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Analysing The Factors Influencing Climate Information for Improved Carbon Farming Among Smallholder Farmers in Baringo County, Kenya

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Abstract

Smallholder agriculture has been a mainstay of livelihoods in Baringo County for decades, but due to climate change effects, it's dependency is extremely challenged. Using survey data of 380 households collected using stratified random sampling, factors influencing climate information for improved carbon farming among smallholder farmers were analysed. Eldama Ravine and Baringo central sub-counties were chosen for the study because of their ecological diversity, agribusiness significance, and vulnerability to climate change. Results revealed that the best media to use in sharing climate information in Baringo county was television (78%) while the least was newspapers (0.3%), probably because of affordability of newspapers. Gender influenced awareness and access to climate information since that male (64%) had higher awareness and access than female (55%). it was also noted that Most (89%) of the respondents agreed and strongly agreed that accessibility of smallholder farmer to agricultural extension services played important role in accessing climate information. ANOVA and Multiple regression (R^2, 0.54) results displayed age($B = -0.44, p = 0.104$), gender($B = 0.014, p = 0.048$), education level($B = 0.021, p = 0.058$), and household income($B = 0.062, p = 0.007$) were significant in influencing climate information. This study concludes agricultural extension information to be important in accessing climate information and the need of empowering women in farm decision-making. It is recommended that gender-sensitive approaches be incorporated into agricultural extension services to empower women in decision-making and bridge the gender gap in climate information access.

Keywords: Climate Change, Agroforestry, Carbon farming

INTRODUCTION

Majority (80%) of the world's most economically disadvantaged individuals reside in rural areas and rely on agriculture as their primary source of livelihood (Zerssa *et al.,* 2021). The rural economy is most vulnerable to climatic variability because of high-dependency on rain-fed agriculture for livelihood. Smallholder farms in Kenya like in other developing economies such as Ethiopia, are facing the dual challenges of economic viability and climate change (Zerssa *et al.,* 2021). But they are exploring avenues such as sustainable agroforestry to improve both productivity and environmental resilience.

In unindustrialized countries, traditional, smallholder agriculture is a mainstay of livelihoods for decades, this important role is currently facing challenges from climate change impacts and is exasperated with industrialization and ever-increasing human population (Tschora and Cherubini, 2019). Agroforestry has been identified as a solution to challenges faced by smallholder farmers as land use approach for climate change adaptation and mitigation (van Noordwijk *et al.,* 2023).

Smallholder farming is the pillar of Baringo county's economy; accounting approximately 58% Gross County Product. Coffee and cotton farming is highlands and lowlands cash crop respectively, food crops grown are maize and beans which is considered as a stable food in the area. Although small-scale farming is promising as a sustainable agricultural practice, its economic scopes remain inadequately explored. Without practicing carbon farming in the ASAL area of Baringo, there is likelihood of the smallholder farmers continuing experiencing low farm productivity, losses of crops and livestock, and worsening of food insecurity and poverty.

As much as carbon farming has the potential to provide solutions for climate resilience in Baringo it is faced with information gap. Hence, this study intends to analyse the factors influencing climate information for improved carbon farming among smallholder farmers. This is important for improved carbon farming among smallholder farmers for developing better policies in carbon farming and agricultural development.

MATERIALS AND METHODS

Baringo county is selected for this research due to its strategic significance in providing various agroecological zones, showing the climatic vulnerability.

