
Determinants of Participation of Smallholder Farmers in Weather Index Insurance in Embu County, Kenya

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Abstract

The study examined how multiple factors influence participation of farmers in Weather Index Insurance (WII) in Embu County, Kenya. Data were collected from a sample of 401 smallholders following multi-stage sampling technique. The study employed the Cragg's Double Hurdle model in determining factors that influence participation and extent of participation in WII. Results revealed that short rain season, household size, land size, perception of the household head on WII, ownership of a mobile phone and location of the farm were important factors in explaining participation in WII. The distance to a registered agro-veterinary products outlet, insurance premium, group membership, the weather station in Runyenjes station and distance to the local weather station influenced probability to participate negatively. Similarly, ownership of mobile phone had a positive influence on the extent of participation in WII while the size of the household, distance to a registered agro-veterinary products outlet and land size were significant with a negative influence. The findings of this study highlight the importance of shaping farmers' perceptions towards WII, promotion of policies that allow for access and use of information and communication technologies (ICT) such as mobile phones by the farming households as a pathway to providing smart solutions to smallholder farmers in dealing with weather related risks. Further, the research recommends for development of policies that would ensure modest WII insurance premiums that are aligned to the unique needs of the smallholder farmers.

Key words: Weather index insurance, agricultural risks, participation, Kenya

Introduction

Agriculture is a fundamental strategy for sustainable development, poverty alleviation, and enhanced food security in developing countries (Gassner, Harris, Mausch, Terheggen, Lopes, Finlayson, & Dobie, 2019; Kebede, 2020). However, it is prone to risks and uncertainties because it is vulnerable to vagaries of nature like drought and excess rainfall. To cushion farmers, the insurance industry has developed weather index products that have been widely implemented in different parts of the world. Subsequently, studies have been carried out on adoption and awareness of crop insurance (Guodaar & Asante, 2018) and analysis of the determinants of adoption of crop insurance so as to understand the role various factors play in enhancing WII uptake among smallholders (Njue, Kirimi, & Mathenge, 2018). The vulnerability of agriculture to extreme weather conditions leads to a substantial loss of income and food among small-scale farmers in Sub-Saharan Africa (Belay, Recha, Woldeamanuel, & Morton, 2017; Gbegbelegbe, Serem, Stirling, Kyazze, Radeny Misiko, Sonder, 2018; Lemessa, Watebaji, & Yismaw, 2019). This is a precarious threat that continually subjects smallholders to unwarranted poverty traps within their farming activities. In a broad view, it implies that a rational management of the risks would provide a pathway for smallholders to incessantly

contribute towards food security, which is consistent with the attainment of the United Nation's Sustainable development goal of ending poverty and hunger (Bitew, Alemayehu, Adeg, & Assefa, 2019; United Nations, 2015).

WII literature has mainly focused on analyzing the determinants or the demand of crop insurance and (Njue et al, 2018; Nshakira-Rukundo, Kamau, & Baumüller, 2021) with limited attention on the factors that influence the intensity of adoption of WII. The intensity of use of a technology is important in providing insights on the expected impacts. Studies reveal that implementation of index based insurance has been slow and subsequent uptake by both potential insurance providers and beneficiaries is still low (Jensen, Mude, & Barrett, 2018; Johnson, Wandera, Jensen, & Banerjee, 2019). This further raises the question as to whether the factors that influence participation and extent of participation in the WII have been well understood. In addition, many studies analyze hypothetical contracts that assess willingness to adopt index based insurance (Ali, Egbendewe, Abdoulaye, & Sarpong, 2020; Sibiko, 2016; Sibiko, Veetil, & Qaim, 2018). Other studies show that the social, economic, institutional factors, perceptions as well risk preference and index insurance attributes largely influence adoption and willingness to adopt WII (Adjabui, Tozer, & Gray, 2019; Sibiko & Qaim, 2020).

This study used a private insurance WII product developed to cushion smallholders from drought and excess rain risks, by protecting their investment in farm inputs used. This WII scheme was established in 2008 and it was designed to target farmers who grow crops like maize and wheat. The insurance premium payable for the scheme was bundled with input costs so that whenever farmers purchase inputs from authorized dealers they would pay an extra 5% in addition to price as premium.

