Determinants of access and utilisation of seasonal climate information services among smallholder farmers in Makueni County, Kenya

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Abstract

Climate change is a major development challenge in sub-Saharan Africa. This region is highly vulnerable to negative impacts of climate change due to low adaptive capacity and overreliance on rain-fed agriculture for food security and livelihood. Climate information services (CIS) have been developed in Kenya to help enhance farmers’ adaptation to climatic shocks, but their access and utilisation remain low. The factors that influence farmers’ access and use of CIS are not well-known. Using survey data from a sample of 250 households in Makueni County, this study estimated a two-step Heckprobit model to analyse the determinants of access and use of CIS. Results showed that the age of the household head reduced the likelihood of accessing CIS whereas household size, income, farm size, livelihood activity, television ownership and group membership increased it. Age, sex of the household head, and frequent exposure to drought reduced the likelihood of using CIS whereas access to improved seed, household income, radio ownership, and livelihood activity increased it. Efforts promoting access to and utilisation of CIS would benefit by building trust among...
farmers through provision of accurate information; promoting adoption of improved varieties of crops; and providing incentives for formation and participation in farmers’ groups.

Keywords: Agriculture, Economics

1. Introduction

Climate variability poses tremendous challenges on sustainable agricultural production and livelihoods in sub-Saharan Africa (SSA). According to the Intergovernmental Panel on Climate Change (IPCC), annual temperatures in Africa have increased steadily by 0.5 degrees Celsius with the drier subtropical regions warming more compared to moist tropics (Eriksen and Rosentrater, 2008). This has resulted in decreased precipitation levels and increased evapotranspiration which amplify water scarcity and unprecedented threats to the region’s rain-fed agriculture.

Persistent climate-related shocks constrain socio-economic development in SSA’s agro-based economies. The IPCC has predicted a 50 percent decline in rain-fed agriculture yields of major staples by 2020 and 90 percent drop in net crop revenues by 2100 in SSA (IPCC, 2007). Moreover, Schlenker and Lobell (2010) predicted 8 to 22 percent decline in maize, sorghum, millet, groundnut and cassava production by 2050 attributed to climate change.

Similar to majority of SSA countries, agriculture is the main contributor of Kenya’s GDP and source of raw materials for local industries. Major climate shocks experienced in Kenya include floods, drought, variable precipitation levels and increased prevalence of pests and diseases. Among these climate shocks, drought is the most common with 28 major droughts recorded in the country in the past 100 years (Gichangi et al., 2015; World Bank, 2016). To reduce the country’s vulnerability to climate risks the government launched the National Climate Change Response Strategy (NCCRS) in 2010 and Kenya National Climate Change Action plan (NCCAP 2013-2017) in 2013 in efforts to identify and promote interventions geared towards enhancing resilience and adaptation to climate change.

Adaptation is a response strategy which entails adjustments to enhance preparedness and response to current and future climate change adversities. Several adaptation options exist based on diversified agricultural practices which are determined by environmental, economic, institutional, cultural and demographic factors. Lack of relevant climate information is one of the major barriers to effective climate change adaptation. According to Jones et al. (2000), access to timely and accurate climate information services (CIS) of approximately three to six months before time is an adaptation initiative prerequisite for agricultural production and risk mitigation.
Climate information services entail the provision of climate forecasts accompanied by agronomic advice meaningful for offsetting uncertainties that constrain farm decision making against climate risks (World Bank, 2016). Previous studies have emphasised that to realise the full potential of climate forecast in agriculture, climate information should be accompanied by strategically formulated response strategies for climate risks adaptation (O’Brien et al., 2000; Klopper et al., 2006). This information influence decisions such as; farmland preparation, planting dates, crop variety, when to harvest and market for output.

Climate information services in Kenya are mainly provided by government agencies, international organisations, research and academia, community-based organisations and non-governmental organisations (CBOs and NGOs). The Kenya Meteorological Department (KMD) is the national meteorological agency mandated to collect and store national climate data and manage the climate information provision framework. The CIS are provided through newspapers, bulletins, radio, television, trained personnel/intermediaries, short media messages (SMS) and internet.

Seasonal forecast is a major form of climate information which entails probabilistic estimations of precipitation and temperature indicators in the forthcoming seasons on two to three months’ time scales (Ziervogel and Calder, 2003). This forecast is important to smallholder farmers because seasonality shapes fluctuations in their vulnerability and resilience to impacts of climate change in Africa and the rest of the world (Roncoli, 2006).