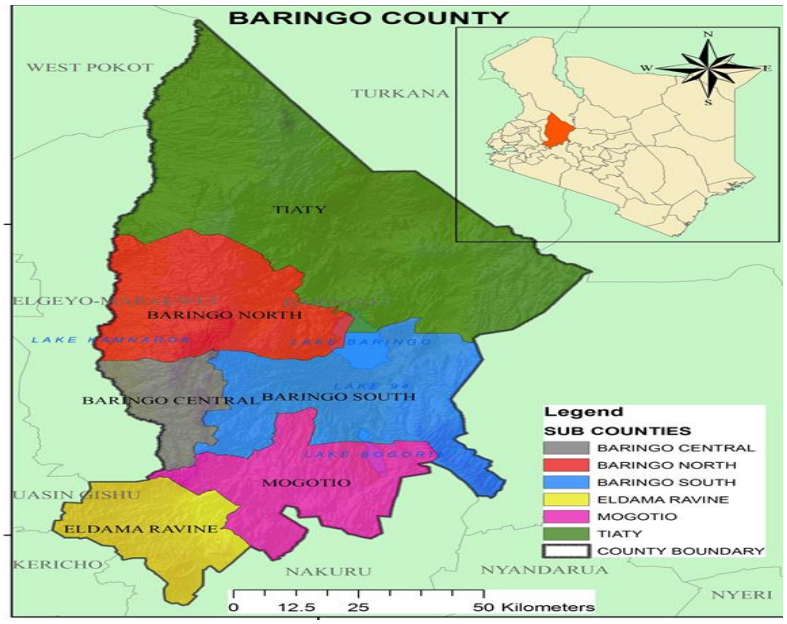

Figure 1: Map of Baringo County (Source: Baringo county CIDP 2023-27)

The selection of Eldama Ravine and Baringo Central as the study areas out of the seven sub-counties in Baringo County was because these sub-counties were the popularity of smallholder agroforestry practices. They have relatively embraced agroforestry related to other sub-counties.

Target Population and Sampling Frame

Approximately 89% of Baringo County citizens inhabiting rural areas and practice farming. Baringo Central and Eldama Ravine are 68% and 75%, respectively. According to census of 2019, Baringo County households was 142,518, Eldama Ravine and Baringo central sub counties comprised of 30,774 and 23,555 households, respectively (GOK, 2019). From the calculation using the respective percentages, the target population of 39,101 including 4 officers was used to get representative sample to administer questionnaires randomly.

Study Design and Sampling technique

Study design

This study used a correlational research design to examine relationships among variables without the researcher controlling or manipulating.

Sampling technique

The study used a purposeful sampling technique for the government officers and Stratified sampling technique to select local community respondents at the sub-county level, location level and village as the lowest level, households' selection was through random sampling technique.

Sample size determination

The study sample size was determined using the Krejcie & Morgan (1970) model.

Data Collection Procedures

A pilot study was conducted on 10%(35 respondents) to pre-test the instruments prior to conducting the actual study. The researcher trained research assistants on the content of the questionnaire, terminologies and general research expectations. They accompanied the researcher during the pilot study to enhance their practical skills.

Data Analysis

Data processing involved collection, recording, organizing, storing and adapting or altering to convert the raw data into useful information. Data processing comprised six stages: collection, preparation, data input, processing, interpretation, and data storage. In determining relationships of different variables, an IBM SPSS software was used. The data from questionnaires, interviews, observations, document analysis and secondary data was subjected to descriptive and inferential statistical analysis ANOVA and multiple regression to determine the strength of association between independent variables and dependent variable.

RESULTS AND DISCUSSION

Socio-Economic and Demographic Information

The survey gathered data on gender distribution, age, household incomes, and educational levels. Out of the administered 380 questionnaires, 374 were returned fully completed. The response rate was 98 percent which was adequate for further analysis. The high response indicates that the data collection tools were well-designed, clear, and relevant to respondents.

Socio-Economic Factors Influencing Climate Information

The socio-economic factors that influenced climate information in the County were comprised of Age; Gender; Household incomes; and, Education level. It also analysed effects of access to climate information on economic activities.

Primary Source of Climate Information

The primary sources of information among the respondents were mainly: Television (78%); radio (16%), Internet (4%), community meetings (1.40%), and Newspapers 0.30%. The age 26 – 35 years was leading accessing through the Internet (3% of 4%), while the age over 60 years were leading accessing through community meetings (1.0% of 1.4%).

