cognizancejournal.com
Nathan Aliel Kachiguma *et al*, Cognizance Journal of Multidisciplinary Studies, Vol.3, Issue.8, August 2023, pg. 1437-1448
(An Open Accessible, Multidisciplinary, Fully Refereed and Peer Reviewed Journal)
ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

Constraints and Opportunities for Increased Coffee Productivity under Climate Change: A Case of Mzuzu Smallholder Coffee Planters Cooperative Union in Malawi

Nathan Aliel Kachiguma PhD[1]; Kennedy Masamba[2]
[1]Department of Agricultural Research Services, Lunyangwa Agricultural Research Station, P. O. Box 59, Mzuzu, Malawi. Email: nkachiguma@yahoo.co.uk
[2]Department of Forestry and Environmental Sciences, Mzuzu University, Private Bag 201, Luwinga, Mzuzu, Malawi. Email: masamba.k@mzuni.ac.mw

DOI: 10.47760/cognizance.2023.v03i08.037

Abstract:
Coffee contributes significant income to economy of Malawi. Most smallholder farmers produce coffee cherry yield below 500 kg per hectare due to various challenges. Information on coffee farming household demographic characteristics, constraints and opportunities for high productivity, knowledge on climate change and indicators, and practices for adapting to effects of climate change on coffee is scarce. A survey was implemented in five coffee growers' cooperatives under Mzuzu Coffee Planters Cooperative Union. Respondents (n = 372) were randomly selected and interviewed using a questionnaire. Data were analysed using Statistical Package for Social Sciences. Mean Derived Scores (MDS) were calculated in Microsoft excel. 74.7% of respondents were male, and belonged to male headed households (87.1%). Respondents (80.4%) were above 40 years old. Only 3.5% were in age category of 18-30. 87.6% of respondents were married. Mean number of individuals in a household was six. Majority of farmers (62.1%) attended primary education. Only 1.65 attended tertiary education. Pests and diseases was the major constraint to high coffee cherry yield productivity (MDS = 4.4). Favourable environmental conditions can contribute towards high coffee productivity (MDS = 4.6). Unpredictable rainfall was the first indicator of climate change (MDS = 5.0). Death of plants (MDS = 5.5) and low cherry yield (MDS = 4.6) are important effects of climate change on coffee. Farmers intercropped coffee with shade trees (MDS = 5.0) to adapt to effects of climate change. Government and development partners should promote minority groups, and agroforestry systems such as intercropping coffee with bananas in order to adapt to effects of climate change and ensure high productivity and sustainable coffee production.

Keywords: Farmers; Coffee; yield; productivity; climate change.

ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

1. Introduction

Coffee belongs to the genus *Coffea*, and comprise of more than 120 species (Carvalho *et al*., 1996). Only *Coffea arabica* and *Coffea canephora* species are cultivated for production of coffee. *Coffea arabica* accounts for 60 to 80 % of the world's total coffee production, while *Coffea canephora* accounts for 20 to 40 % (World Coffee Research, 2017). *Coffea canephora* has high bitterness taste, low acidity and is less susceptible to diseases than *Coffea arabica*. *Coffea arabica* is preferred for its sweeter taste, though it contains less caffeine than *Coffea canephora*. Both species originated from Central and Western Sub-Saharan Africa, but in Malawi only *Coffea Arabica* is produced.

Coffee sector is estimated to generate global annual revenue in excess of $200 billion with a stable annual market growth rate of 2.2% (The Coffee Guide, 2021). Revenue from coffee sales contributes significant income to the national economy of Malawi, such that it is considered fourth important export crop. Chandran and Prabitha (2020) agrees that coffee is an agro based rural industry that plays an important role in development of the country. Although coffee is an important export crop in Malawi, cherry yield production is low due to various challenges (Natural Resource Institute, 2006). Smallholder farmers' coffee cherry yield production is below 500 kg per hectare in most developing countries in Africa compared to other countries where coffee production is in the range of 1000 kg to 2500 kgs per hectare (World Coffee Research, 2017).

Coffee varieties that are cultivated in Malawi have overtime become susceptible to pests and diseases due to recycling of seed among other reasons. In addition to coffee diseases and pests, there has been a surge in drought, floods and soil erosions which could be attributed effects of climate change. There are common and discerning farmers' perceptions on effects of climate change on crop production in Malawi (Zulu, 2017). Inadequate knowledge on farmers' perceptions on effects of climate change on coffee productivity, can undermine adaptation efforts through wrong interventions that may be unsustainable. Agricultural researchers as well as farmers have different and in some cases similar intervention strategies to adapt to effects of climate change on crop productivity (Gemechu *et al*., 2002). The strategies should be determined effectively and incorporated in policy formulation, research and technology development. In Malawi, coffee is grown by both the commercial estates in the southern region and smallholder farmers in the northern region. Information on smallholder farmers' perceptions on constraints and opportunities for increased cherry yield productivity for coffee grown under climate change is scarce. Therefore, this study aimed at assessing demographic characteristics of coffee farming households, farmers' perceptions on constraints and opportunities for increased coffee productivity, effects of climate change on coffee productivity and adaptation strategies. The findings of this study will inform policy makers and development partners on appropriate interventions needed for sustainable coffee production in Malawi.

