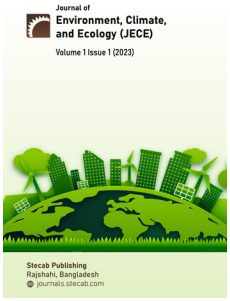

Journal of Environment, Climate, and Ecology (JECE)

Volume 1 Issue 1, (2024)

https://journals.stecab.com/index.php/jece

Published by
Stecab Publishing

Research Article

Access to Agro-Meteorological Information Among Smallholder Farmers in Chongwe District: A Demographic and Socio-Economic Analysis

*[1]Alubi, Tobias, [2]Tembo, Allan, [2]Daka, Alfred

About Article

Article History

Submission: June 12, 2024
Acceptance : July 25, 2024
Publication : August 26, 2024

Keywords

Agro-Meteorological Information, Agricultural Resilience, Climate Change Adaptation

About Author

[1] University of Zambia, Department of Plant Science, P.O. Box 32379, Lusaka, Zambia

[2] National Institute of Public Administration, Plot Number 4810, Dushambe Road, P.O Box 31990, Lusaka, Zambia

Contact @ Alubi, Tobias
tobias.alubi@unza.zm

ABSTRACT

Zambia's agriculture is vital for economic growth but it is recently threatened by the effects of climate change and climate variability. One major problem faced by smallholder farmers is access to agro-meteorological information for farm decision-making and adapting to good agricultural practices. This paper presents the findings of a chi-square and logistic regression analysis exploring the demographic and socio-economic factors associated with the accessibility of agro-meteorological information among smallholder farmers in the Chongwe District of Lusaka province. Questionnaires were administered to 142 smallholder farmers between June and August of 2022. Chi-square Test revealed that there was no association between age (p=0.565), sex (p=0.696), and household size (p=0.063) in accessing agro-meteorological information. However, there is a significant association in accessing agro-meteorological information by smallholder farmers among marital status (p=0.001), household Income (p=0.001), education attainment (p=0.000), and Land size acquisition (p=0.000) at 5% level of significance. The significant associations that existed were further modeled employing odds ratios at 95% confidence intervals to quantify the influence using multi-stage logistic regression analysis. The results showed that education attainment (OR=12.13: CI=1.048-140.384) and land acquisition (OR=13.136: CI=0.564-314.401) influence access to agro-meteorological information for farm decision-making for smallholder farmers. However, marital status, household income, household size and land size did not influence access to climatic information. The results suggest valuable guidance for targeted interventions to enhance agricultural resilience for smallholder farmers in the Chongwe district. It underscores the importance of education in improving access to agro-meteorological information.

Citation Style:

Alubi, T., Tembo, A., & Daka, A. (2024). Access to Agro-Meteorological Information Among Smallholder Farmers in Chongwe District: A Demographic and Socio-Economic Analysis. *Journal of Environment, Climate, and Ecology, 1*(1), 38–45. https://journals.stecab.com/index.php/jece/article/view/81

1. INTRODUCTION

Smallholder farmers of Chongwe District in Zambia benefit from access to agro meteorological information, which boosts their resilience and increases agricultural productivity (Teschemacher *et al.*, 2022). Chongwe is known for its subsistence farming, and the ability of farmers to use weather forecasts, climatic data, and other agricultural advisories services is a major factor in better agricultural outcomes (Jacqueline & Mubanga, 2020). Because extreme weather events are becoming more frequent and have distinct patterns that threaten smallholder agriculture, agro meteorological information is crucial (Ayanlade *et al.*, 2022).

Among the many difficulties faced by the smallholder farmers in Chongwe district is the lack of timely and reliable access to agro-meteorological data, which makes it more difficult for them to make decisions about how best to prepare their land, weed out, plant, irrigate, apply fertilizer, control pests, and harvest (Dhillon & Moncur, 2023). The issue at hand is exacerbated by demographic and socioeconomic factors, such as technology accessibility, educational attainment, land acquisition, and household income (Munir *et al.*, 2023). These factors can potentially impact the capacity of smallholder farmers to obtain and effectively utilize available agro-meteorological data.

