward improving agricultural sustainability in smallholder farming systems faced with climate change. A key informant/expert in the Bamenda III sub-division (BIIK119_2019) noted that, “Smallholder farmers practicing agroforestry obtain a plethora of products include food, fuelwood, building materials, fodder as well as income from the sale of these products. These products makes agroforestry practicing farmers more resilient than their counterparts who do not practice agroforestry.” This is confirmed by another key informant/expert in the Santa sub-division (SK116_2019) who stated that, “The practice of agroforestry by smallholder farmers in Santa sub-division has enabled them to withstand the shocks of climate change because they obtain many products from agroforestry especially fuelwood, food, building materials, fodder and income when products of agroforestry are sold.”

The foregoing shows that agroforestry systems provide smallholder farmers with a multiplicity of products and services which enable them to better withstand the stresses and shocks thrown at them by climate variability and change.

Studies carried out by Awazi and Quandt (2021), Awazi and Tchamba (2019), Bishaw et al. (2013), Iiyama et al. (2014), Mbow et al. (2013b), Molua (2005), Quandt (2020), Quandt et al. (2017, 2018), and Sileshi et al. (2007), have shown that socio-economic benefits abound in agroforestry systems with the most common being fuelwood, building materials, food, local medicines, fodder, and income. However, limited research has been done to examine the contribution of socio-economic benefits of agroforestry toward ensuring the sustainability of smallholder farming systems in the face of climate change. This qualitative study focusing on the role of socio-economic benefits of agroforestry in ensuring the sustainability of smallholder farming system has filled a research gap.

Figure 2 shows that in the midst of climate change, the type of agricultural practice (climate-smart or non-climate-smart practice) determines the quantity of environmental and socio-economic benefits obtained, the capacity to withstand stresses and shocks, and the plausible impacts on smallholder farming systems and smallholder farmers' livelihoods. Climate-smart practices like agroforestry and other agroecological farming practices provide more socio-economic and environmental benefits which contribute toward mitigating climate-induced stresses and shocks leading to strong agricultural sustainability, positively impacting smallholder farming systems and smallholder farmers' livelihoods. Meanwhile, non-climate-smart practices like monoculture and mono-livestock practices provide limited socio-economic and environmental benefits which contribute toward worsening climate change-induced stresses and shocks leading to weak agricultural sustainability, negatively impacting smallholder farming systems and farmers' livelihoods.

Conclusion and Recommendations

Climate change is having major adverse effects on the agricultural sector with smallholder farming systems and farmers being the most negatively impacted. To attain sustainability in the smallholder farming sector, there is an absolute need for more climate-smart and agroecological practices that can withstand climate change-induced stresses and shocks. This purely qualitative study was carried out to understand the role played by agroforestry—a climate-smart and agroecological practice, toward ensuring agricultural sustainability in smallholder farming systems in rural Cameroon, faced with climate change. Agroforestry played a major role in the provision of different environmental benefits including soil erosion control, soil fertility improvement, windbreaks,

micro-climate buffering, and shade, as well as socio-economic benefits like fuelwood, building materials, food, local medicines, fodder, and income. Social, economic, and environmental benefits of agroforestry systems play a major role in enhancing the sustainability of smallholder farming systems in the midst of climate change. From the finding of the study, two principal policy implications arise: First, measures should be taken to scale up agroforestry systems practiced by smallholder farmers so that they can provide more environmental and socio-economic benefits capable of enhancing the sustainability of these smallholder farming systems; Second, there should be mainstreaming of agroforestry into the national and international policy agenda in order to ensure the sustainability of smallholder farming systems faced with the adversities of climate change.

Peer-review: Externally peer-reviewed.

Acknowledgments: The author expresses immense gratitude to the focus group discussants and key informants/experts for sacrificing their time to take part in this study. Immense thanks to all the local authorities and chiefs of the different villages visited for being so collaborative during the entire course of the data collection process.

Declaration of Interests: The author has no conflict of interest to declare.

Funding: The author declared that this study has received no financial support.

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