2. Materials and Methods

2.1 Study area

The study was implemented in five smallholder coffee growers' cooperatives under Mzuzu Coffee Planters Cooperative Union (MzCPCU) (https://www.mzuzucoffee.org/). The five coffee growers' cooperatives are Misuku in Chitipa district, Viphya North in Rumphi district, Nkhatabay North cooperative in Nkhatabay district, Mzimba Southeast in Mzimba district, and Ntchisi East cooperative in Ntchisi district (Table 1 & Figure 1). Each cooperative under MzCPCU is demarcated into coffee growers' business zones. MzCPCU is the largest coffee producing, processing and exporting smallholder farmers' organisation in Malawi.

cognizancejournal.com
Nathan Aliel Kachiguma *et al*, Cognizance Journal of Multidisciplinary Studies, Vol.3, Issue.8, August 2023, pg. 1437-1448
(An Open Accessible, Multidisciplinary, Fully Refereed and Peer Reviewed Journal)
ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

Table 1. Altitude and coordinates of study areas

Cooperatives	District	Altitude (masl)	Coordinates
Mzimba South East	Mzimba	1,200-1,700	36 L 0614067/UTM 8733671
Misuku	Chitipa	1,700-2,000	09^{0}40’05.90’’S 33^{0}’31’53.38’’E
Viphya North	Rumphi	1,200-1,500	11^{0}00’47.43’’S 34^{0}04’19.66’’E
Ntchisi East	Ntchisi	1,200-1,700	36L0603700/UTM8514868
Nkhatabay North	Nkhatabay	1,000-2,000	11^{0}23’51.68’’S 34^{0}10’14.4’’E

Key: masl = meters above sea level; UTM = Universal Transverse Mercator; L = Longitude; E = East.

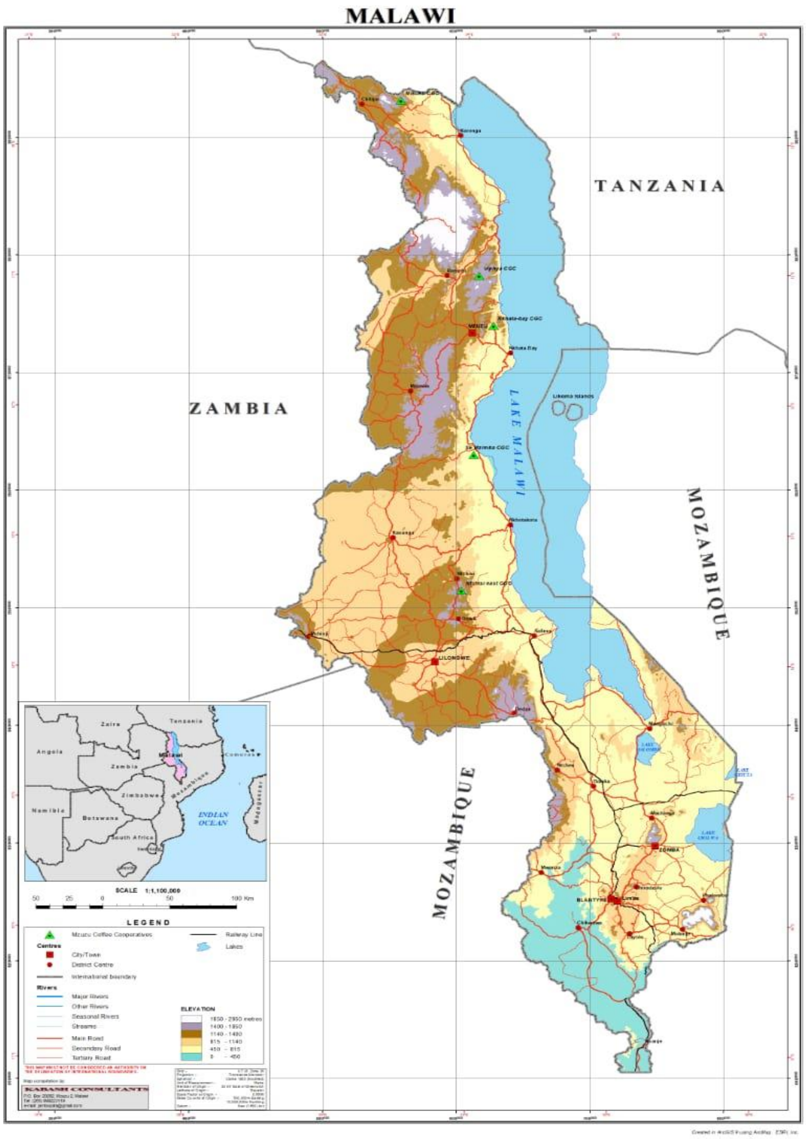

Figure 1. Map of Malawi showing smallholder farmers coffee growers’ cooperatives

2.2 Sampling procedure

The study targeted smallholder coffee farmers operating under MzCPCU. MzCPCU was purposely selected because it is the largest farmers' organization in Malawi with registered coffee farming households. Number of registered households vary across the cooperatives. Household representatives were randomly selected in all the business zones of five cooperatives (Table 2).