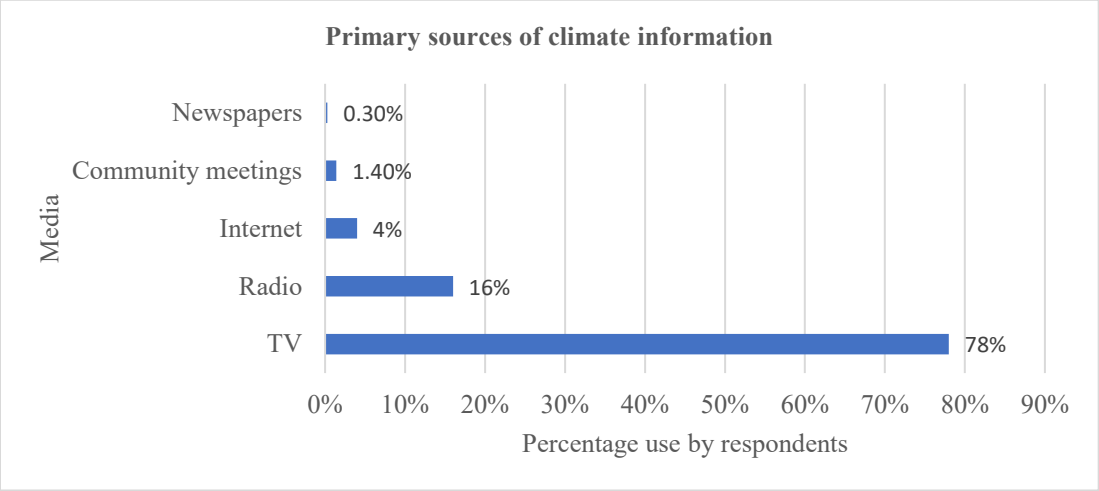

Figure 1: Primary Sources of Climate Information

The above results indicated Television to be the best media in the study area while the least was Newspapers, probably because of two main reasons: most residents were unable to afford a newspaper on a daily basis: most of the residents owned TV and radio.

Influence of Age Category and Access to Climate Information

The three age brackets ranging from 26 – 60 years were leading in levels of awareness on climate information (75%) and equally leading in access to the climate information (65%).

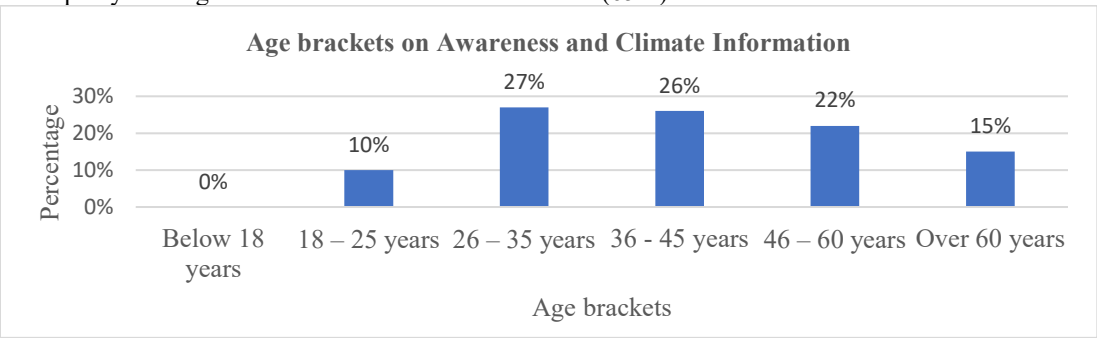

Figure 2: Age Brackets on Awareness and Climate Information

The results in Figure 2 indicate that younger and middle-aged individuals, particularly those in the 26 - 45year age bracket (53%), had the highest awareness. This was attributed to their higher engagement with modern communication technologies, which are key channels for disseminating climate-related information. Additionally, they are active in agricultural training programs, community workshops, and extension services. The 46 - 60year age group (22%) shows a slight decline in awareness, possibly due to reduced exposure to digital platforms and lower participation in structured training programs. While they still played important role in farming, they relied more on traditional sources of information such as word-of-mouth, local leaders, or community gatherings, which would not always provide timely or comprehensive climate-related updates. The lowest awareness rate (15%) was observed among individuals above 60 years, which were attributed to several factors. Older farmers had limited digital literacy. Additionally, they relied on long-established farming practices rather than seeking new climate adaptation strategies.