The objective of this article was to examine the determinants of uptake of WII among smallholder farmers. The novel contribution is that the paper sought to identify the factors that influence participation and extent of participation in WII unlike previous studies that have focused only on the uptake of WII.

Methodology

The study was carried out in Embu County Kenya (Latitude: 0° 31' 59.99" N, Longitude: 37° 26' 59.99"E) this being one of the counties where the WII program had been implemented for more than three years. From a target population of 131,683 (of adopters and non-adopters of WII) a sample of 401 farmers was obtained following a Multi-stage sampling technique. Data were collected from all the five regions namely Embu town, Ishiara, Runyenjes, Siakago and Gachoka using structured and pre-tested questionnaires on a range of variables including data on households' social economic characteristics, demographics, institutional factors, weather issues, WII, farm enterprises yield and income. In addition, the farmers were asked to provide information on whether they adopted the WII scheme hence participation and the number of inputs (fertilizer, seeds and chemicals) that they insured. The extent of participation WII was then determined as a ratio of the cost of input insured relative to the total input acquired.

Empirical model specification

The Double Hurdle model was applied in determining the factors that influence participation and extent of participation in the WII programme (Cragg, 1971). This model makes an assumption that households make sequential decisions in the adoption process and that explanatory variables used may appear in both equations (Bettin, Lucchetti, & Pignini, 2018). The Double Hurdle model has been applied in different empirical studies (Anang & Yeboah, 2019; Kiyangi, Edriss, Phiri, Buyinza, & Agaba, 2016; Kousar, Sadaf, Makhdum, & Ijaz, 2017). This is because it is an improvement of standard Tobit and Heckman model (Danso-Abbeam, Dagunga, & Ehiakpor, 2019). The model yields two equations. If a household had participated (a dichotomous choice) then a Probit model was applied while the extent or level of participation (amount in KES)¹ was expressed as proportion of cost of input acquired (a continuous variable). The model was thus specified as;

$$D_i = 1 \text{ if } D_i^* > 0 \text{ and } 0 \text{ if } D_i^* < 0$$

$$D_i = \alpha'Z_i + u_i \dots \dots \dots 1$$

where D_i^* is a latent variable describing a farmer's decision to participate in WII. It takes the value 1 if the smallholder adopts and 0 otherwise (non-adoption), Z denotes a vector of household's characteristics while α is a vector of parameters to be estimated. The second hurdle in the model involves an outcome equation which uses a truncated regression model to estimate the intensity or extent of adoption of the WII (Cragg, 1971). This uses observations from those respondents who indicated a positive value for the WII. The extent of adoption (Y) has an equation;

$$Y_i = Y_i^* \text{ if } Y_i^* \text{ and } D_i^* > 0 \quad Y_i = 0 \text{ otherwise,}$$

$$Y_{i1}^* = \beta X_1 + V_i \dots \dots \dots 2$$

(Participation decision)

$$Y_{i2}^* = \beta X_2 + U_i \dots \dots \dots 3$$

(Extent level equation)

where, Y_{i1}^* is the observed outcome that describes a household decision to adopt index insurance, X_1 is a vector of variables explaining the adoption decision (such as the individuals' characteristics) and β is a vector of parameters. Y_{i2}^* is the latent extent of input cost (e.g. the premium) paid for WII; X_2 denotes a vector of explanatory variables accounting for intensity (the premium amount paid for the insurance policy). V_i and U_i are the respective error terms that are randomly distributed since the two equations are independent with a mean of zero and constant variance σ^2 (Kariuki, Ayuya, & Nduku, 2019). The Double Hurdle was estimated by maximizing the log-likelihood function and allowed for heteroscedasticity and a non-normal error structure following (Gichuki, & Mulu-Mutuku, 2018), as specified below;