Table 2. Number of business zones, registered households and respondents in five cooperatives

Cooperatives	Business zones	Registered Households	Respondents
Mzimba South East	6	105	59
Misuku	16	596	152
Viphya North	7	116	45
Ntchisi	8	319	59
Nkhatabay	7	213	57
Total	**44**	**1,349**	**372**
Percentage	-	**-**	**27.6**

2.3 Data collection tools and analysis

2.3.1 Focus group discussion

A Focus Group Discussion (FGD) was done in Chigwere business zone under Nkhatabay coffee growers' cooperative in May 2022. Participants in the FGD comprised of 7 male and 5 female household representatives. Household representatives provided information following a checklist questionnaire that was administered. Information collected during the FGD was used to generate a study questionnaire. The study questionnaire was discussed during training of enumerators and proper adjustments were made to the questionnaire.

2.3.2 Pilot testing

Enumerators were trained on data collection using the study questionnaire. After training of enumerators, pilot testing was done in Nchenachena coffee growers' cooperative. Pilot testing was done in three coffee growers' business zones, and five household representatives were interviewed. The aim of pilot study was to test suitability of the draft questionnaire to gather appropriate information. Following the pilot study, proper adjustments were made to the questionnaire before administering it to a larger sample size.

2.3.3 Data collection

A baseline survey was conducted in five cooperatives under MzCPCU. The survey was implemented in June 2022. A total of 59, 152, 45, 59 and 57 household representatives were interviewed, and data were collected using a study questionnaire in Mzimba South East, Misuku, Viphya, Ntchisi and Nkhatabay coffee growers' cooperatives respectively (Table 1). Data were collected on coffee farming household demographic characteristics; factors affecting high coffee cherry yield productivity; opportunities for high coffee cherry yield productivity; farmers' awareness of climate change and indicators; effects of climate change on coffee productivity; and practices for adapting to effects of climate change on coffee. Topographical data were also collected and used to generate a map showing study areas (Figure 1).

2.3.4 Data analysis

Frequencies on qualitative data were analysed using Statistical Package for Social Sciences (SPSS version 16). Mean Derived Scores (MDS) were calculated in Microsoft excel. MDS were derived by combining rankings from different cooperatives into a derived score according to De Groote *et al*. (2002). MDS is an indicator of overall importance of factors. The score represent number of times a factor ranks highly. For each cooperative, a factor receives a value inversely related to its rank as follows: a factor ranked first received a derived score of 5, when it was ranked second it received a score of 4, when ranked 3 it had a score of 3, when ranked fourth it had a score of 2, and when it was ranked fifth it received a derived score of 1.

cognizancejournal.com
Nathan Aliel Kachiguma *et al*, Cognizance Journal of Multidisciplinary Studies, Vol.3, Issue.8, August 2023, pg. 1437-1448
(An Open Accessible, Multidisciplinary, Fully Refereed and Peer Reviewed Journal)
ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

3. Results and Discussion

3.1 Coffee farming household demographic characteristics

3.1.1 Gender and household type of respondents

Respondents (74.7%) were male, and belonged to male headed households (87.1%) in all the five cooperatives (Table 3). According to key informants the high proportion of males to females can be attributed to the fact that coffee is a cash crop and males dominate decision making just like in most households that grow tobacco or cotton as their main cash crops. Chandran and Prabitha (2020) agrees that male growers dominate coffee production because it is a cash crop. Only 2.9% of respondents in Mzimba (n = 4), Ntchisi (n = 6) and Nkhatabay (n = 1) belonged to the category of others. Respondents in the category of others were either single, divorced or widowed. Women and other minority groups may face different forms of discrimination in a society. Therefore, special consideration targeting minority groups during developments interventions would enhance coffee productivity. In order to increase agricultural productivity in Vietnam, the local government introduced programs that targeted ethnic minority communities (Le *et al*., 2020).

Table 3. Gender of respondents and household types in five cooperatives

Cooperatives	**Gender of respondents**		**Household head**		
	Male	Female	Male	Female	Other
Mzimba	36	23	46	9	4
Misuku	136	16	143	9	0
Viphya	34	11	42	3	0
Ntchisi	36	23	51	2	6
Nkhatabay	36	21	42	14	1
Total	**278 (74.7%)**	**94 (25.3%)**	**324 (87.1)**	**37 (10.0%)**	**11 (2.9%)**

Key: Other = Single, divorced or widowed.