However, the potential benefits of CIS can only be realized if they are accessible, accurate, and relevant for decision making of farmers, and if there exists institutional support to provision and actual use (Hansen, 2002). Although the provision of CIS by the KMD alongside other CIS providers has been promising, their access and application to manage climate risks are limited (World Bank, 2016). Both access and use of climate information services are fraught with technical, social, economic and psychological challenges which compromise their benefits in climate change adaptation (Serra and Mckune, 2016). Understanding the factors that inhibit access and use of CIS is imperative to enhance their application in farm decisions (O’Brien et al., 2000; McOmber et al., 2013).

A few studies have assessed the state of access and use of climate information in Africa using different methods. For instance, Mudombi and Nhamo (2014) used descriptives to analyse access to weather forecast in Zimbabwe, Oyekale (2015) used two separate probit models to analyse factors explaining access and utilisation of extreme climate forecast in SSA and Coulibaly et al. (2017) used descriptive analysis to analyse the access and use of CIS in Rwanda. However, the findings of these previous studies are country specific and given the heterogeneity of the countries, the parameter estimates are of little importance in addressing the various constraints to access and utilisation of CIS in Kenya. Furthermore, the decision about whether or
not to use CIS depends first on farmers’ access to such services. Estimating two separate probit models when access to and use of CIS are sequentially related would bias the parameter estimates and generate misleading conclusions. Therefore, this study aimed at bridging these gaps by analysing the determinants of both access and use of climate information services among smallholder farmers in Makueni County, Kenya using a two-step selection procedure.

2. Materials and methods

This research used a qualitative and quantitative approach. Surveys were undertaken among farmers but before the actual survey, a pre-test of the household questionnaire was done. The overall research was undertaken in two weeks including a reconnaissance study.

2.1. Study area

Arid and semi-arid areas in Kenya occupy 83 percent of the total land and receive an annual rainfall of 200–700 mm (Macharia et al., 2012; Mutua et al., 2016). These areas are most vulnerable to negative impacts of climate change due to extreme droughts and heavy reliance on rain-fed agriculture for livelihood. This study was conducted in Makueni County which is one of the arid and semi-arid lands of Kenya characterised by high water scarcity, declining food production and low resilience to climate variability. The county occupies 8,034.7 km² on the South Eastern part of Kenya bordering Kajiado, Kitui, Taita Taveta and Machakos counties with a population of 922,183 people (Republic of Kenya, 2013).

Smallholder farmers dominate mixed farming in the county growing food crops (maize, beans, cowpeas, pigeon peas, sorghum, millet and green grams), fruit trees (citrus, mangoes) and livestock rearing (chicken, goats, donkey and cows). Rain-fed agriculture which is the main livelihood activity is highly responsive to drought and erratic rainfall which are the major climate shocks experienced in the county (Kitinya et al., 2012).

2.2. Sampling and data collection

The study used primary data which collected using farmer interviews and pre-tested structured questionnaires administered on household heads in charge of farm decisions. Multistage sampling was used to arrive at the sampling unit used for the survey. In the first stage, Makueni Sub County was purposively selected due to frequent exposure to drought and erratic rainfall. In the second stage, two wards (Muvau and Wote) were selected from the total of six wards with the help of county agricultural officer. Muvau ward had a total of six sub locations and Wote three sub-locations. In the third stage, two sub-locations were randomly selected from Wote ward and three
from Muvau ward. In the fourth stage, a list of all the villages from the respective sub location was made and 5 villages randomly selected from each sub location. As a final step, systematic random sampling was employed to select ten households from each village to arrive at the desired sample of 250. The analysis was, however, based on 243 households from whom data were complete. Data were entered, cleaned and analysed using STATA version 14.

2.3. Econometric estimation

The dependent variables of both access and use of seasonal CIS were dichotomous. Single equation probit models are often estimated when the dependent variable is binary. In the current case, however, the decision to use seasonal CIS was endogenously determined since farmers had to access CIS first so as to utilise them for farm decision making. In such cases, a Heckprobit model with sample selection is preferred in order to correct for selectivity bias since farmers with and without access to seasonal CIS may have different likelihoods of utilising CIS (Heckman, 1979; Van De Ven and Van Praag, 1981). Various studies such as Deressa et al. (2008), Van den Broeck et al. (2013) and Asrat and Simane (2018) also used Heckprobit in analysing climate change adaptation strategies.