¹ KES is the symbol of the Kenyan Shilling currency

$$\log L = \sum_0 \ln \left[1 - \Phi(z_i; \alpha) \Phi\left(\frac{x_i' \beta}{\delta}\right) \right] + \sum \ln \left[\Phi(z_i; \alpha) \frac{1}{\delta} \phi\left(\frac{y_i - \beta x_i'}{\delta}\right) \right] \dots \dots \dots 4$$

Where Φ and ϕ are the standard normal cumulative distribution function and the density function respectively. Consequently, the test of hypothesis for the Double Hurdle model versus the Tobit model is determined by estimating the Tobit, truncated regression and the Probit models separately (Mahoussi, Adegbola, Aoudji, Kouton-Bognon, & Biaou, 2021). In addition, the log likelihood ratio (LR) test is used to determine the appropriateness of either the Tobit or Double Hurdle model when the determinants in both hurdles are the same (Mahoussi et al., 2021). The LR statistic is computed as shown;

$$\Gamma = -2[\ln L_T - (\ln L_P + \ln L_{TR})] \approx \chi^2 k \dots \dots \dots 5$$

Where L_T is the LR of the Tobit model; L_P is the LR for the probit model; L_{TR} is the LR for the truncated model and k is the number of independent variables in both equations. If the test of hypothesis $H_0 : \lambda = \frac{\beta}{\delta}$ and $\lambda \neq \frac{\beta}{\delta}$, H_0 will be rejected on a pre-specified level if $\Gamma > \chi^2 k$.

Results and Discussion

Descriptive results for participation in Weather Index Insurance

The five regions of the study area presented a varied distribution of farmers participating in WII. Results from the corresponding weather stations (Figure 1) showed that Runyenjes (27.9%) had the highest number of participants followed by Embu town station (24.7%), Siakago (23.9%), Ishiara (16.7%) and Gachoka (6.8%) respectively. Contrary to the expectation, the percentage of participation was markedly lower in the Ishiara and Gachoka yet these areas receive limited precipitation compared with the others. Further, the results revealed that 3%, 5% and 8% farmers undertook the WII policy for 1, 2, and 3 seasons respectively (Figure 2). Similarly, 15%, 20% and 26% show farmers' that insured their crops for 7, 8 and 9 seasons. This presented a relatively higher percentages of farmers insuring their crops for more seasons. A plausible explanation for this would be an improvement in perception towards WII among the farming households.

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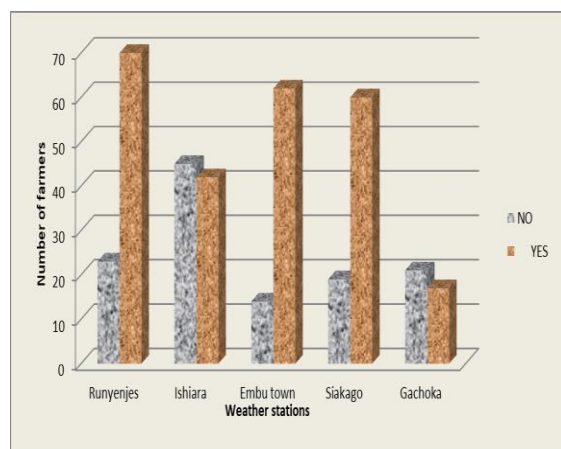