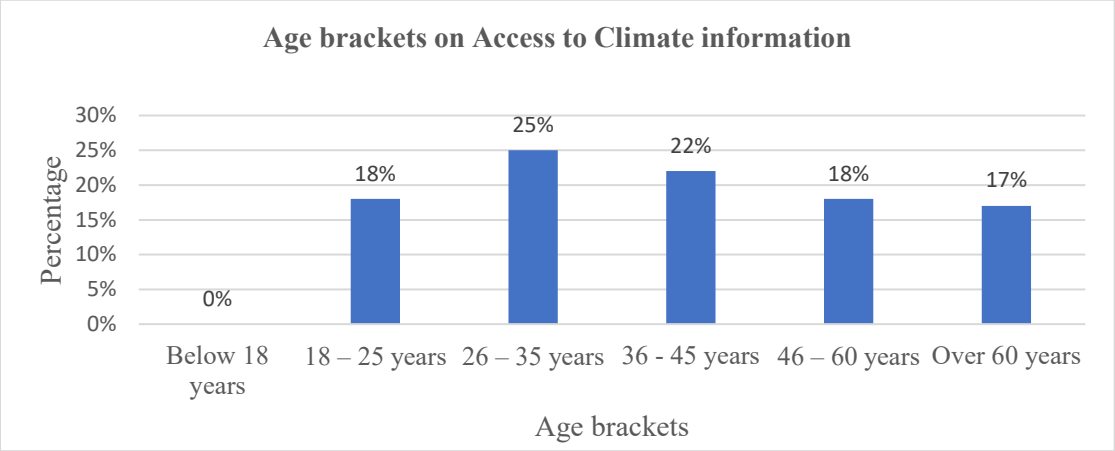

Figure 3: Age Brackets on Access to Climate Information

The results shown in Figures 3 indicated that ages 26 - 60 years were leading in awareness and access to climate information. This could be related with the point that these were very active age brackets, where a majority of them were either employed or possessing primary sources of information like smartphones, radios and Television sets that aided in awareness and accessing climate information.

Influence of Gender on Awareness and Access to Climate Information

Gender influenced awareness and access to climate information as evidenced by the fact that male had higher awareness and access (64%) than female (55%).

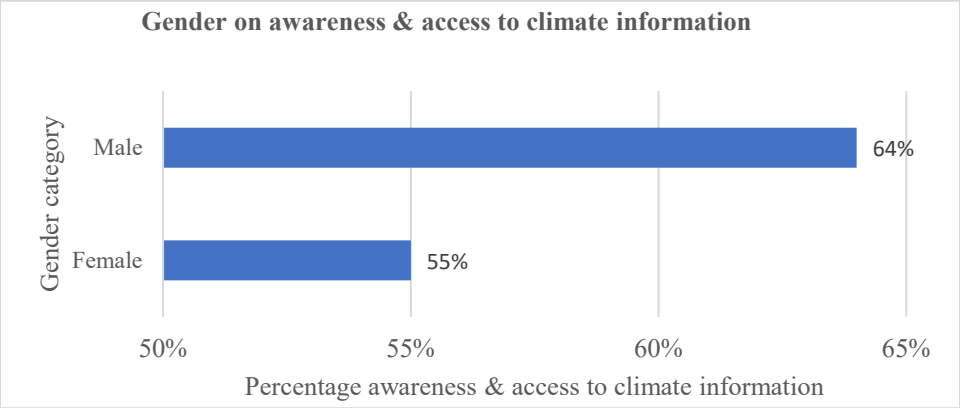

Figure 4: Gender on awareness and access to climate information

The results indicate that male had higher level of awareness and access to climate information than their female counterparts, and yet in most cases, it is women who implement farm activities. This indicates that women require empowerment to increase their awareness as the main implementers of climate information in their farms.

Influence of Education on awareness and access to Climate Information

Education influenced awareness and access to climate information as evidenced by the higher the education level, the more aware were the respondents, and the vice versa. For instance, while when awareness was 47% for primary school

drop-outs, graduate and post-graduates was 73% and 100%, respectively. (Figure 5). This result was supported by a question posed to the respondents on whether education level of smallholder farmer played important role in access to climate information wherefore, 341 of 374 respondents (91%) agreed and strongly agreed. These findings indicate that more capacity building is required, especially on the respondents with education levels of primary to college level to bridge the information gap.