To fully comprehend these obstacles, though, one must have a solid awareness and understanding of both economic and demographic aspects, such as land ownership and income levels, as well as characteristics like age, education, and farm size (Tatis Diaz *et al.*, 2022). Atsiaya *et al.*, (2023) report that their research indicates that socioeconomic factors and demographics have a major influence on farmers' access to and use of agro-meteorological information for farm decision making. Younger farmers with greater levels of education, for instance, are more likely to look for, get, and use agro-meteorological information (Finizola e Silva *et al.*, 2024). Furthermore, farmers who have access to internet and mobile phone services are more likely than their counterparts who do not to receive and act upon weather-related information (Yu & Gambrah, 2024).

1.1. Main objective

The major objective of this study was to evaluate smallholder farmers' present access to agro-meteorological information in Chongwe District and then determine the socioeconomic and demographic elements influencing that access. In order to serve better the requirements of smallholder farmers in Chongwe District, the study attempts to shed light on how effective the current agro-meteorological services are as well as offer workable suggestions for how to improve them.

By carefully examining the several variables that are being investigated and how they impact farmers' access to agro-meteorological data, this extensive research aims to support the creation of focused interventions that can enhance agricultural productivity and provide long-lasting resistance to climate change.

2. LITERATURE REVIEW

Access to comprehensive and timely agro-meteorological information is critical for the realization of sustainable agricultural productivity (Agyekum *et al.*, 2022). Smallholder farmers in developing countries remain particularly vulnerable to the impacts of climate change, due to among other things, their limited capacity to access and utilize such vital information (Mitter *et al.*, 2024; Lindoso *et al.*, 2012). In Zambia, despite agriculture being mostly rain-fed, it has been observed that very few smallholder farmers use weather and climate information in their farming practices (Ngoma *et al.*, 2021; Makondo *et al.*, 2014). In Chongwe some smallholder farmers use some form of weather and climate information, mainly traditional means such as observing the behavior of plants and animals and/or indigenous knowledge (Ndhlovu & Muchapondwa, 2020 ; Zvobgo *et al.*, 2023). This is amid accessibility of agro-meteorological information from the Zambia Meteorological Department and several research institutions in the country. Various factors could be attributed to the limited access and/or usage of agro-meteorological information among the smallholder farmers in Chongwe District. Demographic factors such as age, gender, education level, and household size significantly influence farmers' access to agro-meteorological information (Jha & Gupta, 2021). Elderly farmers may face challenges in accessing and utilizing modern information communication technologies (ICTs) compared to younger farmers (Byrappa Gowdu Viswanathan *et al.*, 2018). Similarly, gender disparities may exist, with women having limited access due to cultural norms or unequal opportunities for education and ICT literacy (Campos & Scherer, 2024). Moreover, the level of education plays a critical role, as farmers with higher education levels are more likely to understand and utilize meteorological information effectively (Nyang'au *et al.*, 2021). Additionally, household size may affect access, as larger households may have more competing demands on resources, making it harder to invest time and money in accessing such information (Hosany & Hamilton, 2023).

According to Onyango *et al.*, (2023),socioeconomic factors also play a significant role in determining access to agro-meteorological information. Income level is a key determinant, as wealthier farmers may afford better communication devices and internet connectivity to access weather forecasts and agricultural advisories (Khan *et al.*, 2022). Moreover, access to agricultural extension services and membership in farmer organizations can facilitate access to such information, as these platforms often disseminate weather forecasts and climate-related advisories (Ngigi & Muange, 2022). Furthermore, access to physical infrastructure such as roads and electricity can affect farmers' ability to access information hubs or utilize ICTs effectively (Ndimbo *et al.*, 2023).