Figure 1: Frequency of adoption of WII

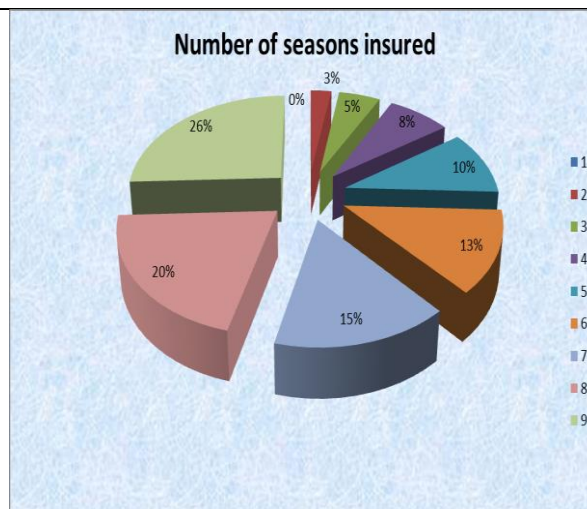


Figure 2: Number of seasons insured

With regard to farmers' compensation for crop failure, the analysis showed that majority of the smallholder farmers were compensated during season 1 and season 2 (Figure 3). The results also indicate that progressively less than 10% of the affected farmers were being compensated in the third and subsequent seasons. The decline in the rate of compensation to the smallholders in the event of crop loss possibly resulted from inadequate premiums collected due to low numbers of policy holders or the operation of basis risk. In both cases this is not appropriate for the sustainability of a WII product in a market where there is largely low public confidence towards agricultural insurance among smallholders. Inconsistencies in compensation can be a source of negative attitude towards WII where individual households suffer crop loss and the insurance does not compensated or sometimes compensation is done in part.

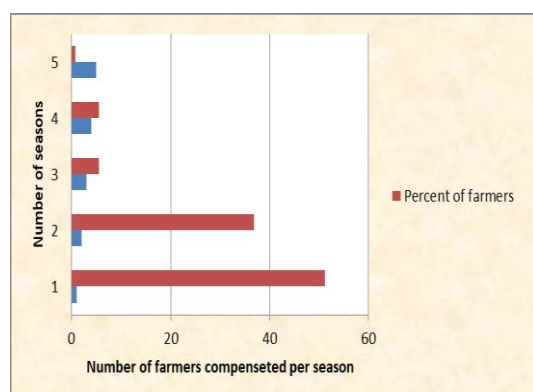


Figure 3: Frequency of farmers' compensation

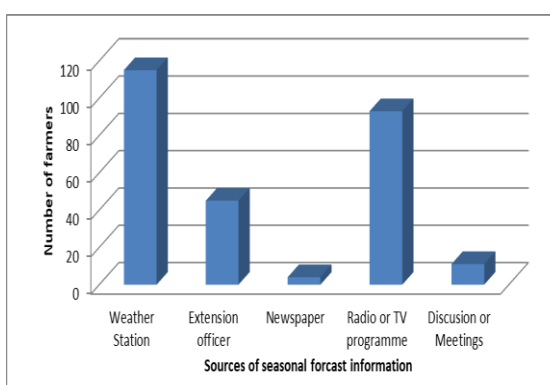


Figure 4: Sources of weather forecast information

Weather forecast information is vital in informing critical decisions in participating in WII. Various sources of weather forecast information were identified in the study including weather stations, extension officers, print media such as the newspapers, radio and television and discussions or meetings (Figure 4). Among them, weather stations, radio and television were found to be a main source of weather forecast information. Results in Figure 5 reveal that the distribution of land owned by the

smallholders ranges between 1-1.9 acres and accounts for over 30 percent of the farmers. In addition, over 20 percent of the smallholders have less than 1 acre of land while around 14 percent own 4 acres and above. This pattern of ownership is important in explaining the uptake of WII technology owing to the small land sizes of the farmers.

