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Challenges Faced in using Legume Intercrop as a Climate Smart Agriculture Practice to Enhance Coffee Production among Smallholder Coffee Farmers' in Kisozi Sub County

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ABSTRACT: The study's goal was to identify the barriers to using legume intercropping as a climate-smart agricultural strategy to increase coffee production among Kisozi Sub County's smallholder coffee growers. The study employed a variety of research methods, including a set of well-structured questionnaires and semi-structured interviews with Kisozi Sub County agricultural extension staff heads. A sample of 345 smallholder farmers was interviewed using a descriptive research approach. The findings showed that climate change has had a significant impact on flowering, coffee bean falling, and leaf scorching. The most significant obstacles to legume intercropping were a lack of a suitable legume selection, aged coffee plants, and a lack of access to extension services. According to this study, climate change has a variety of effects on coffee output, including an increase in the occurrence of drought conditions and, in some cases, an increase in rainfall. The study also discovered that legume intercrops promote profit maximization because smallholder farmers can harvest multiple crops at once and provide nitrogen to the soil, which coffee bushes require to feed themselves and produce high-quality beans. It was determined that the most significant barrier to legume intercrops for high-quality coffee production is elderly coffee plants. This study advocates for the promotion of legume intercropping as an appropriate smart agriculture strategy in coffee production. Keywords: Legume Intercrop, coffee production, Kisozi Sub County, smallholder coffee farmers.

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INTRODUCTION

Ancestors of today's Oromo people in Ethiopia's Oromia region were the first to cultivate coffee plants and recognize its stimulating properties (Myhrvold, 2021). Ethiopian coffee was first sold to Yemen by Somali merchants from Berbera and Zeila, who obtained it from Harar and the Ethiopian interior (Myhrvold, 2021). There are several legends surrounding the beverage's origin, one of which involves the Moroccan Sufi mystic Ghothul Akbar Nooruddin Abu al-Hassan al-Shadhili. As a result, a large amount of Ethiopian coffee was shipped to Aden via Berbera (Malecka, 2015). In general, the world's three primary coffee-growing and exporting regions are all located in the equatorial zone: Central and South America, Africa and the Middle East, and Southeast Asia (Amanda, 2018). The best beans are grown at high altitudes in a moist, tropical climate with rich soils and temperatures around 70°F (21°C), which the tropics provide (Amanda, 2018). Although coffee is a perennial crop, there are two major harvest seasons in Uganda for both Arabica and Robusta coffee (March-June and September-November). Robusta's primary producing season in Masaka and the western regions is May to August, and November to February in the central and eastern regions. Arabica's main growing seasons are April to June in the Western Region and October to February in the Eastern and West Nile Regions (Antle and and Ray, 2020). Uganda's coffee production is primarily subsistence-level and rain-fed. This makes the industry extremely vulnerable to weather volatility, climatic risks (particularly droughts), and climate change. The most common climate-smart agricultural practices in the United States for boosting agricultural productivity, food availability, and resilience to climate hazards include crop diversification, small-scale irrigation, permanent planting basins, application of green manure, conservation agriculture (rotations, intercropping, mulching, and reduced tillage), and agroforestry (IFAD, 2013).Legume intercropping is one example of a climate smart agriculture technology and practice that offers opportunities for addressing climate change issues while also fostering agricultural economic growth and development (IFAD, 2013).

According to one study, intercropping grain legumes with cereals may increase the use efficiency of soil nitrogen. They estimated that the global sole cropped grain legume nitrogen acquisition from soil to be approximately 14.2 Tg N/yr, or one-third of the global synthetic fertilizer nitrogen use (109 Tg N/yr) for all crops, assuming that grain legumes recovered on average 40% of the fertilizer N. (Jensen et al.,2020). Legumes improve soil nutrient circulation and water retention by fixing atmospheric nitrogen and releasing high-quality organic matter into the soil. Among the many significant advantages that legumes bring to society, their role in reducing the effects of climate change receives little attention. In comparison to agricultural systems based on mineral N fertilization, legumes can reduce the emission of greenhouse gases (GHG) like carbon dioxide (CO_2) and nitrous oxide (N_2O), play a significant role in the sequestration of carbon in soils, and reduce the system's overall reliance on fossil fuels (Stagnari et al., 2017).