The Heckprobit model was implemented in a two-step procedure. In the first step, the selection equation analysed the determinants of access to seasonal CIS whereas in the second step the outcome equation analysed the determinants of use. To control for selectivity bias Inverse Mills Ratio (IMR) from the first step (selection equation) were included in the second step (outcome equation) (Van De Ven and Van Praag, 1981). The Heckprobit models with sample selection assume the error terms of the selection equation and outcome equation are correlated. Formally, the model can be described as follows:

\[
Y_1 (\text{ASCIS}) = \begin{cases} 
1, & \text{if the farmer had access to seasonal CIS} \\
0, & \text{otherwise}
\end{cases}
\]

\[
Y_2 (\text{USCIS}) = \begin{cases} 
1, & \text{if the farmer used seasonal CIS in farm decision making} \\
0, & \text{otherwise}
\end{cases}
\]

\[
Y_2 = \beta X_i + \beta_1 \alpha_i + \epsilon_{1i} \quad \text{Main Equation (1)}
\]

Equation 1 is the second stage equation plus the inverse mills ratio as an additional explanatory variable to solve for selectivity bias. \( Y_2 \) (use of CIS), was meaningfully observed if \( Y_1 \) (access of CIS) = 1.

\[
Y_1 = \alpha Z_i + \epsilon_{2i} \quad \text{Selection Equation (2)}
\]
\[ Y_2 = \beta X_i + \epsilon_1 \quad \text{Latent Equation} \]  
\[ \epsilon_1 \text{ and } \epsilon_2 \sim N[0,1] \]

\[ \text{Corr } [\epsilon_1, \epsilon_2] = \rho \]

\( \beta \) and \( \alpha \) were the vector of coefficients associated with the independent variables, \( X_i \) and \( Z_i \) represented the exogenous variables (socio-economic characteristics) that determined \( Y_2 \) and \( Y_1 \) respectively, \( \epsilon_1 \) and \( \epsilon_2 \) were the respective error terms normally distributed with zero mean, unit variance and correlation \( \rho \). When the \( \rho \neq 0 \) the standard probit model 3 would yield biased estimates. Therefore, to correct for selectivity bias this study considered that

\[ \text{Prob } (Y_1 = 1) = \text{Prob } (\epsilon_2 > -\alpha Z_i) = \text{Prob } (\alpha Z_i) = \Phi(\alpha Z_i), \]

Whereby, \( \Phi \) represented the cumulative distribution at \( \alpha Z_i \). Hence

\[ E[Y_2|Y_1 = 1] = \beta X_i + \rho \sigma \lambda_i(\alpha Z_i) \quad (4) \]

Where \( \lambda_i = \phi(\alpha Z_i)/\Phi(\alpha Z_i) \), with \( \phi \) representing the probability density function at \( \alpha Z_i \). \( \lambda_i \) is the inverse mills ratio (IMR) which is the ratio of value of density function of standard normal distribution \( \alpha Z_i \) and the probability of being in the sub sample with access to seasonal CIS which is similar to cumulative distribution valued at \( \alpha Z_i \) for the households with access and a complement of 1 for households without access. On the other hand \( \rho \sigma \) is the regression coefficient on the inverse mill ratio \( \beta \lambda \). Therefore, to correct for selectivity bias and achieve unbiased efficient estimates IMR was included in the second stage equation (1).

In correspondence with previous studies on factors influencing access and utilisation of climate information such as Ingram et al. (2002), Oyekale (2012), Kirui et al. (2014), Yong (2014) and Ochieng et al. (2017), the independent variables included in the selection equation (Determinants of access to CIS) were; 