3.1.2 Age category of respondents

Table 4 shows that 80.4% of respondents were above 40 years old in the five cooperatives. Misuku cooperative had the highest number of respondents (n = 47) in 41-50 years old age category, followed by Ntchisi (n = 17). Only 3.5% of respondents were in age category of 18-30 in Misuku (n = 9), Viphya (n = 2) and Nkhatabay (n = 2). The findings indicate that coffee production in the study areas is dominated by the elderly. Chandran and Prabtha (2020) also reported that majority of coffee growers were above 40 years old in Kaniyambetta Panchayat in India. The findings suggest that youth involvement in decision making and coffee cultivation is low. Low participation of youths in coffee production may contribute to unsustainable coffee production. Sette (2012) agrees that low youth and women empowerment is a sustainability challenge in coffee cultivation in Ethiopia. The government policy should aim at encouraging active youth involvement in decision making and coffee production.

Table 4. Age categories of respondents in five cooperatives

Cooperatives	**Age categories of respondents**				
	18-30	31-40	41-50	51-60	>60
Mzimba	0	5	13	12	29
Misuku	9	29	47	45	22
Viphya	2	14	12	11	6
Ntchisi	0	7	17	21	14
Nkhatabay	2	5	11	31	8
Total	**13 (3.5%)**	**60 (16.1%)**	**100 (26.9)**	**120 (32.3%)**	**79 (21.2%)**

ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

3.1.3 Marital status and number of people in a household

Majority (87.6%) of total respondents were married (n = 326), followed by the widowed (8.6%) in the five cooperatives (Table 5). The mean number of people in a household was six in three cooperatives (Mzimba, Misuku and Viphya), and five in Ntchisi and Nkhatabay cooperatives. Most farming households rely on family labour in coffee cultivation in order to reduce production costs, while others cannot afford to pay for hired casual labour. Labour constitutes more than 50% of total production costs in most coffee production systems (ICO, 2019).

Table 5. Marital status and number of people in a household in five cooperatives

Cooperatives	**Marital status**				**Number of people in a household**		
	Single	Married	Widowed	Divorced	Minimum	Maximum	Mean
Mzimba	1	43	15	0	1	14	6
Misuku	5	143	4	0	1	12	6
Viphya	1	41	2	1	2	13	6
Ntchisi	0	52	4	3	1	9	5
Nkhatabay	0	47	7	3	2	12	5
Total	**7 (1.9%)**	**326 (87.6%)**	**32 (8.6%)**	**7 (1.9%)**			

3.1.4 Highest level of education in a household

Majority of respondents (62.1%) attended primary education, while 32.3% attended secondary education (Table 6). Only 1.6% attended tertiary education in Mzimba (n = 1), Misuku (n = 1) and Nkhatabay (n = 4) cooperatives. Level of education is critical for farmers to understand agricultural advisory services, and adopt improved technologies. Rattan (2022) agrees that education, outreach and extension services are useful tools for creating awareness about climate change and climate smart agricultural practices for sustainable crop management and productivity. Therefore, the importance of promoting education among coffee producing households in Malawi cannot be overemphasized. Contrary to the findings of this study Chandran and Prabitha (2020) reported that majority of coffee growers attended secondary school education in India.

Table 6. Level of education in a household in five cooperatives

Cooperatives	**Level of education**			
	None	Primary	Secondary	Tertiary
Mzimba	4	43	11	1
Misuku	1	81	69	1
Viphya	0	29	16	0
Ntchisi	3	45	11	0
Nkhatabay	7	33	13	4
Total	**15 (4.0%)**	**231 (62.1%)**	**120 (32.3%)**	**6 (1.6%)**

3.2 Constraints and opportunities for increased coffee productivity

3.2.1 Factors affecting high coffee cherry yield productivity

Pests and diseases had the highest mean derived score of 4.4, and was the major constraint to high coffee cherry yield productivity followed by inadequate farm inputs (3.2), and lastly inadequate reliable source of coffee seeds and seedlings (1.0) (Table 7). In Malawi, farmers can access loans for purchasing pesticides and farm inputs from money lending institutions, however, lending interest rates are high and prohibitive for most smallholder farmers. Perhaps the recently introduced government programme on Agricultural Commercialisation (AgCom) will sort out some of the challenges farmers face. AgCom is providing farmers' cooperatives with farm inputs where farmers have a tangible business plan. AgCom programme will probably contribute towards sustainable coffee production in Malawi. Chandran and Prabitha (2020) and Le *et al*. (2020) agrees that pest infestation, diseases and inadequate farm inputs are some of the factors affecting high coffee cherry yield productivity in India. Sette (2012) further agrees that inadequate access to financial services, and low levels of public investment in agriculture, significantly contribute to low coffee productivity in smallholder farmers' fields in Ethiopia.