Furthermore, Nkuba *et al.*, (2023) indicated that availability and accessibility of technology infrastructure, such as mobile phones, internet connectivity, and radio stations, are crucial factors influencing farmers' access to agro-meteorological information. While mobile phones are prevalent in rural areas, network coverage and affordability of data services remain challenges (Cabrera-Castellanos *et al.*, 2021). Moreover, internet penetration in rural areas may be limited, restricting farmers' access to online weather platforms and agricultural information portals (Tong *et al.*, 2024). Radio broadcasts remain an important means of disseminating weather forecasts and agricultural advisories, especially in remote areas with limited internet connectivity (Meinam, 2023). However, the effectiveness of

radio broadcasts may be constrained by language barriers or competing programs.

It is also noted that cultural beliefs, social networks, and institutional arrangements also impact farmers' access to agro-meteorological information (Tarchiani *et al.*, 2021). Additionally, traditional knowledge systems and indigenous forecasting methods may coexist with modern meteorological services, influencing farmers' perceptions and utilization of weather information (Zuma-Netshiukhwi *et al.*, 2013). Moreover, social networks and community-based organizations play a crucial role in disseminating weather-related information and building resilience to climate variability (Carmen *et al.*, 2022). Institutional support from government agencies, NGOs, and research institutions is essential for developing and disseminating context-specific weather forecasts and climate-related advisories tailored to the needs of smallholder farmers (Nyoni *et al.*, 2024).In conclusion, access to agro-meteorological information among smallholder farmers in Chongwe District is influenced by a myriad of demographic, socioeconomic, technological, cultural, and institutional factors. Addressing these factors requires a holistic approach that involves targeted interventions to improve ICT literacy, expand access to technology infrastructure, strengthen institutional support, and promote gender equality and social inclusion. Additionally, fostering partnerships between government agencies, NGOs, research institutions, and local communities can enhance the effectiveness and relevance of weather-related information services. By addressing these challenges, policymakers and stakeholders can empower smallholder farmers to make informed decisions, enhance agricultural productivity, and build resilience to climate change impacts in Chongwe District and beyond.

3. METHODOLOGY

The study adopted a case study approach, leveraging survey data from 142 smallholder farmers in Chongwe District in 2022. Statistical analysis involved the utilization of the chi-square test to examine associations between demographic and socioeconomic variables and the accessibility of agro-meteorological information. Additionally, odds ratios and 95% confidence intervals were employed to quantify the influence of key explanatory variables on access to agro-meteorological information.

3.1. Research Design

A case study approach was used to facilitate an in-depth appreciation of the research topic and allowed for the focused investigation of a specific example within a broad field of inquiry (Greenwood, 1993). This methodical approach enabled systematic monitoring of various aspects within the selected case, including data collection, analysis, and interpretation (Taherdoost, 2021). The study adopted a quantitative methods approach, relying on structured quantitative data from primary sources, particularly through the use of a close-ended questionnaire (Mohajan, 2020).

3.2. Research Site

The research was carried out in the Chongwe District of Lusaka Province. The targeted smallholder farmers were located in an agro-ecological region with low to medium agricultural potential and favorable meteorological conditions for rain-fed agricultural crop development (Nyang'au *et al.*, 2021).

3.3. Population of the Study

The population studied comprised of smallholder farmers from Chongwe district's agricultural camps of Kanakantapa, Nkomesha, Kampekete, Palabana, Katoba, and Lwimba. 219 smallholder farmers with less than two hectares of land in the Chongwe district's selected agricultural campus were determined as suitable responses. According to Food Agricultural Organisation, (2017), a smallholder farmer is defined by their living standards, land ownership, access to land, agricultural activity, and production scale, access to resources and assets, and share of family labor. However, in this study, a smallholder farmer was defined as any farmer farming land of less than 2 hectare (Kamara *et al.*, 2019).