Legumes have a high potential for conservation agriculture due to their multiple functions, as they can be used as a growing crop or as crop residue (Stagnari et al.,2017). Legume intercropping with coffee farming systems has also been adopted by a number of coffee farmers in the developing world, including Uganda, with increased yields reported, though this has yet to be quantified. Coffee production in Uganda is being hampered not only by declining soil nutrient quality, but also by climate change and variability-related issues such as low coffee yield. Farmers in the eastern region, particularly in the district of Kamuli, have complained about reduced Robusta coffee output due to stalk borer attacks, a terrible situation that is directly related to climate change. Temperature fluctuations and drought have emerged as major challenges to coffee output and quality, and it has been demonstrated that a suitable legume intercrop boosts coffee productivity in the face of climate disorder. The purpose of this study is to see how intercropping with legumes as a climate-smart agricultural strategy affects coffee production among smallholder farmers. Smallholder coffee producers are experiencing a decrease in coffee yield, which can be attributed to climate change. This is frequently demonstrated by rising temperatures, droughts, and changes in rainfall pattern and amount. To mitigate the effects of climate change and increase coffee yields for the benefit of smallholder coffee growers, simple and cost-effective adaptation and mitigation strategies must be developed.

One option for mitigating the effects of climate change is to use legume intercropping as a climate-smart agricultural strategy for coffee production among smallholder farmers, particularly in the Kamuli region. However, there is a scarcity of data on farmers' perceptions of climate change and its impact on coffee production, as well as how Kisozi subcounty smallholder coffee growers use legumes to mitigate the effects of climate change and variability. The impact of coffee legume intercropping as a climate-smart agricultural strategy on coffee production among smallholder coffee farmers in the Kamuli region of Kisozi Sub County was investigated in this study. In Uganda, coffee production is dominated by smallholder farmers who lack adequate mobilization into viable economic units. They also produce on highly fragmented land, with most households having 0.33 hectares of land (Uganda Bureau of Statistics, 2014).

Because of low input use, a lack of improved technologies, insufficient extension and business advisory services, price fluctuations and low returns, and a lack of appropriate agronomic practices, farmers do not have an incentive to invest in better farm management practices in coffee, resulting in a decline in coffee production and quality (Uganda Bureau of Statistics, 2014). Production and productivity in Uganda's smallholder farms are also hampered by aging coffee trees that may need to be replanted or rejuvenated, declining soil fertility, pest, disease, and weed infestations, high input costs (fertilizers, pesticides, and labor), current climate and weather changes that affect the environment for coffee production, and the Coffee Research Institute, all of which have reduced farmers' ability to effectively improve soil fertility through maintenance (Mugwe et al., 2013).

Inappropriate intercrop systems have resulted in increased soil erosion and further destruction of soil conservation structures (terrace embankments). These constraints are intended to ensure higher production margins, particularly for smallholder farmers, who are more vulnerable to yield losses than large-scale farmers (Mugo et al., 2013).

These factors explain the coffee sector's poor relative performance and further decline in coffee yields when compared to high-producing countries such as Vietnam and Brazil; thus, there is room for improvement in coffee production and productivity through expansion into new areas, replanting, adapting to climate change, and encouraging large-scale coffee farming (Bamwesigye et al., 2015). The International Coffee Organization, in accordance with Article 34 of the International Coffee Agreement 2007, provides Members with studies and reports on relevant aspects of the coffee sector (Bilder, 2007). Since March 2015, the ICO composite price has been consistently lower than the 10-year average of 137.24 US cents/lb, raising concerns about the economic viability of coffee production and putting coffee producers' livelihoods at risk in many countries. Prolonged periods of low prices strain farm liquidity, resulting in less-than-optimal input use during the following production cycle, lowering yields and quality (Bilder, 2007).

The expectation of future coffee prices that are too low to cover full production costs can stymie important investments in coffee plantation renovation. Replanting is especially important in mitigating the effects of climate change and responding to increased pest and disease pressure (Marcelo, 2018). Finally, low or negative profitability may cause farmers to abandon coffee production in favor of more profitable agricultural crops.

As a result, there is widespread concern in the coffee industry that a prolonged period of low coffee prices will harm the supply of high-quality coffee beans and have a negative impact on household incomes in coffee-growing communities. As a result, concerned authorities should develop specific policies to address the issue of economic sustainability of coffee production, as well as to stabilize supply in the future and compensate farmers (Marcelo, 2018). At the farm level, major coffee production inputs include seed/seedlings, fertilizers, farm implements (spraying pumps, pruning knives, and so on), crop protection goods, rural financing, and consultancy services. In some cases, planting materials are provided for free; in others, they are obtained through commercial or community-managed nurseries; and in still others, they are gathered from wild-growing plants or high-quality coffee bushes. Because of the prevalence of counterfeit products, coffee producers use few chemical and organic fertilizers and prune almost never (Uganda Coffee National Strategy 2015/16-2019-2020).