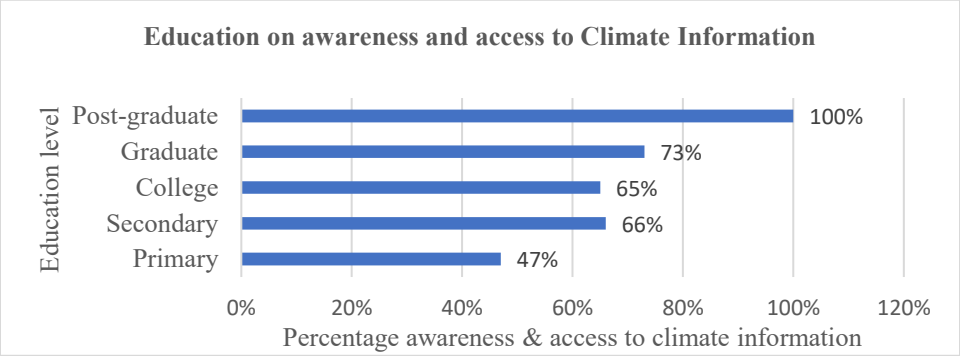

Figure 5: Education on awareness and access to Climate Information

Influence of Household Income on Awareness and Access to Climate Information

Household income influenced awareness and access to climate information. The respondents equivalent to 83% agreed and strongly agreed that household income of smallholder farmer played a significant role.

Accessibility to Agricultural Extension on Awareness and Access to Climate Information

Accessibility of smallholder farmer to agricultural extension influenced awareness and access to climate information. As indicated by respondents equivalent to 89% agreed and strongly agreed.

Effect of Socio-economic Factors Among Smallholder Farmers on Access to Climate Information

The main socio-economic factors that determine access to climate information by the small holder farmers were listed down as: Age (28%); Education level (26%); agricultural extension services (15%); Household income/poverty (14%); digital platforms and internet services (13%); Farming experience (2%); electricity (2%); Gender of the farmer (1%). (Figure 6).

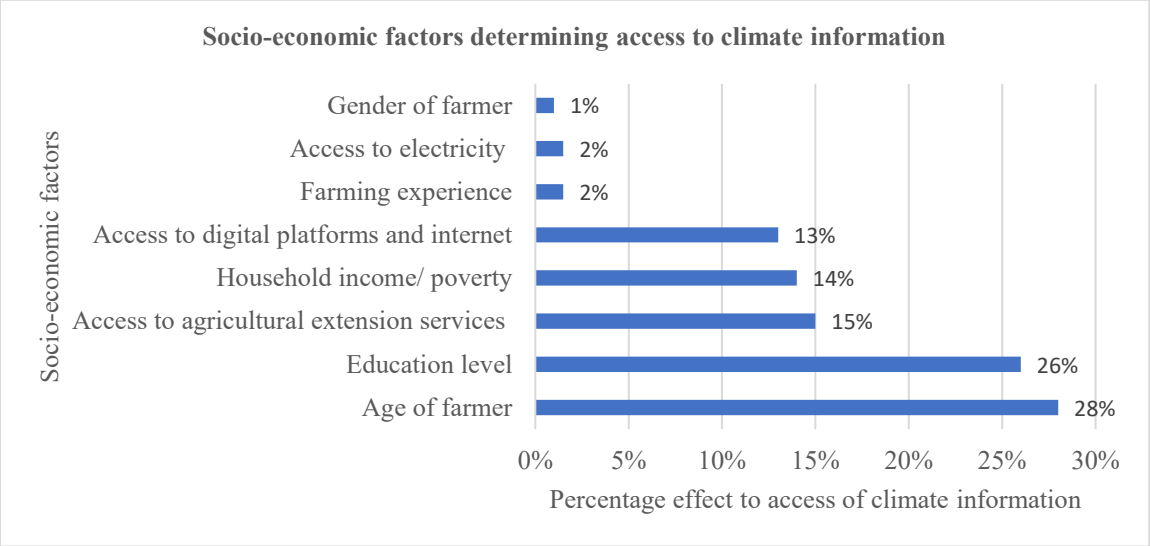

Figure 2: Socio-economic Factors Determining Access to Climate Information

The implication of these findings in Figure 6 is that policies and programs aimed at improving climate information dissemination should prioritize education, extension services, and digital accessibility, particularly for older and less-educated farmers, to bridge the knowledge gap and enhance climate adaptation efforts.