The Southern Africa Development Community (SADC) pilot project was implemented in Malawi in order to address the challenge of inadequate reliable source of coffee seed and seedlings. This was achieved by capacitating the tissue culture laboratories in the Department of Agricultural Research Services. The tissue culture laboratory at Bvumbwe Agricultural Research Station is now able to do micro-propagation of coffee seedlings through somatic embryogenesis using tissue culture techniques. Through somatic embryogenesis farmers will be supplied with coffee seedlings free from pests and diseases and also that are genetically true to type.

Table 7. Constraints to high coffee yield productivity ranked in order of importance in cooperatives.

Factors	**Rank in cooperatives**					
	Mzimba	**Misuku**	**Viphya**	**Ntchisi**	**Nkhatabay**	**MDS**
Coffee pests & diseases	1	2	1	3	1	4.4
Inadequate of farm inputs	2	4	2	2	4	3.2
Unreliable & stable market	4	1	3	5	3	2.8
Inadequate extension services	3	3	5	4	2	2.6
Inadequate of reliable seed/seedlings source	5	5	-	6	5	1.0

Key: Rank = First rank was given a score of 5, second rank was scored 4, third rank was scored 3, fourth rank was scored 2, and fifth rank was scored 1; MDS = Mean Derived Scores; - = Not ranked.

3.3 Opportunities for high coffee cherry yield productivity

Favourable environmental conditions (MDS = 4.6) was considered the most important factor that contribute towards high coffee productivity, followed by availability of research and extension services (MDS = 3.6) (Table 8). Optimum environmental factors for coffee growth and production include: high altitude, cool temperatures, high rainfall and fertile soils with high moisture holding capacity fertile soil. The altitude for the study areas fall in the range of 1,200 to 2,000 meters above the sea level, with average temperature range of 18 to 25^{0}c (https://helenacoffee.vn/malawi/). Potential ideal areas for coffee growing in Malawi include Mwera and Namwera Hills in Mangochi, Tsangano in Ntcheu and Neno districts (Smallholder Coffee Farmers Trust, 2001). Mzuzu Coffee Planters Cooperative Union intends to increase coffee production and number of cooperatives to the potential coffee growing areas (Figure 1). Similarly, it was observed in Ethiopia that conducive environmental and climatic conditions were opportunities for sustainable coffee production (Sette, 2012). Government needs to take a leading role in providing researchers with adequate resources to develop varieties that can adapt to the changing environmental conditions. Further to that, extension services in the country should be revamped by employing adequate agricultural extension workers in the public sector. Government and commercial investors should also consider establishment mega coffee farms in potential coffee growing areas.

cognizancejournal.com
Nathan Aliel Kachiguma *et al*, Cognizance Journal of Multidisciplinary Studies, Vol.3, Issue.8, August 2023, pg. 1437-1448
(An Open Accessible, Multidisciplinary, Fully Refereed and Peer Reviewed Journal)
ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

Development partners should complement government efforts to ensure high and sustainable coffee production in Malawi.

Table 8. Factors that enhance coffee cherry yield production ranked in order of importance

Factors	**Rank in cooperatives**					
	Mzimba	**Misuku**	**Viphya**	**Ntchisi**	**Nkhatabay**	**MDS**
Good environment (soils, rain, temp	1	3	1	1	1	4.6
Research & extension services	3	1	2	4	2	3.6
Stable & high selling prices	4	2	-	2	3	3.3
Possibility for intercropping	2	4	3	-	4	2.8
Knowledge in manure making	5	5	-	3	-	1.7

Key: Rank = First rank was given a score of 5, second rank was scored 4, third rank was scored 3, fourth rank was scored 2, and fifth rank was scored 1; MDS = Mean Derived Scores; - = Not ranked.

3.4 Climate change and adaptation strategies

3.4.1 Knowledge on climate change and indicators

Farmers (99%) were aware of climate change (Figure 2). Unpredictable rainfall pattern was ranked the first indicator of climate change with a mean derived score of 5.0, followed by floods (MDS = 3.3), dry spells (MDS = 3.0) and lastly changes in temperature (MDS = 2.3) (Table 9). The results of this study suggest that cooperative managers are probably disseminating information about climate change as farmers are aware of climate change and indicators. Farmers' awareness of climate change and indicators of climate change, is a positive step towards adopting climate smart agriculture technologies, and adapting to the effects of climate change. Most coffee growers have knowledge of climate change as one of the emerging factors affecting high coffee cherry yield productivity and cup quality (Chandran & Prabitha, 2020; Sette, 2012). Coffee is considered to be at high risk of being affected by changes in climate change (Koutouleas *et al*., 2022). Similarly, irregular rainfall significantly affected coffee production in India in 2017 (Coffee board, 2018). Chandran and Prabitha (2020) agrees that climatic fluctuations and irregular rainfall patterns in recent years have contributed towards the collapse in coffee productivity.