- **farmer characteristics** (Age of household head measured in years, sex of household head—equal to 1 if male and zero female, Household size—number of resident household members, Year of completed formal education of household head, major livelihood activity—equal to 1 if farming and 0 if otherwise, Household monthly cash income in Kenya Shillings);
- **farm characteristics** (Farm size in hectares, Frequency of exposure to drought),
- **institutional factors**, (access to extension services—equal to 1 for farmers with access to extension services and 0 if otherwise, access to credit—equals 1 if household received credit and 0 if otherwise, Group membership—equal to 1 if the household has a member who participated in a farmers’ group and 0 if otherwise),
- **communication assets** (radio ownership—equals 1 if household own a radio and 0 if otherwise, television ownership—equals 1 if household owned a television and 0 if otherwise). Similar variables were used in the outcome equation. For identification purposes, however, group membership was omitted from the outcome equation but included in the selection
equation. Additionally, farm characteristics, such as access to organic fertilizers—a dummy variable equal to 1 if the household applied organic fertilizers and 0 if otherwise, access to improved seed—a dummy variable equal to 1 if the household grew an improved variety of crop and 0 if otherwise, access to farm equipment—a dummy variable equal to 1 if a household had access to farm equipment and 0 if otherwise were included in the outcome but not selection equation. Variables measuring access to farm inputs were included in the outcome equation (determinants of use of SCIS) because access to basic agricultural technologies such as new crop varieties, fertilizers and farm equipment are important to ensure farmers utilise and benefit from climate information services (Ingram et al., 2002; Klopper et al., 2006).

3. Results and discussion

3.1. Socio-economic characteristics of smallholder farmers in Makueni County

Table 1 shows the descriptive statistics of explanatory variables included in the model. The results showed that 65 percent of the sampled households were male-headed. The age of the household head ranged between 23 — 90 years with a mean of 53 years. This finding concurs with the World Bank report that majority of youth do not participate in agriculture in Kenya (Brooks et al., 2013). The expected direction of influence of age on access and use of CIS is ambiguous in that older farmers may have accumulated experience in farming which they may use

Table 1. Summary statistics of sample households.

| Variables                              | Mean   | SD      | Expected sign |
|----------------------------------------|--------|---------|---------------|
| Age of Household Head (years)          | 53.1   | 14.2    | +/-           |
| Sex of household head (% male)         | 65.0   |         | +/-           |
| Household size (number of resident members) | 5.0  | 1.9     | +/-           |
| Education of the household head (years) | 9.7   | 4.3     | +            |
| Land allocated to farming (hectares)   | 3.3    | 2.8     | +            |
| Households monthly Income (Ksh)        | 21,481.4 | 20,615.2   | +            |
| Access to improved seed (% yes)        | 74.0   |         | +            |
| Access to credit (% yes)               | 60.0   |         | +            |
| Access to Extension services (% yes)   | 27.0   |         | +            |
| Farming is the major income activity (% yes) | 50.0 |         | +            |
| Group Membership (% yes)               | 78.0   |         | +            |
| Household applied organic fertilizers (%yes) | 82.3 |         | +            |
| Household owns a radio (%yes)          | 86.8   |         | +            |
| Household owns a television (%yes)     | 32.6   |         | +            |

Source: Author’s survey 2017.

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to cope with climatic shocks hence risk-averse to new information. On the other hand, such farmers may understand the adverse effects of climatic shocks making them more receptive to new information.

The education levels were categorized into three; primary education (1–10 years), secondary education (11–14 years) and tertiary level (above 15 years). The results showed that the average years of education was 9 years which implied that majority of household heads had attained primary education. This is supported by the World Bank (2004) report that 87 percent of Kenya’s population have gone through primary education. Moreover, the community believes education is the means to break poverty vicious cycle since farming is fraught with various climate shocks. The effect of education on access and use of CIS is also ambiguous and subject to empirical analysis. Whereas educated household head can be expected to actively search for, grasp, and apply information about CIS, such farmers may also have a greater incentive to work, at least part-time, off-farm in non-agricultural activities that are less sensitive to climatic shocks.

The results also indicated that 78 percent of the sample households were members of development groups. Table banking, credit facilities, social welfare and agronomic services were the various services offered in the groups.

Access to credit may ease liquidity constraints faced by farmers in accessing production resources. The results showed that 60 percent of households had access to credit facilities. Lack of collateral, inability to pay back borrowed loans, and lengthy procedures were the main hindrances to credit access.

Majority of the households interviewed had access to improved seeds but only in small quantities due to high prices. Although Kenya has a more developed seed system compared to other African countries, their access by farmers is limited (FAO, 2015). This results in farmers using indigenous seeds from the previous harvest which compromises agricultural yields.

Despite extension services being the major change agents towards the transformation of subsistence farming to modern agriculture, only 27 percent of the households accessed them (Table 1). Mwangangi et al. (2012) also noted that the lack of extension services was a major hindrance to agricultural development in Makueni County. According to Makueni County Annual report (2017), the current ratio of extension officer to the farmer is 1:1,700 which is very high compared to the recommended ratio 1:400 by the FAO hence compromising effective access and use of appropriate agricultural technologies.