The effective use of high-quality inputs is a necessary condition for long-term productivity increases (Baker and Haggar, 2007). Smallholder farmers have extremely limited access to credit, which contributes to low agricultural input utilization. Until rural financing becomes more widely available and less expensive, the subsector will continue to rely on intermediaries who charge exorbitant fees to fill the void. Tree trimming and replanting are also necessary, but require long-term financing lines, as is the upgrade of processing equipment and tools. Access to credit has been a watershed moment in the development of coffee in all coffee-producing countries (Barry, 2020). Overall, extension services are insufficient, and those that are available are under-equipped. Coffee-specific extension services are currently unavailable through the public sector. Some farmers' organizations, as well as several exporters and non-governmental organizations/foundations, provide coffee-specific advice and extension with assistance from development partners (Barry, 2020). The majority of extension services provided to the coffee industry are aimed at improving agronomic practices such as pruning, fertilization, pest and disease management, and so on.

Main objective

To establish the challenges faced in using legume intercrop as a climate smart agriculture practice to enhance coffee production among smallholder coffee farmers in Kisozi Sub County.

MATERIALS AND METHODS

Research design

Claybaugh (2020) defines research design as the overall strategy utilized to carry out research that defines a succinct and logical plan to tackle established research questions through the collection, interpretation, analysis, and discussion of data. This study employed a mixed methods approach. The first part of the study consisted of a series of well-structured questionnaires (for legume intercrop and coffee production) and semi-structured interviews with leaders of subcounty agricultural extension officers at Kisozi Sub County level. Therefore, the researcher applied a descriptive research design. This research design offers the researcher a profile of the relevant aspects of the phenomena of interest from an individual, organizational, and industry-oriented perspective (Kasu, 2019).

Study subject

This research was conducted in Kisozi Sub County, Kamuli District, Eastern Uganda. Kamuli District is a part of the former Busoga area; it shares borders with the districts of Kayunga, Kaberamaido, and Soroti to the west, and Lake Kyoga to the north. The district shares borders with the Kaliro and Iganga Districts in the northeast, and Jinja in the south. Along the Jinja-Kamuli road, it is about 40 kilometres from Jinja town. The Kamuli District is predominantly agricultural, with coffee and sugarcane being the principal cash crops farmed on a small and big scale. Kulika Uganda carried out a four-year coffee sustainability project that promoted legume intercropping as a climate change adaptation approach. This clearly justifies the study's selection of Kisozi Sub County in Kamuli District.

Study population

According to Shu (2014), a study population is a subset of the target population from which the sample comes. The total number of coffee farmers in this study is 4500, but the sample was drawn from 2508 smallholder coffee farmers in Kisozi Sub County. This number comprises males and females, but the study considered households such that responses came from any gender that was readily available in a household at the time of the study.

Determining sample size

Kibuacha (2021) defines a sample size as a research term used to define the number of individuals included in a research study to represent a population. Among more than five approaches to calculating sample size, this study adopted Taro Yamane's developed in 1967 to determine an appropriate sample size for a given population (Uniproject Materials, 2016). The researcher adopted Yamane's (1967) formula to calculate the ample size as follows:

$n = \frac{N}{1+N(e)^2}$ where n = sample size, N (2508) the total population targeted and e = percentage of error in selecting sample (5% or 0.05), and 1 is representative of any omissions.

$n = \frac{2508}{1+2508\,(0.05)^2} = \frac{2508}{1+2508 \times 0.0025} = \frac{2508}{1+6.27} = \frac{2508}{7.27} = 344.9 \sim 345$ smallholder coffee farmers.

Therefore, the sample size for 2508 was 345 respondents. These were not inclusive of Kisozi Sub County agricultural extension officers.

Instruments of data collection

Data collection refers to the process of gathering and measuring information on target variables to answer relevant research questions and evaluate outcomes (Quan-Hoang, 2018). In this study, the researcher used questionnaires and interview guides. This is because the study was two-way qualitative and quantitative. In this study, the researcher prepared a set of structured questions for smallholder coffee farmers in Kisozi Sub County. The questionnaire was comprised of various sections, including: respondents' social demographic characteristics; questions on climate change; legume intercrop; and coffee production. The composition of the questionnaire was in such a way that each of the questions about the main study variables was rated on a Linkert scale running from 1-Strongly Disagree, 2-Disagree, 3-Not sure, 4-Agree, and 5-Strongly Agree.