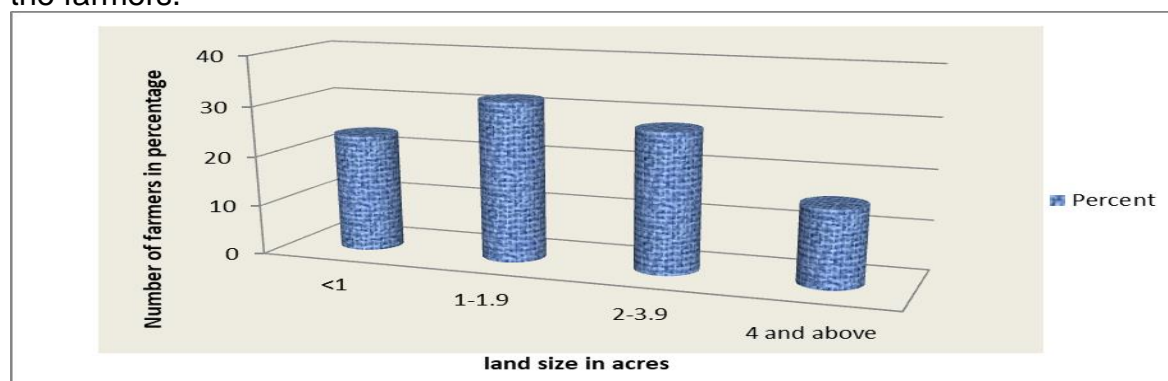


Figure 5: Land size among smallholder

Craggs' Double Hurdle model results on determinants of participation in WII

As noted, the Tobit model is nested in the Cragg model and it is possible to compare these two models through a standard LR test when the determinants in the probability and intensity of adoption are the same (Mahoussi et al., 2021). Thus, rejection of the null hypothesis ($\Gamma > \chi^2_k$) argues for the superiority of the Double Hurdle model over the Tobit model and therefore establishes that the decision about adoption and extent of adoption or participation are made in two different stages. The test results of the Double Hurdle versus the Tobit model indicated the rejection of the Tobit model and hence the Double Hurdle model was applied.

The empirical results obtained by estimating the Double Hurdle model are presented in Table 1. The results show that different sets of variables influence the decision to adopt WII and the extent of adoption. This suggests that the two decisions (participation and extent) are independent. Size of the land is considered an important asset in adoption of technology and intensity of adoption. In this study it was found that an increase in the size of land by one unit increases adoption of WII by 1.02%. Interestingly, the result shows also that an increase in land size influences the extent of participation negatively by 9.58%. Ownership of a large parcel of land essentially would allow farmers room to try new technologies while at the same time practice their conventional farming. Studies reveal that some technologies are scale neutral and therefore having a big land does not persuade farmers to adopt improved agricultural technology (Okoffo, Denkyirah, Adu, & Fosu-Mensha, 2016). Thus, on one hand it can be said that such a technology as WII holds as a good fit for smallholders up to some level then that ceases to be; hence the positive effect. On the other hand, it portrays a tendency by small holders to take up the insurance in peace-meal such as only insuring a small portion of their inputs. In which case an increase in the size of land, then influence the extent of adoption negatively because farmers may not be willing to insure the entire crop on the cultivated land.

The perception of the household head on WII positively influenced the decision to adopt WII with a probability of 0.39%. This suggests that at least farmers perceived WII as a technology that might be useful in addressing weather related risks hence they adopted it. To the contrary, studies have established that farmers have a negative perception towards index insurance or they are unwilling to pay for the insurance products (Adzawla, Kudadze, Mohammed, & Ibrahim, 2019; Budhathoki, Lassa, Pun, & Zander, 2019; Oduniyi, Antwi, & Tekana, 2020). Further, analysis on the extent of adoption shows that perception is not significant however, it has a negative association. This agrees with the earlier discussion that presents the perception of farmers towards the effectiveness of WII as good but, it is possibly overridden by the presence of multiple risks to the extent that a negative attitude might instead be observed (Isaboke, Qiao, Nyarindo, & Ke, 2016). The results bring into perspective a somewhat desire to take up the insurance, hence the positive influence of perception; but this is precipitously reduced in the extent of adoption decision which then results to a negative effect of farmer perception possibly because WII does not address other risks associated with the weather variations.

The study also reveals that ownership of a mobile phone had a positive influence both in the decision to adopt as well as the extent of adoption with a probability of 3.08% and 0.11%, respectively. Mobile phone technology plays a central role in the implementation of index insurance by collecting premiums from the farmers and in relaying pay-outs to farmers (Ndagijimana, 2021).

Payment of insurance premium forms the basis of a contractual relationship between the insurer and the policyholder of a weather index product. The insurance premium variable was significant at 1% level and had a negative influence on the uptake with a probability of 0.43%. Traditionally, agricultural insurance schemes have faced financial challenges because of the high administrative and operational costs, adverse selection and moral hazard problems (Reyes, Agbon, Mina, & Gloria, 2017) thus index based insurance provides an alternative risk-reducing tool with the potential to alleviate the financial effects of adverse weather (Salgueiro, 2019). However, it still increases the costs of inputs to the smallholder farmers and hence negative influence thus agreeing with the argument that the poor smallholders might be the least likely individuals to have resources that are required to purchase policies.