Mixed farming was the major income activity in the area. This was mainly practiced by smallholder farmers since the households interviewed had an average farm size of 3.3 ha.
However, farming was mainly practiced for subsistence needs with only little surplus sold to meet non-food household needs. High dependence on rain-fed agriculture for livelihood increases the county’s vulnerability to climate change. Therefore enhancing drought resilience agricultural practices and livelihood diversification will reduce the County’s vulnerability to climate change and increase food security.

Irrespective of maize been highly sensitive to climate change, it was grown by all households interviewed in the area. This is because maize is the main staple food in the study area. The other cereals grown were; beans, pigeon peas, cowpeas, sorghum, millet, greengrams and fruit trees. This portrays high diversification in food production in the study area.

Among the livestock kept were; chicken, goats, donkey and humped cattle breed (zebu) which is adaptable to hot tropics. These were mainly kept as a source of food, wealth, manure and income to enhance household sustainability. The indigenous zebu cattle also provided draft power for the cultivation of crops.

### 3.2. Access and use of seasonal climate information services

Descriptive statistics on the access and use of CIS are summarised in Fig. 1. As shown 94 percent of sample households had access to seasonal forecast. Out of these, 78 percent reported that seasonal forecast was accompanied by agronomic advice. Among the farmers who accessed seasonal CIS only 40 percent utilised it in farm management decisions. This finding concurs with that of (Serra and Mckune, 2016) who established that despite the wide dissemination of climate information services the rate of utilisation in farms to manage climate-related risks is minimal. Lack of trust and unreliability of the climate information services were reported as the main hindrances to the utilisation of climate information services. This finding is supported by that of Ziervogel et al. (2005) who indicated that household use of climate information was dependent on the trust placed on the forecast. Moreover, Mudombi and Nhamo (2014) indicated that climate information should be reliable, trusted and understandable for farmers to utilise it in climate change adaptation.

The various agronomic advice that accompanied seasonal forecast included introduction of new crop varieties, growing of early maturing varieties, adoption of drought-tolerant varieties of crops, early land preparation and adjusting planting dates. Change in planting dates, time of land preparation, type of crop grown, a shift in crop variety, area allocated to crops were the various farm practices influenced by seasonal climate information services. These findings are similar to those of Serra and Mckune (2016) and Mudombi and Nhamo (2014) who found that crop rotation, intercropping, conservation tillage, manure management, change in crop type and variety and change in planting dates were the various farm changes influenced by climate information.
Results in Fig. 2 showed that majority of households accessed climate information services through radio and television dissemination channels. High access to climate information via radio has been linked to low cost, wide coverage, use of vernacular language and low maintenance cost (Ingram et al., 2002; Oyekale, 2015).

### 3.3. Determinants of access and use of seasonal CIS

A test for independence was done to justify the use of Heckprobit over standard probit model using STATA software. A formal test of independence rejected the null hypothesis that the correlation in errors terms of the selection and outcome equations was significantly different from zero (Wald Chi-square = 4.44, p-value = 0.035) hence justifying the use of Heckprobit model. The log likelihood of the model was also significant at 1 percent (Wald Chi-square = 58.89, with p-value<0.00) indicating a high explanatory power of the model. Moreover, access to improved seed and organic fertilizers were potential suspects of endogeneity. Hausman test was done to test for endogeneity. The results showed that both variables were exogenous.

Table 2 presents Heckprobit results of the determinants of access (columns 2–4) and use (columns 5–7) of CIS. Average marginal effects are reported. The results
of the selection equation showed that age of household head correlated with a reduced likelihood of access to CIS whereas household size, television ownership, income, farming and group membership correlated with an increased likelihood of access to CIS. Specifically, an increase in the age of the household head by one year resulted in a 0.9 percent decreased likelihood of accessing seasonal CIS. The age of the household head is correlated to farming experience. Therefore, older farmers have enhanced their climate monitoring and risk spreading skills which enable them to cope with climate change risks hence less demand for seasonal CIS (Yong, 2014; Uddin et al., 2014). Moreover, Kirui et al. (2014) established that older farmers preferred indigenous knowledge over modern climate information services.