The ANOVA and Multivariate Analysis on Socio-Economic Factors Affecting Climate Information

Table 1 shows R Square = 0.542, meaning that the socio-economic factors, including age, gender, education level, household income, and access to agricultural extension services, explain approximately 54.2% of the variation in access to climate information. Adjusted R Square at 0.53 confirms that the model still has a strong explanatory power even after adjusting for the number of predictors. This result indicates that the model is a good fit, and that the socio-economic variables used in the study significantly influence the level of access to climate information. These findings are supported by Alidu et al. (2022), who indicated that age, household income, education level, and access to extension services were key socio-economic drivers of climate information access and climate-smart agricultural decision-making among smallholder farmers.

Table 1: Model Summary for Socio-economic Factors and Climate Information

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.621[a]	0.542	0.53	0.499

a. Predictors: (Constant), Access of Farmer to Agr Ext to Access Climate Info, What is your Gender, What is your Age, Highest Education Level, Household Income on Access to Climate Info

The Analysis of Variance (ANOVA) results in Table 2, below, indicate that the overall regression model is statistically significant. The F-calculated value of 78.56 is higher than the F-critical value of 3.912 at the 0.05 level of significance. This suggests that the model provides a better fit. The p-value (Sig.) of 0.001 is well below the conventional threshold of 0.05, which further confirms that the observed relationship between the socio-economic predictors and the

dependent variable is statistically significant. These findings are in agreement with those of Alidu et al. (2022), who found that socio-economic attributes such as income level, age, education, and extension access are critical in determining farmers' awareness and use of climate information services.

Table 2: ANOVA for Socio-economic Factors and Access to Climate Information

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.821	5	1.964	78.56	0.001[b]
	Residual	8.366	330	0.025		
	Total	18.187	335			

a. Dependent Variable: Access to Sufficient Climate Info
b. Predictors: (Constant), Access of Farmer to Agr Ext to Access Climate Info, What is your Gender, What is your Age, Highest Education Level, Household Income on Access to Climate Info

In conclusion, given the strong R squared value of 54.2% and the high F-value at 78.56 and low p-value at 0.001, the study concludes that socio-economic factors significantly influence access to climate information.

In Table 3, the multiple regression analysis explored how socio-economic factors influenced access to sufficient climate information among smallholder farmers in Baringo County. The regression model is expressed as follows:

$$Y = 2.647 - 0.044(\text{Age}) + 0.014(\text{Gender}) + 0.021(\text{Education Level}) + 0.062(\text{Household Income}) - 0.083(\text{Extension Access})$$

Where:
Y = Access to sufficient climate information

The results show that Gender (B = 0.014, p = 0.048) is statistically significant. This means that male farmers were slightly more likely to access climate information compared to female farmers. Education Level (B = 0.021, p = 0.058) also had a positive influence, suggesting marginal significance. This means farmers with higher education levels had better access to climate information. Equally, household income (B = 0.062, p = 0.007) had statistical significance, indicating that higher household income improves access to climate information. This was associated with better access to communication devices and extension services.