3.4. Sample Population

A study sample represents a population that is accessible and serves as a representative subset of the entire population (Mugenda, 2003). Utilizing Taro Yamane's model, as discussed by Kamara *et al.*, (2019), allows for the prediction of sample size when the population is known, and a smaller sample is selected using random sampling techniques. To ensure accuracy, a 95% confidence interval was applied, following the guidance of Nanjundeswaraswamy & Divakar, (2021), indicating a 95% probability that the sample results accurately reflect the true condition of the population within a specific range. Taro Yamane's model facilitates the sampling of a population with the desired level of precision, with the formula for computing sample size being a crucial component of this approach:

$$n=N/(1+N(e)^2) \quad (1)$$

Where,

N = Sample size

N = Total population of smallholder farmers

e = Error tolerance

A total of 142 smallholder farmers, operating on less than 2 hectares of land, were selected from agricultural camps located in Kanakantapa, Nkomesha, Kampekete, Palabana, Katoba, and Lwimba. The selection process employed a simple random technique, as recommended by Kalton, (2011). This method is known to minimize sampling error within the population, thereby enhancing the accuracy and precision of estimation methods utilized in the study.

3.5. Sampling Techniques

The researcher employed simple random sampling to select smallholder farmers for the study. This method involved creating a comprehensive list of potential respondents, assigning each a unique number, and then using a computer-generated random table to choose participants. By utilizing this approach, human bias in respondent selection was minimized, ensuring that every individual had an equal opportunity to be included in the study. This technique is recognized for its fairness and impartiality in participant selection.

3.6. Data Collection Tools

In Chongwe district, 142 questionnaires with highly structured closed-ended questions were administered using the Kobo collect application via face-to-face surveys. This method ensured uniformity in questioning among respondents, facilitating systematic and comprehensive data collection.

3.7. Data Analysis

The paragraph describes the analysis of data collected via Kobo collect, involving stages such as importing into a spreadsheet and transferring to SPSS IBM 22.0 software. Various analytical methods including univariate, bivariate, and multivariate approaches were used. Chi-square tests evaluated socioeconomic factors' association with agro-meteorological data access, while logistic regression gauged probabilities that determine access to agro-meteorological information for farm decision making.

The model for this study is represented as

$$Y=\beta_0 +\beta_1X_1 +\beta_2X_2 +\beta_3X_3 +.....+ \beta_mX_m + \varepsilon, \quad (2)$$

In this equation, Y represents the dependent variable, which is access to agro-meteorological information. The coefficients β_0 to β_m represent the constant term and the coefficients of the independent variables (X_1 to X_m) respectively. These independent variables are explanatory factors affecting access to agro-meteorological information. Additionally, β represents the error term, capturing the difference between the observed and predicted values of the dependent variable.

The model focused on access to agro-meteorological information as the dependent variable. Drawing from research by Antwi-Agyei & Stringer, (2021), and (Muema, 2018) it incorporated various explanatory variables. But in this study the following variables were included: farmer characteristics such as age, marital status, and education level, alongside farm characteristics like land size and acquisition method. Demographic factors such as gender, and socio-economic factors including education level and household income were also considered. This comprehensive approach aimed to explore the diverse influences on access to agro-meteorological information, facilitating a deeper understanding of its determinants.

4. RESULTS AND DISCUSSION

In Table 1, Chi square test was used to ascertain the existence of association on the access to agro-meteorological information on smallholder farmers for farm decision making. The results obtained shows that are no significant association that exist between age group, gender and household size. The results indicate no significant association between age groups and access to agro-meteorological information (p = 0.565). However, notable variations exist among different age cohorts, with the highest access observed in the 45 and above category (50.0%). The younger the age group the lower the urge to access the agro meteorological information. The results also shows that gender differences in access agro meteorological information are not statistically significant (p = 0.696). While a higher proportion of males accessed information (72.73%) compared to females (27.27%), the difference was not significantly different. This also shows that whether a respondent is male or female, it does not give gender a bias to accessing agro-meteorological information. While the association between household size and information access was not statistically significant (p = 0.063), smaller households (one and two members) tended to have lower access. Furthermore, association were found to exist between marital status and information access (p = 0.001). Married individuals exhibited higher access (59.1%) compared to singles (9.1%), divorced (4.6%), separated (13.6%), and widowed (13.6%). Married individuals usually has a common goal of achieving good farm management decision making based on access and use of agro-meteorological information. Significant associations were observed between land size (p = 0.027), land acquisition (p = 0.000), and information access. The positive association is due to increased risk associated with size of the land to a farmer. Also land acquisition for farming entails the need to access agro meteorological information on the rainfall patterns and other parameters for farm decision making. Smaller land sizes (0-3 hectares) and those with land allocated by the clan exhibited higher access. The clan longevity on the land, tend to have more agro meteorological information on land suitability over time.