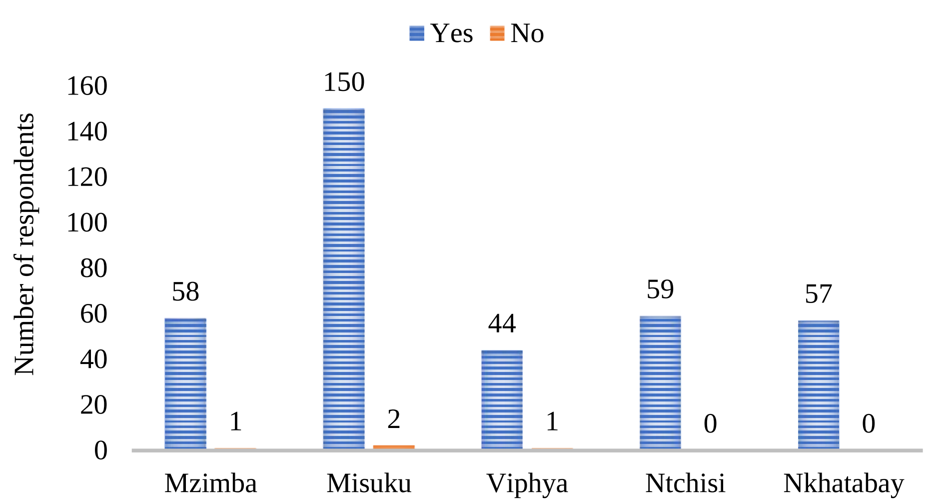

Figure 2. Distribution of respondents aware of climate change issues

Table 9. Indicators of climate change ranked in order of importance in five cooperatives

Indicators	**Rank in Cooperatives**					
	Mzimba	**Misuku**	**Viphya**	**Ntchisi**	**Nkhatabay**	**MDS**
Unpredictable rainfall pattern	1	1	1	1	1	5.0
Floods	4	3	2	-	-	3.3
Dry spells	4	3	2	-	-	3.0
Soil erosions	2	5	3	-	-	2.7
Change in temperatures	3	4	4	2	-	2.3

Key: First rank was given a score of 5, second rank was scored 4, third rank was scored 3, fourth rank was scored 2, and fifth rank was scored 1; MDS = Mean Derived Scores; - = Not ranked.

3.4.2 *Effects of climate change on coffee plants and productivity*

Farmers ranked death of plants as the most important effect of climate change on coffee (MDS = 5.5) (Table 10). Low cherry yield of coffee was ranked the second with MDS of 4.6, and lastly emerging pest infestations and poor cup quality (MDS = 2.3). Deaths of coffee plants is probably due to die back of branches that is caused by irregular rainfall pattern and fluctuations in temperature that follow years of heavy bearing. Fluctuations in temperature are also contributing to early ripening of coffee berries consequently low cup quality. Pham *et al*. (2019) indicated that coffee as a perennial crop is sensitive to climate change, as such, it is likely to be highly susceptible to fluctuations in climate. Effects of climate change on coffee include low cherry yield, early flowering and early ripening of fruit berries among others (Chandran & Prabitha, 2020). Key informants indicated that changes in climate change have been recognized in the past ten years. This is probably so due to more awareness campaigns on climate change issues in the past recent years. Farmers under Mzuzu Coffee Planters Cooperative Union can easily adopt climate smart agriculture technologies and practices because they know the effects of climate change on coffee productivity.

Table 10. Effects of climate change on coffee plants and productivity ranked in order of importance in five cooperatives

Effects of climate change on coffee	**Rank in cooperative**					
	Mzimba	**Misuku**	**Viphya**	**Ntchisi**	**Nkhatabay**	**MDS**
Death of plants	-	4	-	2	-	5.5
Low cherry yield	1	2	2	1	1	4.6
Early ripening of coffee	2	1	5	3	2	3.4
Low cup quality	-	5	5	2	3	2.3
Pest damaged beans	-	5	4	2	3	2.3

Key: First rank was given a score of 5, second rank was scored 4, third rank was scored 3, fourth rank was scored 2, and fifth rank was scored 1; MDS = Mean Derived Scores; - = Not ranked.