Interview guide

The interview guide guided the researcher in conducting dialogues with the Kisozi Sub County agricultural extension officer. The researcher held each interview session for a period of not more than 45 minutes. Normally, leaving the last 15 minutes to the top of the hour was to enable the interviewees to make organized programs that would probably start with another hour.

Procedure to data collection

Upon approval and acceptance of the plan by supervisors, the researcher defended the proposal and won credits, which resulted in the acquisition of an introduction letter to the respondents to conduct research. The researcher next went to the Kisozi Subcounty agricultural extension officer's office to request permission to conduct the study among smallholder coffee producers in Kisozi Sub County. The researcher then set aside a day and scheduled meetings with smallholder coffee farmer households through their parish and village councillors. Local councillors received and read a letter from the university indicating that the research was strictly academic. Permission for data collection via questionnaires and interview guides was obtained as described above. The researcher took the initiative to clarify all the questionnaire's content specifications to the smallholder coffee farmers, and when necessary, the researcher assisted the farmers in continuing to interpret questions. This was notably prevalent in households that lacked smallholder farmers with literacy skills. To achieve a high rate of completed surveys, the researcher visited each family three times, with a two- to three-day delay between each visit. Between intervals of inspection, the researcher collected questionnaires including complete information.

Data analysis

Inferential statistics were made by putting data into an SPSS spreadsheet. The percentage scores, the mean, and the standard deviations were used to show the data. For qualitative data from the Kisozi Subcounty agricultural extension officer, the researcher used thematic and content analysis. Where there was a need, the researcher read the Kisozi Subcounty agricultural extension officer's words word for word. This was done in part to improve the reliability and validity of the results. Two methods were also used to improve the analysis of problems. First, a correlation analysis was done between each problem and each item on coffee production. At a p-value of 0.01 or 0.05, significant results were found. Then, a regression analysis was done to see what effect legume intercropping had on coffee production among

Table 1: Challenges of Legume Intercrop as a smart climate change practice

Challenges	Agree	Not sure	Disagree	Mean	St. Dev.
*No adequate mobilization	201(59)%	47(14)%	97(27)%	3.41	1.42
Aging coffee trees	193(57)%	56(16)%	96(27)%	3.34	1.40
*Inappropriate intercrop systems	213(62)%	50(14)%	82(24)%	3.48	1.36
Low prices of coffee on the market	191(55)%	42(12)%	112(33)%	3.36	1.53
No rural financing of smallholder farmers	167(48)%	52(15)%	126(37)%	3.10	1.45
*Extension services not readily available	216(63)%	46(13)%	83(24)%	3.55	1.38
*The use of chemicals	224(65)%	49(14)%	72(21)%	3.66	1.35
Poor care to coffee plants by farmers	152(44)%	49(14)%	144(42)%	2.94	1.50
Average				3.35	1.42

Source: Primary Data from Smallholder coffee farmers in Kisozi Sub County

smallholder farmers in Kisozi Sub County, Kamuli District, and what problems they had to deal with.

RESULTS AND DISCUSSION

This was about the difficulties of legume intercrops in coffee production. Lack of adequate mobilization; aging coffee trees; inappropriate intercrop systems; low market coffee prices; no rural financing of smallholder farmers; extension services not readily available; use of chemicals; and poor care of coffee plants by farmers were used to establish this.

The results are as follows: (Table 1). From the indicators in (Table 1), there are several challenges that smallholder farmers face during legume intercrop to promote coffee production in Kisozi Sub County, Kamuli District. However, there are eight (8) major challenges faced in legume intercrop.

The first is that the community of smallholder farmers lacks adequate mobilization to support legume intercrop, as reflected in the scores (Mean = 3.41 > 3.35; standard deviation = 1.41). This means that, without adequate mobilization, the benefits of legume intercrop towards coffee production can easily miss the activity of smallholder farmers in Kisozi Subcounty, Kamuli District.

These results are in tandem with findings in the report by the Uganda Bureau of Statistics (2014) which reveals that smallholder farmers who lack adequate mobilization into viable economic units dominate coffee production in Uganda, and that they also largely produce on highly fragmented pieces of land, in most cases estimated at 0.33 hectares per household.