Table 1. Chi-square Test: demographic and socioeconomic factors associated with accessibility of agro-meteorological information

Explanatory variable	Access of Agro-geometrical information		P-value
	Accessed	No access	
Age			
19-24	0.0	2.4	0.565
25-29	9.09	6.5	
30-34	9.09	10.5	
35-39	22.7	9.7	
40-44	9.1	12.1	
45 and above	50.0	58.87	
Sex			
Male	72.73	68.6	0.696
Female	27.27	31.5	
Marital status			
Single	9.1	9.1	0.001
Married	59.1	86.9	
Separated	13.6	2.0	
Divorced	4.6	0.0	
Widowed	13.6	2.0	
Household income			
Less than K5000	36.4	21.8	0.000
K5001-K10,000	45.5	78.2	
Above K10,000	18.2	0.0	

Education attainment			
Primary	4.6	0.0	0.000
Secondary	90.9	46.0	
Tertiary	4.6	54.0	
Household size			
one	0.0	15.3	0.063
Two	31.8	31.5	
Three	45.5	45.2	
Four	22.7	8.1	
Land size			
0-3 hectares	50.0	75.8	0.027
4-6 hectares	45.5	19.4	
7-10 hectares	4.6	4.8	
Land Acquisition			
Allocated by clan	77.3	58.9	0.000
Bought	13.6	41.1	
Rented	9.1	0.0	

Source: Author's survey (2022)

In table 2; married individuals indicated an odds ratio of 0.665. Generally, results showed that marital status; married (OR=0.665: CI=1.048-0.973-4.144); separated (OR= 3.574: CI=0.281-45.475); widowed (OR=6.407: CI= (0.365-112.495) were not significant at 95% Confidence Interval (CI), respectively. Even though married individuals have an odds ratio of 0.665, the results suggests a reduced likelihood of accessing agro meteorological information for farm decision making, separated implied an increased likelihood of access to agro meteorological information compared to singles.

In Table 2: the results for household income (OR=0.583: CI=0.133-2.566) showed that they were not statistically significant at 95% CI. Those earning between K5001 and K10,000 exhibit an odds ratio of 0.583, suggesting a reduced likelihood of accessing information. Land size also showed no significant differences where 4-6 hectares indicated (OR= 1.818: CI=0.339-9.739) and 7-10 hectares (OR=13.136: CI=0.564-314.401), respectively. Notably, smallholder farmers with land sizes ranging between 7-10 hectares had a higher odds ratio of 13.136, but with confidence interval between 0.564 and 314.401. The results obtained suggest that if the access of the agro-meteorological information occurs for farm decision making, it will be attributed to a mere chance. Though land acquisition was not statistically significant as indicated in Table 2, those smallholder farmers that bought land exhibit an odds ratio of 2.687, suggesting an increased likelihood of accessing information for farm decision making. However, education attainment indicated that it influences the access to agro meteorological information for farm decision making (OR=12.13: CI=1.048 -140.384). This implies that those with secondary education as level of education are 12 times more likely to access agro meteorological information for farm decision making as compared to those smallholder farmers with primary level of education.