Group membership of the smallholder farmers was significant at 5% level with a negative influence on the adoption of WII. Thus by belonging to a group there was a 0.22% probability of reducing the adoption of WII. Smallholder farmers, mostly participate in group activities. This facilitates mobilization of resources, sharing of ideas and achievements in the social, cultural, religious, political and economic objectives through collective action (Othman, Garrod, & Oughton, 2021). It is much easier to penetrate and reach farmers who are in organized groups by development partners or government agencies through farmer field days (FFD), trainings and giving of extension services than reaching out to individual farmers. Introduction of WII followed this group approach for implementation. However, because of the negative influence observed, the result suggests that while groups provide a good

platform for introducing improved technologies, there is a possibility that farmers may continue to pursue the group objectives rather than pay attention to new technologies uptake such as the WII.

Distance of the farm land from the weather station was measured in Kilometers. The study found that an increase in distance by one kilometer from the weather station reduces the probability of adopting WII by 0.02% with the results being significant at 10%. Each of the five weather stations served farmers in a 20 kilometer radius. This leads to a possibility that farmers in the different locations of the 20 kilometers can experience variations, for example in rainfall amounts relative to what is recorded at the local weather station. Similarly, distance to a registered Agro-veterinary shop outlet influenced both adoption and extent of adoption negatively. This variable had a probability of reducing adoption by 0.08% if the distance from the said outlet increased by one unit. The extent of adoption would also be reduced by a probability of 0.38%. Distance in this case implies limiting access to the WII products.

The location effects were also considered to be important in explaining the adoption and extent of adoption of WII. The five locations considered were captured as dummies. The probabilities associated with adoption of WII were 0.05% (Embu town), 0.84% (Ishiara), 0.16% (Siakago) and 4.82% (Gachoka) respectively. In addition, it was observed that Runyenjes location negatively influenced the adoption of WII with a probability of 1.09%. It is likely that the differences in socioeconomic attributes as well as agro-ecological factors of the five regions explains the differences in participation patterns. On the other hand, Ishiara and Gachoka were significant on the extent of participation with probabilities of 0.09% and 0.61% perhaps because the two regions are located on relatively drier areas. The agro-ecological zones and location variables are not common in adoption studies (Banda, 2017). However, in this study the variables are important in explaining the uptake and intensity of use of WII technology.

The household size was significant at 10% level with a probability of 0.13% to positively influencing adoption of index insurance. This variable also had a negative influence on the extent of adoption with a probability of 1.07%. This implies that larger households may have diversified to multiple crops/livestock production so as to obtain sufficient food for the household and effectively cope with the common weather related risks. Secondly, by positively increasing the probability of adoption this result suggest that households with more members might view WII as a suitable measure of risk mitigation. In large household sizes there may be varied opinions, exposure and information or ideas from different members of a household that could affect how the household head makes decisions regarding uptake of a technology. It is also possible that there were hardly any resources available to allocate to WII owing to the size of the household. Hence, this may explain the negative influence that is observed in the extent of adoption of index insurance among smallholders (Okoffo et al., 2016).

Embu County experiences a bimodal rainfall pattern where the long rains fall

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between March and June, while the short rains fall between October and December. This was captured as a dummy in the study and it was guided by the fact that possibly farmers perceived the short rain season as an appropriate season to purchase the WII policy because of the likely crop failure due to drought or insufficient precipitation (Osgood et al., 2018). Thus as expected the variable short rain season turned out to be significant at 1% level and influenced the adoption of WII positively with a probability of 0.37.