In addition, the study established that most smallholder coffee farmers in Kisozi Sub County, Kamuli District use inappropriate intercrop systems (Mean = 3.48 > 3.35; standard deviation = 1.361.42). By implication, not every legume can be intercropped with coffee; rather, the farmer must make a good choice of the legume before intercropping. This is related to findings by Mugo et al. (2013) revealing that inappropriate intercrop systems have resulted in further destruction of soil conservation structures (terrace embankments) and increased soil erosion. These constraints are with the aim of guaranteeing greater production margins, especially for smallholder farmers who are more vulnerable to yield losses compared to large-scale farmers.

The third major challenge of intercropping is the lack of readily available extension services among smallholder farmers in Kisozi Subcounty (Mean = 3.55 > 3.35; standard deviation = 1.38 1.42). This is a gap that ought to be filled by extension workers. Farmers were particularly appreciative of Kulika Uganda, which supported agricultural extension services in the study area. In fact, one farmer had this to say:

"….Kulika did a great job among farmer in this sub county and even the entire district. Through their programme, farmers learnt many things. Personally, I must say that before the Kulika programme, I was farming with a lot of ignorance but now, am well aware of many farming practices…." A coffee farmer from Nankandulo parish during interview.

Despite a few farmers who were unaware of climate change, the amount of climate change awareness among coffee producers in Kisozi Sub County is excellent. During interviews, farmers demonstrated that they frequently reflect on this knowledge during their farming planning cycles. Extension services are critical in providing farmers with critical information that directs their farming operations. Barry (2020) noticed the same thing when he discovered that overall, extension services are insufficient, and those that are provided are poorly prepared. Coffee-specific extension is not currently available through public sector extension programmes. Some farmers' groups, as well as a number of exporters and non-governmental organizations/foundations, offer coffee-specific guidance and extension with the help of development partners. According to Barry (2020), the standard extension services supplied to the coffee sector focus on improving agronomic methods such as pruning,

fertilization, pest and disease management, and so on. The use of chemicals is also a challenge (mean = 3.66 >3.35; standard deviation = 1.35 1.42). In practice, if chemicals are utilized correctly, they improve yields. However, authors and researchers have varied perspectives on the concept of chemicals. Seed and seedlings, fertilizers, farm implements (spraying pumps, pruning knives, etc.), crop protection goods, rural financing, and consulting services, according to Baker and Haggars (2007), are the principal coffee production inputs at the farm level. P
lanting materials are sometimes given away for free, sometimes purchased from commercial or community-managed nurseries, and in some circumstances taken from wild plants or coffee bushes thought to be of high quality.

The authors emphasized that effective use of high-quality inputs is a necessary requirement for long-term productivity growth. There is also the issue of aged trees, which is backed by 57% of smallholder coffee farmers. As a result, caring for coffee trees entails eliminating aged trees while preserving highly productive ones. However, this is not always the case among many smallholder farmers due to a lack of information.

Mugwe et al. (2009) emphasized the same point, indicating that ageing coffee trees that may require replanting or rejuvenation; declining soil fertility; pest, disease, and weed infestations; high input costs (fertilizers, pesticides, and labour); current climate and weather changes that affect the environment for coffee production; and the Coffee Research Institute have all reduced farmers' affluence.

Conclusion

When planting legume intercrops, smallholder coffee farmers in Kisozi Sub County, Kamuli District face eight (8) severe challenges. Smallholder farmers are insufficiently organized into viable economic groups. Approximately 0.33 hectares of land are used for agriculture by smallholder farmers. Extension programmes are key for supplying farmers with vital information that guides their agricultural practices. In general, the coffee industry lacks adequate extension services, and those that are available are poorly equipped. Several farmer organizations provide consulting and extension services pertaining to coffee, with the aid of development partners. The authors underline that the efficient use of high-quality inputs is a fundamental condition for sustained productivity increase. Moreover, 57 percent of smallholder coffee growers concur that aged trees are an issue. Care for coffee trees involves removing older trees and retaining the more productive ones.

Recommendations

Both the government and the community need to take immediate action to increase their climate change resilience. Smallholder farmers should use legumes as an intercrop in coffee production because of the many benefits they provide, which will help them better manage their coffee estates and agricultural practices. The government should provide more agricultural aid services to encourage farmers to enhance their farming methods. This can be done by enhancing the agricultural extension services offered to the public, particularly by educating farmers about the effects of climate change and mitigation strategies, the importance of legumes in reducing the effects of climate change, and the availability and provision of inputs (seed), particularly the pertinent leguminous crops for use as intercrops in coffee plantations. The sole sub-county in the Kamuli district where coffee is grown was the focus of this investigation. In areas where the effects and perceptions of climate change differ, case-by-case mitigation strategies should be created. Other districts should be the focus of a study comparable to this one.

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