Table 2. Logistic regression of factors associated with accessibility of agro-meteorological information

Explanatory variable	Odds ratio	95% Confidence Interval	
Marital status			
Singles	1		
Married	0.665	[0.973	4.144]
Separated	3.574	[0.281	45.475]
Widowed	6.407	[0.365	112.495]
Household income			
less than K5,000	1		
K5001-K10,000	0.583	[0.133	2.566]
Education attainment			
Primary	1		
Secondary	12.13	[1.048	140.384]
Land size			
1-3 hectares	1		
4-6 hectares	1.818	[0.339	9.739]
7- 10 hectares	13.136	[0.564	314.401]
Land acquisition			
Allocated by the clan	1		
Bought	2.687	[0.285	2.530]

4.1. Discussion

This study examined into the factors that affect smallholder farmers' ability to obtain agro-meteorological data for farming decision-making. Although there were no statistically significant connections between household income and marital status (married, separated, or widowed) at the 95% confidence interval (CI), other characteristics such as education level and land acquisition status were found to be significant determinants.

It's interesting to note that married people had a lower odds ratio (OR=0.665) than single people, which may indicate a decreased chance of accessing this data. It's possible that decision-making responsibilities in married homes restrict access for one partner, especially for wives in some societies. On the other hand, compared to singles, separated people had a higher (OR=3.574), suggesting a higher chance of information access. This might result from a change in who makes decisions after a breakup. On the other hand, the results corroborate the research by Jha and Gupta (2021), which discovered that married couples had a higher likelihood of accessing climate-related information than single individuals (Jha & Gupta, 2021). One noteworthy aspect that emerged was education level. Compared to farmers with only a primary education, those

with a secondary education had a 12-fold higher likelihood of accessing information (OR=12.13; CI=1.048-140.384). This emphasizes how crucial educational initiatives are in providing farmers with access to agro-meteorological knowledge. Similarly, Muema's (2018) study found that education had a key role in helping smallholder farmers close the knowledge gap by increasing their access to meteorological information.

The status of land acquisition also had some bearing. People who purchased land had a higher (OR=2.687) than those who inherited land, however this difference was not statistically significant, indicating a potential relationship between proactive information searching and land ownership. According to a study done in 2019 by Kamara and his colleagues, farmers who own property may be more involved in commercial agriculture and, as a result, have more motivation to look for knowledge to increase yields and profitability (Kamara *et al.*, 2019). However, there was no discernible correlation between land size. Higher landholding persons (7–10 hectares) had a very high (OR=13.136; 95% CI=0.564-314.401).

5. CONCLUSION

The factors influencing smallholder farmers' capacity to acquire agro-meteorological data for farming decision-making were examined in this study. While education level was found to be a significant factor, income and marital status did not demonstrate statistical significance. Farmers with a secondary education were considerably more likely to have access to this knowledge than farmers with only a primary education. The state of land acquisition also appeared promising, with those who bought land showing a tendency towards greater access to information. These results emphasize the value of educational initiatives designed to provide smallholder farmers with the know-how to obtain and apply agro-meteorological data. Targeted interventions that take into account variables like land ownership and marital status could improve agricultural decision-making and increase the transmission of information. It is advised that future studies employing bigger sample sizes confirm these preliminary results and investigate the underlying causes of the observed correlations. The following recommendations are offered to enhance smallholder farmers' access to agro-meteorological information in light of the study's findings: Create instructional initiatives especially for smallholder farmers that emphasize the value of using agro-meteorological data in farm decision-making. Programmes should be tailored to various reading levels, providing opportunities for people with little or no formal schooling. To reach a larger audience, make use of a variety of distribution platforms, including radio broadcasts, smartphone applications, and farmer field schools. Secondly, examine the unique information-accessibility issues that married couples and single people encounter. Create communication plans that tackle these issues and provide the household's decision-makers more authority. Examine smallholder farmers' reasons for buying land, and create initiatives that take advantage of their proactive information-seeking tendencies to increase the availability of agro-meteorological data. Thirdly, to confirm the results of marriage status and land acquisition status, conduct more studies with bigger sample size. To create solutions that are more precisely targeted, investigate the underlying causes of the observed connections. Examine the long-term effects on farm productivity and decision-making processes of having better access to agro-meteorological information.

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