Table 3: Coefficients for Socio-economic Factors and Access to Climate Information

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2.647	0.281		9.408	0.000	2.094	3.201
	What is your Age	-0.44	0.035	-0.71	-1.273	0.104	-0.113	0.024
	What is your Gender	0.14	0.075	0.10	2.191	0.048	-0.133	0.161
	Highest Education Level	0.21	0.038	0.03	2.052	0.058	-0.073	0.077
	Household Income on Access to Climate Info	0.62	0.048	0.07	2.117	0.007	-0.088	0.099
	Access of Farmer to Agr-Ext to Access Climate Info	-0.83	0.051	-0.98	-1.639	0.102	-0.184	0.017

a. Dependent Variable: Access to Sufficient Climate Information

In conclusion, among the socio-economic variables, Gender and household income were statistically significant predictors of access to climate information. The model suggests that male farmers and those with higher income levels have better access to climate-related information. While age, education level, and extension services had positive effects, they were not statistically significant at the 5% level. These findings emphasize the need for targeted policies that enhance gender equity and reduce income-related disparities in climate information dissemination among the smallholder farmers of Baringo county.

Response and Effect of Climate Information on Economic Activities

Male farmers had a higher response of 55% against their female counterparts at 50%. This could be related to the societal role that the male played in decision-making and land ownership and other family properties as the household heads. (Figure 7). Also, the level of education of smallholder farmers had effect on the response rate to climate change. However, the difference of response between the different levels of education was very minimal; with Secondary level leading at 56%, and College level being least at 49% (Figure 8).

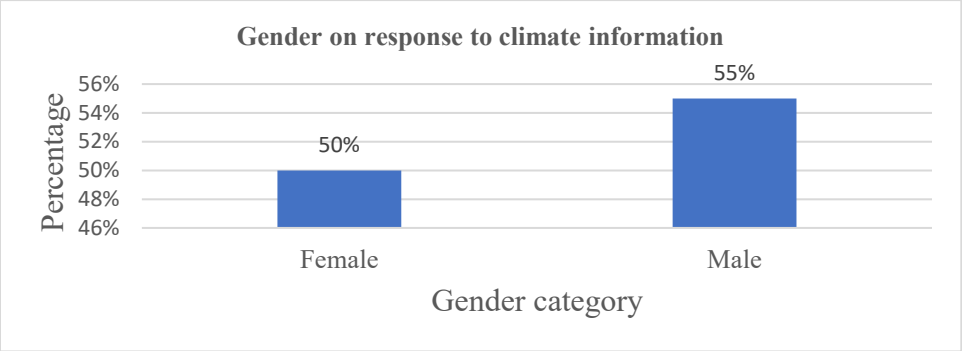

Figure 7: Gender on Response to Climate Information

The results in Figure 7 depict the fact that in many rural settings, men are traditionally recognized as the primary decision-makers in agricultural activities, land use, and financial investments. Men are more probable to engage with training programs, agricultural extension services, and climate information dissemination platforms that enable make informed decisions on farm management than their female counterparts. On the other hand, while female farmers (50%) also access climate information significantly, their engagement is constrained by gender-based challenges such as limited land ownership, reduced participation in decision-making, and a heavier burden of household responsibilities yet they play an important role in farming.

The implications of these findings suggest that gender-inclusive approaches should be adopted in climate information dissemination.

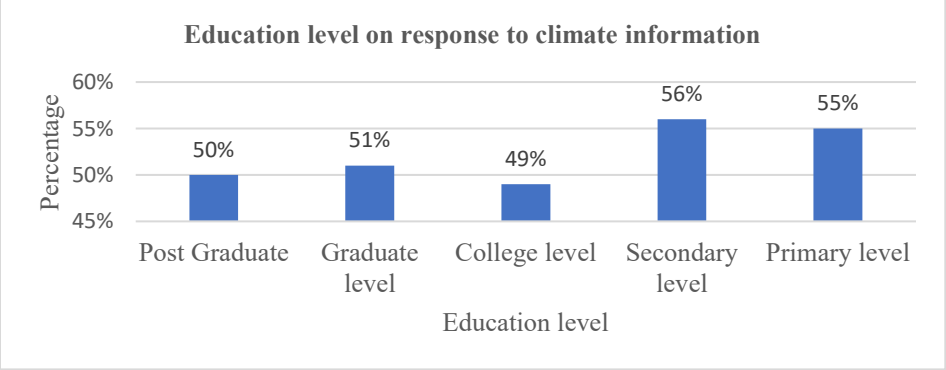

Figure 8: Education Level on Response to Climate Information

The outcomes in Figure 8 suggest that education level influenced the response rate to climate change information, while the differences through education levels were minimal, indicating that access to climate information was not significantly restricted by educational attainment. The highest response rate (56%) was recorded among secondary education level farmers, followed by primary education (55%)level farmers. This indicates that farmers with basic formal education are highly engaged in seeking and utilizing climate information, possibly because they form the majority of smallholder farmers and are more likely to rely on farming as their primary livelihood.