An increase in household size by one member increased the likelihood of access to seasonal CIS by 2.8 percent. This implied that households with more members had a higher chance of accessing CIS from different sources. According to Deressa et al. (2008), households with more members were more likely to adapt to climate change due to readily available labour hence a higher demand for climate information services.

A unit increase in farm size increased the likelihood of accessing climate information services by 2.3 percent. This is because households with large farm size are able to diversify crops options and spread risks associated with unpredictable climate hence high demand for CIS. This finding concurs with that of Rehman et al. (2013) who established that an increase in farm size resulted in increased access to agricultural information. Moreover, farmers with large farms have a higher demand for climate information due to the enormity of expected loss attributed to climate change (Oyekale, 2015).

Television ownership increased household’s likelihood of access to seasonal climate information services. Television was the main dissemination channel of climate information after radio. This finding is similar to that of Oyekale (2012) who established that in television ownership increased access to climate forecast in Limpopo river in South Africa.

A unit increase in household monthly income significantly increased the likelihood of accessing seasonal CIS by 7 percent. Lack of finances constrains farmers from accessing the required resources to use seasonal forecast in their farm management decisions against climate risks (Ingram et al., 2002). Therefore, higher household income increase household adaptive capacity to climate change. Similarly, households that relied on farming as the main livelihood activity had a higher likelihood of accessing seasonal CIS. This is because these households may be compelled to seek information and technologies that increase their yields compared to other farmers with alternative sources who take farming as a mere tradition (Mulinya, 2017).
Group membership increased household’s likelihood of access to CIS. This is because these groups promote farmers’ social capital which enhances networking and information flow. Roncoli et al. (2009) reported similar finding in Burkina Faso that farmers who participated in farmer workshops accessed climate information and understood better probabilistic climate forecast compared to the farmer who did not attend.

As shown in column 5–7 of Table 2, age, sex of the household head and previous exposure to drought reduced the likelihood of utilising CIS while household income, farming, access to improved seed and radio ownership correlated with an increased likelihood of using CIS. Specifically, an increase in the age of the household head by one year correlated with a 0.6 percent reduced likelihood of utilising seasonal CIS.

The results also showed that female-headed households had a higher likelihood of utilising seasonal climate information services compared to their male counterparts. This is attributed to the fact that women contribute the highest percentage of rural agriculture compared to men in Africa (FAO, 2015). This finding concurs with those of McOmber et al. (2013) and Shongwe (2014) who reported that women are the main agents in climate change adaptation.

A unit increase in household monthly income significantly increased the likelihood of utilising seasonal CIS by 24 percent. The results further showed that households which relied on farming as the main livelihood activity had a higher likelihood of using seasonal CIS. This finding corroborates with that of Frisvold and Murugesan (2013) who reported that households that derived a higher percentage of their income from farming had a higher chance of utilising climate data.

Frequent exposure to drought reduced household’s likelihood of utilising seasonal climate information services in their farm decision making by 15 percent. This finding agrees to that of Ziervogel and Calder (2003) who found that farmers who were exposed to previous climate shocks were reluctant to use climate information in farm decision due to reduced or lack of confidence in them. The limited use of CIS could be linked to the fact frequent exposure to climate shocks forced farmers to seek alternative livelihood options that were not vulnerable to climate change (Ogara, 2016).

Radio ownership increased the likelihood of utilising seasonal climate information services. This relates to the fact that radio was the preferred dissemination channel of climate information services in the study area. This finding is supported by that of Hampson et al. (2014) who established that majority of the farmers used climate information disseminated through radio which was the most trusted and preferred channel. Moreover, majority of radios stations disseminate information in vernacular languages which enhance the utilisation of climate information by all farmers.
Table 2. Marginal effects of access and use of seasonal climate information services.