Table 1: Determinants of participation in WII

Variable description	Probit (D)			Truncated (Y>0)		
	Coefficient	Std. Err.	dy/dx	Coefficient	Std. Err.	dy/dx
Sex of household head 1= <i>Male</i>	-0.0604	0.167	0.00061	0.0193	0.108	0.0128
Age of household head	-0.0818	0.019	-0.0082	-0.0001	0.002	-
Household size	0.0031*	0.087	0.0013	-0.0152***	0.004	0.0004
Education level	-0.0479	0.030	-0.0053	-0.0602	0.112	-
Rain season 1= <i>short season</i>	0.8546***	0.259	0.0037	-0.0007	0.821	0.0032
logoff-farm income	-0.0371	0.701	-0.0213	0.3542	0.018	-
Distance to a registered Agro-vet outlet	-0.2938**	0.013	0.0008	-0.0976***	0.007	0.0086
Number of extension contact	1.0765	0.475	0.0209	0.1035	0.065	0.0021
Land under cultivation	-0.1624	0.502	-0.0028	-0.3073	0.019	-
Experienced crop loss	0.0117	0.109	0.0006	0.8062	0.012	0.0425
Land size	1.2664*	1.003	0.0102	-0.2946***	0.033	0.0095
Group membership1= <i>belong to group</i>	-0.9252**	0.618	0.0022	-0.0005	0.093	-
Perception of household head	0.5443**	0.941	0.0039	-0.1104	0.112	0.1006
Access to extension 1= <i>Yes</i>	0.8722	0.296	0.0014	-0.0277	0.416	-
Mobile phone 1= <i>Yes</i>	0.0187***	0.363	0.0308	0.2756**	0.802	0.0121
Dummy for <i>Embu</i> town station 1= <i>Embu</i>	0.1374**	0.727	0.0005	-0.0335	0.616	0.0011
Dummy for <i>Ishiara</i> station 1= <i>Ishiara</i>	0.1168**	0.179	0.0084	0.0225***	0.313	0.0045
Dummy for <i>Siakago</i> station 1= <i>siakago</i>	0.6389***	0.315	0.0016	0.0098	0.708	-
Dummy for <i>Runyenjes</i> station 1= <i>Runyenjes</i>	-0.0062*	1.405	-0.0109	-0.0613	0.001	0.0009
Dummy for <i>Gachoka</i> station 1= <i>Gachoka</i>	0.1964***	0.907	0.0482	0.0483**	0.028	0.0103
Distance to market	0.0708	0.208	0.0000	-0.0000	0.101	-
Distance from weather station	-0.1043*	0.892	-0.0002	-0.0067	0.069	0.0002
Forecasts 1= <i>Access</i>	-0.1572	0.012	-0.0096	-0.0723	0.215	-
Years of farming	-0.9404	0.509	-0.0014	0.0543	0.011	0.0017
Credit 1= <i>Access</i>	0.0006	0.245	0.0128	-0.0162	0.507	-
Insurance premium	-0.4871***	0.883	-0.0043			0.0021
Cons	0.032	0.693		0.502	0.053	
Wald χ^2 (15)	77.900					
Log Likelihood	-119.634					
Prob>chi2	0.000					
Number of observations	401					

***, **, * denotes significant at 1%, 5% and 10% probability levels, respectively

Conclusions and Recommendations

Short rain season, household size, land size, perception of the household head, ownership of a mobile phone and location of the farm as having a positive influence on participation in WII. The distance to a registered agro-veterinary products outlet, insurance premium, group membership, Runyenjes station and distance to the local weather station influenced probability to participate negatively. Similarly, ownership of a mobile phone had a positive influence on the extent of participation in index insurance while the size of the household, distance to a registered agro-veterinary products outlet and land size were significant with a negative influence.

In conclusion the results reveal that popularizing WII among the rural folks so as to promote acceptability by changing the perceptions of farmers and providing information that WII is a useful tool that could be used to address the weather related risks is vital. The findings also highlight the importance of promoting policies that allow for access and use of ICT such as mobile phones by the farming households as a pathway to providing smart solutions to smallholder farmers as they combat weather related risks. Further, the study recommends the need for policies that would ensure WII insurance premiums are modest and aligned to the requirements of the target farmers.

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