3.4.3 *Farmer practices for adapting to effects of climate change on coffee*

Farmers ranked intercropping with coffee shade trees (MDS = 5.0), followed by early planting (MDS = 3.6) and lastly mulching to conserve soil moisture (MDS = 2.2) as some of the ways of adapting to effects of climate change on coffee (Table 11). Extension workers should promote adoption of available climate smart agriculture technologies and practices in order to cushion effects of climate change on coffee. As a way of mitigating and adapting to the effects of climate change on coffee productivity, agroforestry practices have been proposed as a nature-based strategy (Koutouleas *et al.*, 2022). Coffee agroforestry systems, in which coffee grow under shade in association with other trees on the same plot of land are widespread in many tropical countries, and are said to be beneficial to coffee production. Shade in coffee improves the micro-environment by conserving soil moisture, and reduced effects of high temperatures on coffee. In the northern region of Malawi, coffee is mostly intercropped with bananas. However, according to Koutouleas *et al.* (2022) agroforestry systems of intercropping coffee with shade trees is a highly contentious factor for coffee production in terms of potential yield reduction, as well as additional management needs that come due to interactions of shade trees, pests and fungal disease infections. According to Vaast *et al*. (2006), coffee grown under agroforestry systems productivity can be 15 to 30% lower than in full-sun systems. However, when agroforestry systems are properly managed, they can buffer climatic fluctuations, and benefit from biological and economic synergies, leading to sustainable land management and stable higher incomes for smallholder coffee farmers (DaMatta, 2004). Under shade just like in high altitude areas in this study such as in Misuku cooperative, coffee beans are denser and far more flavour intense, notably with fine acidity and a pleasant aroma which fetches premium prices on the market (Muschler, 2001).

Table 11. Practices for adapting to effects of climate change ranked in order of importance in five cooperatives.

Farmer practices	**Rank in cooperative**					
	Mzimba	**Misuku**	**Viphya**	**Ntchisi**	**Nkhatabay**	**MDS**
Intercropping with shade trees	1	1	1	1	1	5.0
Early planting	2	2	2	4	2	3.6
Applying manure	5	3	3	3	3	2.6
Planting drought tolerant varieties	4	5	3	6	-	2.5
Mulching	3	4	4	5	3	2.2

Key: First rank was given a score of 5, second rank was scored 4, third rank was scored 3, fourth rank was scored 2, and fifth rank was scored 1; MDS = Mean Derived Scores; - = Not ranked.

4. Conclusion

The study revealed that males are heads in most coffee farming households and are key decision makers. In most households coffee production is dominated by the elderly. Coffee production households saved on costs by making use of family labour as it was observed that on average a household had six individuals. Majority of respondents attained primary school only, therefore, education and training for coffee farming households should be promoted to enhance adoption of technologies. Pests and diseases were the major constraint to high coffee cherry yield productivity. However, good management practices and favourable environmental conditions can contribute towards high coffee productivity. Farmers were aware of climate change issues. Unpredictable rainfall pattern was the major indicator of climate change that led to low cherry yield and death of plants. In order to adapt to the effects of climate change farmers are intercropping coffee with shade trees such as bananas. Government policy and development partners should promote minority groups such as the youth, widowed and the divorced to ensure high productivity and sustainable coffee production. Climate smart agriculture technologies such as agroforestry systems should be promoted in order to adapt to the effects of climate change.

Conflict of Interests

The authors have not declared any conflict of interests.

Acknowledgements

The authors thank Southern Africa Development Community (SADC) through the Global Climate Change Alliance Plus (GCCA+) for funding this study. The Senior Deputy Director for Agricultural Research Services (SDDARS) responsible for Lunyangwa Agricultural Research Station and the entire staff, are also acknowledged for their support in various ways. Our sincere gratitude also goes to Mzuzu Coffee Planters Cooperative Union for allowing us to interact with coffee farmers in the cooperatives. Last but not least, we thank the smallholder coffee farmers for sparing their precious time to provide us with information during the interviews.

ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

References

1. Carvalho A., Ferwerda F.P., Frahm-Leliveld J.A., Medina D.M., Mendes A.J. and Monaco L.C., 1996, **Coffee**. In F.P. Ferwerda & F.Wit (Eds.), Outline of Perennial Crop Breeding in the Tropics. Miscellaneous Papers 4 (pp. 189-235). Wageningen. Netherlands.
2. Chandran, N. and Prabitha, P. B., 2020, A Study on the Challenges Faced by Coffee Growers of Kaniyambetta Panchayat of Wayanad District. *International Journal of Advances in Agricultural Science and Technology*, 7(11): 145-156.
3. Coffee Board., 2018, Annual report 2017-18. Government of India, Ministry of commerce & industry. Available online at https://www.indiacoffee.org/. [January, 2023].
4. DaMatta, F., 2004, Ecophysiological constraints on the production of shaded and unshaded coffee: a review. *Field Crops Research*, 86: 99-114. DOI: 10.1016/j.fcr.2003.09.001.
5. De Groote, H., Siambi, M., Friesen, D. & Diallo, A., 2002, **Identifying farmers' preferences for new maize varieties in Eastern Africa.** In: Bellon, M. R. & Reeves, J. (Eds.) Quantitative analysis of data from participatory methods in plant breeding. CIMMYT, Mexico, DF.
6. Gemechu, K., Yohannes, G., Kiflu, B., Chilot, Y., & Asgelil, D. (Eds.), 2002, Towards farmers participatory research: Attempts and achievements in the Central High lands of Ethiopia (pp. 41-47). *Proceedings of Client-Oriented Research Evaluation Workshop*, pp. 16-18, October 2001. Holleta Agricultural Research Center, Holleta, Ethiopia.
7. Koutouleas, A., Sarzynski, T., Bordeaux, M., Bosselmann, A. S., Campa, C., Etienne, H., Turreira-Garcia, N., Rigal, C., Vaast, P., Ramalho, J. C., Marraccini, P., and Raebild, A., 2022 April 28, Shaded-Coffee: A Nature-Based Strategy for Coffee Production Under Climate Change? A Review. *Frontiers in Sustainable Food Systems*. DOI: 10.3389/fsufs.2022.877476.
8. Le, Q. V., Jovanovic, G., Le, D. T. and Sanya Cowal, S. 2020, Understanding the Perceptions of Sustainable Coffee Production: A Case Study of the K'Ho Ethnic Minority in a Small Village in Lâm Đồng Province of Vietnam. Sustainability 2020, 12, 1010. DOI: 10.3390/su12031010.
9. Muschler, R., 2001, Shade improves coffee quality in a sub-optimal coffee-zone of Costa Rica. *Agroforestry Systems*, 51: 131–139. DOI: 10.1023/A:1010603320653.
10. Natural Resource Institute, 2006, *The Potential for Diversification in Coffee Exporting Countries. (vol. 1 and 2)*. UK. University of Greenwich.
11. Pham, Y., Smith, K. R., Mushtaq, S. and Cockfield, G. 2019, The impact of climate change and variability on coffee production: a systematic review. *Climatic Change (2019) 156*: 609-630. https://doi.org/10.1007/s10584-019-02538-y.
12. Rattan, L., 2022, Sustaining soil for advancing peace: World is one family. *Journal of Soil and Water Conservation*. DOI:10.2489/jswc.2022.0411A.
13. Sette, J. D., 2012, Ethiopia Coffee: Challenges and Opportunities. International Coffee Organization. *Ethiopian Coffee Export Conference*, 8-9th November 2012. Addis Ababa, Ethiopia.
14. Smallholder Coffee Farmers Trust, 2001, *Smallholder Coffee Production Handbook*. Malawi. Likuni Press and Publishing House.
15. The Coffee Guide, 2021, Available online at: https://www.thecoffeeguide.org/. [March 09, 2023].
16. Vaast, P., Bertrand, B., Perriot, J.-J., Guyot, B. and Génard, M., 2006, Fruit thinning and shade improve bean characteristics and beverage quality of coffee (Coffea arabica L.) under optimal conditions. *Journal of Science Food and Agriculture*, 86: 197–204. DOI: 10.1002/jsfa.2338.
17. World Coffee Research, 2017, *Coffee Varieties of Mesoamerican and the Caribbean*. World Coffee Research 5728 John Kimbrough Blvd., Suite 201, College Station, TX 77843-2477. Available online at https://www.worldcoffeeresearch.org. [January, 2023].
18. Zulu, L., 2017, January, *Existing Research and Knowledge on Impacts of Climate Variability and Change on Agriculture and Communities in Malawi*. Malawi Report No. 9. East Lansing, Michigan: Global Center for Food Systems Innovation, Michigan State University.

cognizancejournal.com
Nathan Aliel Kachiguma *et al*, Cognizance Journal of Multidisciplinary Studies, Vol.3, Issue.8, August 2023, pg. 1437-1448
(An Open Accessible, Multidisciplinary, Fully Refereed and Peer Reviewed Journal)
ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

A Brief Authors Biography

1st Author: Nathan Aliel Kachiguma. The author works for Department of Agricultural Research Services as Principal Agricultural Research Scientist since 2010. He joined the Department in 2003. As a coffee research scientist, he is responsible for implementing government supported research projects, laying out lab and field experiments, parameter scoring in the lab, on-station field and on-farm experiments, statistical analysis of quantitative and qualitative data, preparing progress reports and presentations. He is currently implementing a project on 'Increasing coffee production and farmers' access to good quality seedlings through tissue culture techniques in Malawi' supported by Southern Africa Development Community, and 'Evaluation of Introduced and Local Arabica Coffee Genotypes on Yield, Growth and Tolerance to Major Pests and Diseases in Malawi' in partnership with World Coffee Research. His interest is also on part time teaching in local universities. The author has published seven peer reviewed research articles. Nathan holds a PhD in Plant breeding.

2nd Author: Kennedy Masamba. University Lecturer and researcher with over 20 years of successful track record in implementation of agricultural/forestry research and training programmes. Currently he teaches plant breeding and genetics at Mzuzu University under the Department of Forestry and Environmental Sciences. Previously he worked as a Principal Scientist responsible for Horticulture in the Department of Agricultural Research Services. With graduate training in plant breeding, horticulture and natural resources management, he has led multi-disciplinary teams in development of horticultural technologies and dissemination of improved technologies. Kennedy has MSc (Horticulture) and also doing PhD (Breeding) at the University of Malawi.