| Dependent Variable                  | Selection equation (Access to SCIS) | Outcome equation (Use of SCIS) |
|-------------------------------------|-------------------------------------|--------------------------------|
|                                     | dy/dx  | std Err | P value | dy/dx  | std Err | P value |
| Age                                 | -0.009 | 0.002   | 0***    | -0.006 | 0.003   | 0.037** |
| Gender of HH                        | -0.060 | 0.056   | 0.284   | -0.162 | 0.081   | 0.045** |
| Household Size                      | 0.028  | 0.015   | 0.061*  | -0.020 | 0.019   | 0.283   |
| Education                           | -0.012 | 0.008   | 0.107   | 0.000  | 0.011   | 0.968   |
| Total farm land                     | 0.023  | 0.008   | 0.005***| -0.006 | 0.009   | 0.517   |
| Frequency of draught                | -0.042 | 0.054   | 0.439   | -0.146 | 0.070   | 0.036** |
| Extension services                  | -0.055 | 0.069   | 0.427   | 0.104  | 0.082   | 0.208   |
| Credit facilities                   | 0.072  | 0.059   | 0.227   | 0.021  | 0.072   | 0.769   |
| Main income activity                | 0.194  | 0.066   | 0.003***| 0.252  | 0.080   | 0.002***|
| Monthly Income                      | 0.072  | 0.024   | 0.003***| 0.236  | 0.037   | 0***    |
| Ownership of radio                  | 0.082  | 0.096   | 0.389   | 0.220  | 0.071   | 0.002***|
| Ownership of TV                     | 0.098  | 0.049   | 0.046** | 0.039  | 0.065   | 0.553   |
| Access to improved seed             | 0.125  | 0.073   | 0.88    | 0.133  | 0.072   | 0.066*  |
| Group membership                    | 0.132  | 0.050   | 0.008***|        |         |         |
| Access to organic fertilizers       | 0.131  | 0.080   | 0.103   |        |         |         |
| Access to farm equipment            | 0.200  | 0.274   | 0.466   |        |         |         |

Notes: The coefficient of total income was zero which implied high variance in the variable, therefore natural log was taken and used for analysis in the model. Number of obs 231, Censored obs 52, Uncensored obs 179, Log likelihood = -187 Wald chi2 (16) 58.89 Prob > chi2 0.0000. LR test of indep. eqns. (rho = 0); chi2 (1) = 4.44 Prob > chi2 = 0.035. Notes: ***, ** and * represent 1%, 5% and 10% significance levels respectively.

Access to improved seed increased households’ likelihood of utilising climate information services. This finding is supported by that of Patt et al. (2005) who found that access to climate information services was less valuable in farm management decisions without access to farm inputs. Farmer’s ability to utilise climate information services in farm decision making is dependent on their access to required farm inputs to maximise benefits of climate information services (O’Brien et al., 2000).

4. Conclusion

The access and utilisation of climate information services for climate change adaptation is limited. This study analysed the various factors that affect both access and use of climate information services. The Heckprobit model was used for analysis to correct for selectivity bias since the farmers who utilised CIL were non-randomly selected from those who accessed it. The results showed that more than half of households accessed seasonal climate information services. Among these households that accessed CIL less than half used it in their farms for climate change...
adaptation. Lack of trust and unreliability of climate information services were reported as the main barriers to their utilisation in farm decisions against climate risks.

The results of the heckprobit model showed that age of household age correlated with reduced likelihood of access to CIS while, farming, household income, television ownership, group membership, farm size and household size increased it. On the other hand age, sex of household head and frequent exposure to drought were correlated to reduced likelihood of utilising CIS whereas household income, access to improved seed, farming and television ownership increase it.

4.1. Recommendations

A limited number of households utilised climate information services in farm management decisions. Lack of trust and unreliability of CIS were reported by farmers as the main constraints to use of CIS. Therefore, provision of accurate, timely and usable information should be the priority of the Kenya Meteorological Department and other providers of climate information services.

Household’s access to improved seed enhanced the utilisation of CIS. Therefore, resources should be provided to ensure access of improved seed at low cost by all farmers to enhance climate change adaptation. Moreover, female-headed households were more likely to utilise climate information services compared to men-headed households. Therefore, this study suggests policies that promote women access to production resources to enhance utilisation of CIS. In addition, the providers of CIS should enhance dissemination of the information through channels that favour women.

Younger farmers had a higher likelihood of accessing and using climate information services. Therefore the providers of CIS should target younger farmers in formulation and dissemination to enhance climate change adaptation. Television and Radio ownership also increased the likelihood of access and use of climate information services. Therefore, the providers of climate information services should enhance timely and frequent dissemination of detailed climate information to ensure majority of farmers’ access and utilise it.

Declarations

Author contribution statement

Emily Muema: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

John Mburu: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.
Jeanne Coulibaly: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Jane Mutune: Contributed reagents, materials, analysis tools or data.

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**Competing interest statement**

The authors declare no conflict of interest

**Additional information**

No additional information is available for this paper.

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