Farmers with graduate (51%) and post-graduate education (50%) had slightly lower response rates. This could indicate that higher education does not necessarily translate to greater engagement with climate change information in smallholder farming. Individuals with higher education levels may have diverse income sources, including formal employment, and might not be as dependent on climate information for their agricultural activities compared to those with lower education levels who rely more directly on farming for survival. The lowest response rate (49%) was observed among those with a college-level education, which is somewhat unexpected. This could be due to a smaller representation of college-educated individuals in farming communities, or their focus on non-agricultural sectors, leading to less direct interaction with climate information platforms.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The socio-economic factors that influenced climate information comprised of the following: Age; Gender; Household incomes; and, Education level. Television was the most effective medium, newspapers were the least used due to affordability constraints and limited accessibility, younger and middle-aged smallholder farmers (26–45 years) had the highest awareness (53%) due to greater engagement with digital platforms and agricultural training programs. Awareness declined among older farmers (46–60 years: 22%, above 60 years: 15%) due to limited digital literacy and reliance on traditional practices. Male farmers had higher awareness and access to climate information than female farmers, despite women being the primary implementers of farm activities. This highlights the need for gender-inclusive climate information strategies to empower women.

Higher education levels corresponded with greater awareness, ranged from 47% for primary school dropouts to 100% for post-graduates, indicating the importance for capacity-building programs to bridge the information gap. Household income significantly influenced access, with 83% of respondents acknowledging its role, while financial constraints limited access to digital platforms and extension services.

Access to extension services played a major role, with 89% of respondents affirming its importance in climate information dissemination. Age (28%) and education level (26%) were the most influential factors, followed by extension services (15%) and household income (14%). Digital platform access (13%) played a growing role, while gender (1%), electricity access (2%), and farming experience (2%) had minimal impact. Men, as primary decision-makers, had greater access to climate information and extension services. Women (50% access rate) faced challenges like limited land ownership, exclusion from decision-making, and heavy household responsibilities, necessitating gender-sensitive interventions. Also On the education, farmers holding secondary education had the highest response rate (56%), while post-graduate farmers (50%) and college-educated farmers (49%) had lower response rates, suggesting that reliance on climate information is higher in people with farming as primary livelihood.

The policy implication is that climate information dissemination should be inclusive, leveraging digital platforms for younger farmers, traditional methods (radio, community meetings) for older farmers, and simplified training for different education levels. Gender empowerment, financial support, and strengthened extension services are critical for equitable access to climate information.

These findings agree to study by Alidu *et al.* (2022), who establish that age, household income, household size, access to agricultural extension services and assets were the key drivers of smallholder farmers' joint decision to access climate information and adopt carbon farming practices. This implies that the socioeconomic factors had positive influence on climate information.

RECOMMENDATIONS

Since the main primary sources of information among the respondents were television and radio, when sharing climate information, it is recommended that Television and Radio to be used. Since that male farmers had a higher response rate to receiving climate information than their female counterparts, mainly due to the societal role that the male played in decision-making and ownership of land and other family properties, yet women are normally the main implementers of farming activities. Gender equity should be promoted by empowering women in decision-making and integrating gender-sensitive approaches into agricultural extension services.

Strengthening extension services by training officers and increasing accessibility is essential. Affordable technology access, such as subsidized smartphones, should be facilitated to enhance climate information reach. Programs should address income disparities by providing subsidies for climate-resilient inputs and information-sharing platforms. Increase awareness through Community-based sensitization of the farmer groups, particularly among less educated farmers. Expanding media use by broadcasting climate programs in local languages will improve inclusivity. Policy reforms should support women's land ownership and decision-making roles in agriculture. Lastly, climate education should be integrated into schools and community programs to build long-term awareness and resilience.

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